solutions plus

Scaling the Use of Electric Bicycles for Urban Deliveries In Dar es Salaam, Tanzania

UEMI Wuppertal Institut ITDP UN-HABITAT FOR A BETTER URBAN FUTURE

Project	SOLUTIONSPlus - Integrating Urban Electric Mobility Solutions in the Context of the Paris Agreement, the Sustainable Development Goals and the New Urban Agenda
Title	Pre-Feasibility Study on the Use of Electric Bicycles for Urban Deliveries: Transitioning from Conventional Motorcycles to Electric Bicycles in Dar es Salaam
Publication date	18 June 2024
Coordination	Urban Living Lab Center (ULLC)
Contributing partners	Urban Electric Mobility Initiative (UEMI), Wuppertal Institute (WI), Institute for Transportation and Development Policy (ITDP) Africa, Dar Rapid Transit Agency (DART), United Nations Human Settlement Programme (UN-Habitat)
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Cover picture	Nicolay, 2022
Disclaimer	The views expressed in this publication are the sole responsibility of the authors named and do not necessarily reflect the views of the European Commission.

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Abbreviations

A2EI	Access to Energy Institute
AfEMA	Africa E-Mobility Alliance
BRT	Bus Rapid Transit
CBD	Central Business District
CoC	Certificate of Conformity
CPF	Customs Processing Fee
DIT	Dar es Salaam Institute of Technology
DART	Dar Rapid Transit Agency
EURIST	European Institute for Sustainable Transport
FABIO	First African Bicycle Information Organisation
ITDP	Institute for Transportation and Development Policy
ICE	Internal Combustion Engine
IRR	Internal Rate of Return
KPI	Key Performance Indicator
RDL	Road Development Fee
TASAC	Tanzania Shipping Agencies Corporation
UNEP	United Nations Environment Programme
UN-Habitat	United Nations Habitat
UDSM	University of Dar es Salaam
UEMI	Urban Electric Mobility Initiative
ULLC	Urban Living Lab Center
WI	Wuppertal Institute
ATE	Association of Tanzania Employers
CKD	Completely Knocked Down
CO2	Carbon Dioxide
EAC	East African Community
EUR	Euro
GDPR	General Data Protection Regulation
GHG	Greenhouse Gas
GPS	Global Positioning System
ITA	International Trade Administration
JNHPP	Julius Nyerere Hydropower Project
MW	Megawatt
NGO	Non-Governmental Organization
NPV	Net Present Value
SKD	Semi Knocked Down
SSA	Sub-Saharan Africa
USD	United States Dollar
VAT	Value-Added Tax

Executive Summary

Why electric bicycles?

Electric bicycles present an innovative solution to the challenges posed by conventional means of urban delivery. They are quieter than motorised vehicles such as fossil-fueled motorcycles largely used in Dar es Salaam (Tanzania). Additionally, they emit no pollutants at the point of use, use less space in cities, and improve the range and convenience of cycling. Electric bicycles are more resource-efficient than larger electric vehicles such as motorcycles or cars, as they require much smaller batteries.

Research conducted by SOLUTIONSplus in 2023 showed that electric bicycles represent a tangible reality in Africa, not just wishful thinking. According to the AfEMA e-mobility companies database, which tracked 159 electric mobility companies in Africa as of December 2023, 19% of these companies in the continent offer various electric bicycles. The SOLUTIONSplus African Electric Bicycles Start-up Booklet gave a voice to 18 selected pioneering start-ups engaged in designing, manufacturing, assembling, and deploying electric bicycles in African urban and rural areas. These e-bicycles serve multiple purposes, from rural goods transport to urban food deliveries. They also play a growing role in personal commutes, shared mobility, and first and last-mile connectivity.

SOLUTIONSplus pilot and results

In 2022, SOLUTIONSplus launched a pilot of pedal-assist electric bicycles in Dar es Salaam, used by the FASTA cycling cooperative for the transport of medical supplies and maintenance materials of the Aga Khan Hospital, as well as other goods. The project brought together the strengths of the SOLUTIONSplus partners (Urban Living Lab Center, UN-Habitat, UNEP, ITDP Africa) to finance the project, coordinate and communicate, EURIST and FABIO for co-financing, providing the AfricroozE e-bicycles and training, the cycling cooperative FASTA using the e-bicycles, and the Dar es Salaam Institute of Technology hosting the training and enabling overnight charging of the batteries.

Results of the six-month pilot showed high satisfaction among the cyclists with regards to the e-bicycles, which were reported to facilitate punctuality, allow riders to plan delivery speeds and cover longer distances efficiently, earn trust and credibility from customers for timely deliveries, and reduce risks of not being paid due to delivery delays. The e-bicycle itself, as an innovative mode of transport, was seen as part of the advertisement of the cycling cooperative. During the pilot, repairs encountered were minor, without major issues, but this will need further monitoring as a follow-up one year after the start shows additional repair needs. While the pilot was deemed successful overall, challenges were identified. This includes high taxes and cumbersome import processes, a lack of availability or affordability of some spare parts, a lack of safe cycling infrastructure and cycling parking amenities, and low awareness among the government and citizens about e-bicycles. In addition, the pilot identified the need to improve the order volume, consistency and revenues of the cycling cooperative: the Urban Living Lab Center is supporting FASTA on this through smartphone equipment, a booking app and business support.

Going forward: scaling up electric bicycles in Dar es Salaam

This study explores the viability of scaling the number of electric bicycles for delivery services within Dar es Salaam, and their applications. In particular, the study aims to assess the potential for electric bicycles to replace conventional motorcycles, thereby contributing to a reduction in carbon emissions, improving urban air quality, and enhancing the efficiency of delivery services in the city.

To do so, the study followed a three-fold approach: (1) a deep-dive analysis of the current delivery sector in Dar es Salaam via three surveys to capture different perspectives (residents, establishment, drivers survey); (2) modelling financial and environmental impacts of substituting ICE motorcycles with electric bicycles, and (3) final recommendations to scale the e-bicycles pilot and enable widespread adoption of electric bicycles in Dar Salaam.

Technical feasibility of using e-bicycles instead of ICE motorcycles

Our analysis of the urban delivery sector in Dar es Salaam confirms that ICE motorcycles play a critical role, representing the most popular vehicle used for establishment and home deliveries.

Our analysis shows the potential for e-bicycles to provide similar services as ICE motorcycles, based on the following criteria:

- **Type of products:** establishments and drivers report similar items: mostly food products, cold drinks, sugar, drinking water, and rice, followed by apparel, textiles and laundry, and electronic devices on a less frequent basis. Residents mostly use deliveries for restaurant meals and retail shopping, e.g. clothing, electronics. These products can be transported by electric bicycles, especially in the cargo models with extra space in the back or the front.
- **Weight:** the average mass of the products evaluated in the establishment survey is 86 kg, while the 75th percentile is 100 kg. These masses are within the carrying capacity of the electric bicycle, as some electric bicycle models have up to a 120 kg load capacity. The size of products may be a more important limitation.
- **Range:** to be able to offer a similar daily range as ICE motorcycles (circa 115 kilometers per day), electric bicycles with the same specifications as the pilot would need to proceed to two battery swaps. Our recommendation is to use e-bicycles equipped with two batteries.
- **Perception:** establishments have positive expectations towards electric bicycles, to reduce transportation costs and cost efficiency. While the willingness to pay is significantly lower for purchase when comparing a regular e-bicycle with an ICE motorcycle (average price), it is very close when asking about the willingness to pay for rental and for hiring an operator. In addition, cargo models with extra load in the front, in the back, or with three wheels attracted a higher willingness to pay. Yet, the discrepancy between the willingness to pay for regular e-bicycles and actual prices highlights a gap between market expectations and the perceived value of electric bicycles among potential users (drivers and establishments). E-bicycles are associated at first glance with regular bicycles, which often suffer from a low social status.

Overall, the analysis shows a potential to substitute ICE motorcycles with electric bicycles, especially if they entail a carrying space in the back (long-tail model) or in the front (long john) and are equipped with two batteries. To ensure the versatility of applications enabling both the transport of goods and passengers, it is recommended to equip e-bicycles with footrests for passengers.

Financial and environmental impacts of using e-bicycles instead of ICE motorcycles

Modelling the financial and environmental impacts of substituting ICE motorcycles with electric bicycles having two batteries shows positive results. An impressive Internal Rate of Return (IRR) of about 115% IRR (investor's perspective) is achieved in a four-year scenario where ICE motorcycles would be replaced by pedal-assist electric bicycles equipped with a second battery to be swapped during the day to be able to perform the same number of daily deliveries as typical for motorcycles (9.7). The IRR is, however, negative (-31.33%) in the absence of this second battery, as only 6 daily deliveries would be possible. It is assumed that electric bicycles benefit from the custom duty exemption granted for locally assembled vehicles.

The environmental impact assessment shows that the shift from ICE boda bodas to electric bicycles demonstrates significant potential for reducing CO2 emissions. An ICE motorcycle emits 2,875 kg of CO2e, while an electric bicycle only emits 152 kg of CO2e per year. Therefore, substituting an ICE motorcycle with an electric bicycle, under current characteristics of electricity generation, would result in an annual reduction of 2,723 kg of CO2e, equivalent to a substantial 95% decrease in CO2 emissions. These benefits will increase with the launch of the Julius Nyerere Hydropower dam.

Recommendations

Lastly, the study identifies final recommendations for the uptake of electric bicycles in Dar es Salaam.

To scale the e-bicycles pilot with AfricroozE and FASTA, we provide recommendations on the e-bicycles, batteries and parts and on charging modalities. The availability and affordability of spare parts, as well as building a workforce of trained mechanics, are critical aspects. We identify recommendations to improve FASTA operations and earnings, in terms of customer base expansion, booking modalities, and equipment to transport goods.

To enable the widespread adoption of electric bicycles in Dar Salaam, we identify the specifications and the design for electric bicycles which would have the highest chance to compete with ICE motorcycles. We provide recommendations on training, maintenance & repairs on electric bicycles. A key dimension is to improve conditions for cycling, by creating a comprehensive network of bicycle paths, and implementing secure and convenient parking amenities. The fiscal and trade environment must be clarified and improved for electric and conventional bicycles, with administrative import barriers removed. Lastly, awareness raising with both the government and citizens is critical to showcase the benefits and convenience of electric and regular bicycles.

Recommendations for the wider adoption of e-bicycles for urban deliveries in Dar es Salaam

E-Bicycles, Batteries, Parts & Charging:

- ✓ Utilise two batteries to ensure e-bicycles can cover the same mileage as motorcycles.
- ✓ Ensure e-bicycles are designed with adequate space for goods, a minimum 100kg payload capacity, and a gender-inclusive, lower-step frame.
- ✓ Embrace an iterative approach, including recommendations from cyclists to design subsequent prototypes, as done by AfricroozE for its second iteration following feedback from the cyclists in March 2023.
- ✓ Establish a reliable spare parts supply chain and further train local mechanics to ensure timely repairs and maintenance.

Training, Maintenance, Repairs & Operations:

- ✓ Continue providing regular training for cyclists on optimal e-bicycle use, including gear and engine alignment, progressive braking, and safe riding in various conditions (recommended training frequency of every 6 months in the first 2 years).
- ✓ Train cyclists in basic repair skills to ensure immediate troubleshooting capabilities.

Fiscal and Trade Environment:

- ✓ Clarification of the tax situation applicable to e-bicycles, in particular concerning the new industrial license removing custom duty for locally assembled vehicles.
- ✓ Ensure that e-bicycles are included in any e-mobility policy incentives, and advocate for a preferential tax regime for e-bicycles and bicycles to support this sustainable mode.
- ✓ Simplify import processes for key components of e-bicycles to facilitate easier and more cost-effective entry into the market.

Use cases

- ✓ Approach digital platform stakeholders to offer trial phases or partnerships with e-bicycle companies.
- ✓ Approach companies, highlighting environmental benefits and links to their Corporate Social Responsibility.
- ✓ Approach Tanzanian government authorities for public fleet use, e.g. municipal fleet.
- ✓ Experiment various further business models such as leasing, public sharing, and purchasing.

Cycling Infrastructure:

- ✓ Create a comprehensive network of bicycle paths and lanes interconnecting residential areas, business hubs, and main destinations.
- ✓ Upgrade the current cycle lane infrastructure with the installation of adequate signposting, road paint and deployment of traffic calming measures.
- ✓ Implement secure and convenient parking amenities for e-bikes at public transport centers, markets, and popular locations to ensure safety when not in use.

Awareness Raising:

- ✓ Increase awareness among government officials and the public about the benefits and convenience of electric bicycles through events, communication campaigns, and practical demonstrations, to improve the social perception of cycling.
- ✓ Organize events such as car-free days to promote sustainable urban mobility.
- ✓ Organise test trials as a proven approach to convince users of the value and convenience offered by e-bicycles, to bridge the willingness-to-pay gap and enhance market acceptance.
- ✓ Engage with influencers, university networks, and participate in exhibitions to enhance the visibility and acceptance of e-bicycles.

1 Introduction

Purpose of the study

Electric bicycles present an innovative solution to the challenges posed by conventional means of urban delivery. They are quieter than motorised vehicles such as fossil-fuelled motorcycles largely used in Dar es Salaam (Tanzania). In addition, electric bicycles emit no pollutants at the point of use and use less space in cities. Furthermore, e-bicycles are more resource efficient than large motorised vehicles, even electric motorcycles or cars using much larger batteries.

The SOLUTIONSplus demonstration project in Dar Es Salaam fosters innovative and urban electric mobility solutions for both passenger connectivity through the electrification of three-wheelers services connecting to BRT stations, and for innovative urban logistics. In 2022, SOLUTIONSplus launched a pilot of pedal-assist electric bicycles in Dar es Salaam, used for the transport of medical supplies, maintenance materials and other goods by the FASTA bicycle cooperative.

This prefeasibility study explores the viability of scaling the number of electric bicycles for delivery services within Dar es Salaam, and their applications. In particular, the study aims to assess the potential for electric bicycles to replace conventional motorcycles, thereby contributing to a reduction in carbon emissions, improving urban air quality, and enhancing the efficiency of delivery services in the city. Conventional motorcycles (boda bodas), powered by internal combustion engines (ICE), are a current cornerstone of delivery services in Dar es Salaam and their number is rising rapidly. Identifying pathways to promote less polluting, safer and more space efficient mobility should be identified.

Study objectives & scope

This report presents the findings of the pre-feasibility study, offering insights into the practicality, benefits, and challenges of adopting electric bicycles for delivery services in Dar es Salaam. It serves as a foundational resource for decision-makers, investors, founders and logistics stakeholders considering fostering the transition towards electric bicycles for urban deliveries. This Pre-Feasibility study centers around the following objectives:

- Evaluate the current market for delivery services in Dar es Salaam, in particular the role of conventional motorcycles.
- Assess the technical feasibility of e-bicycles for delivery services in terms of range, delivery capacity, and compatibility with existing infrastructure.
- Analyse the environmental benefits of transitioning to electric bicycles, focusing on potential reductions in carbon emissions and other pollutants.
- Examine the financial implications, including the initial investment and operational costs, compared to conventional motorcycles.
- Identify the regulatory and policy environment affecting the adoption of e-bicycles.

Approach and data collection

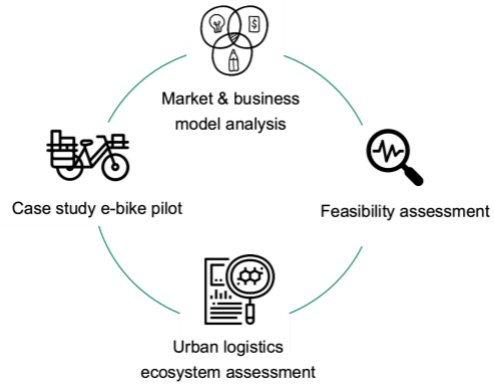


Figure 1 Areas of investigation

This pre-feasibility study uses a comprehensive methodology collecting complementary assessments to assess the potential and feasibility of electric bicycles for urban deliveries in Dar es Salaam. It involves a thorough investigation of the city's logistics ecosystem and profiles.

A variety of quantitative and qualitative data have been collected to gain a comprehensive understanding of the current state and potential future trends. Various analyses are carried out, such as customer profile analysis and logistics market analysis. In addition, the study looks at the existing landscape of business models and markets for e-bicycle delivery on regional and local levels. It also assesses the potential for replacing traditional ICE boda bodas with e-bicycles. The study's main geographic focus is on the city center.

Context: Dar es Salaam's urban mobility landscape

Urban delivery and collection activities in Dar es Salaam are influenced by a variety of characteristics and actors. Various modes of transport are currently used in the city to transport goods and people, including non-motorised modes such as pedestrians and bicycles, and motorised vehicle types such as vans, boda bodas (motorbikes), bajajis (tricycles), gutas, vans, trucks, conventional cars and dalaldals (minibuses). In addition, the city's public transport system is complemented by the DART-BRT corridors that criss-cross the urban area. Table 1 provides an overview of the common delivery and transport methods in the city.

Table 1 Overview of popular vehicle types in Dar es Salaam

	*Backpack/carrying bags* Goods are put on the back or shoulders of the porter. This is method is common for short distance trips such as moving goods from one vendor to another at markets.
	*Pushcarts* Human operated cart which is operated by pulling. Locally known as '*mkokoteni*'.
	*Traditional bicycle* A traditional bicycle is a human-powered vehicle with two wheels, a frame, pedals, a chain, and a handlebar. In Dar es Salaam, they are commonly used in the outskirt of the city for delivery of goods.
	*Traditional tricycle* A traditional tricycle, characterized by three wheels, a frame, pedals, a chain, and a handlebar, in most cases they are locally modified bicycles used for carrying heavier loads. However, in Dar es Salaam, they are mainly utilized for goods delivery in the outskirts of the city.

Boda boda

Initially used for bicycle transportation in Uganda and Kenya, boda boda is now the term used for motorcycle taxis in several East African countries (not all, for instance not in Rwanda). It specifically refers to two-wheeler moto taxi in Dar es Salaam. Boda bodas are used to carry passengers or goods, especially in urban areas where public transit is limited or congested.

Bajaji

Bajajis, known elsewhere as tuktuks, are three-wheeled vehicles mainly used for transporting passengers and goods. However, in Dar es Salaam, they are commonly employed as paratransit, available for hire or operating on a predefined route for a fixed fare.

Gutas

Guta is a Swahili name referring to cargo tuktuks which are three-wheeled vehicles specifically designed for transport of goods.

Cargo Van/truck

These are commonly small vans locally known as *kirikuu.* These vans are used to move bulk or large sized cargo.

Daladala

A daladala is a minibus share taxi service in Tanzania and some other East African countries. They are called matatus in Kenya. Daladalas have their fares and routes allocated by a transport regulator.

Photo credits: Furaha Mariki

While this overview can be drawn from observing daily transport activity in the city, limited data exists on urban delivery operations. Therefore, this study seeks to provide and summarise valuable insights from the data collection conducted as part of the SOLUTIONSplus project. The key findings are presented in Chapter 4.

2 Electric bicycles: an innovative option for urban deliveries in sub-Saharan Africa

2.1 Electric bicycles can facilitate mode shift

Electric bicycles can serve as an environmentally friendly mode of transport, improve last-mile access to public transport, provide greener vehicles for urban deliveries, encourage healthier lifestyles, and offer more affordable mobility in the face of rising petrol prices. Real-life experience in numerous cities worldwide has demonstrated the many benefits of electric bicycles, that allow to:

- Significantly increase trip convenience, especially in hilly conditions or hot weather.
- Allow higher loads to ferry passengers such as children, or carry goods, for instance, after shopping trips, which is also convenient for companies.
- Allow users to travel longer distances.

The functionality of electric bicycles changes compared to conventional bicycles as the longer trips and higher loads allow them to compete with large, motorised vehicles, especially in urban environments. In Europe, they are increasingly used to ferry goods or passengers such as children, in the form of electric cargo bicycles. For those two reasons of low acquisition costs and functionality improvement, they can be adopted by private users instead of cars. Their innovative characteristics give them a desirable social status, especially for an urban population moving away from space-consuming and cost-intensive private vehicles.

This potential to attract people to (electric) cycling and facilitate modal shift has been documented. Research has shown that electric bicycles have the potential to substitute to larger motorised vehicles (UN-Habitat, 2022). In 2018, a large study conducted in the United States and Canada showed that 46 per cent of private e-bicycle trips replaced commute trips that otherwise would have been made by car (MacArthur et al., 2019). In Knoxville, a study indicated that 11 per cent of shared e-bicycle trips had replaced car trips (Langford et al., 2013). Castro et al (2021) found that a quarter of e-bicycle trips in seven European cities substituted car trips. In a meta-analysis, Bourne et al (2020) found that e-bikes substitute for 20 to 86 per cent of private car trips. This behaviour change translates into significant reductions in carbon emissions (Philips et al., 2022).

To facilitate a growing role for electric bicycles, it is recommended that governments support them through policies and measures such as fiscal incentives – e.g. tax reduction for import or VAT – and non-fiscal incentives, such as the implementation safe cycle networks, secure cycle parking, minimum cycle parking requirements in buildings, car-free zones, or bike share systems.

2.2 Electric bicycles are used for a wide range of applications in Africa

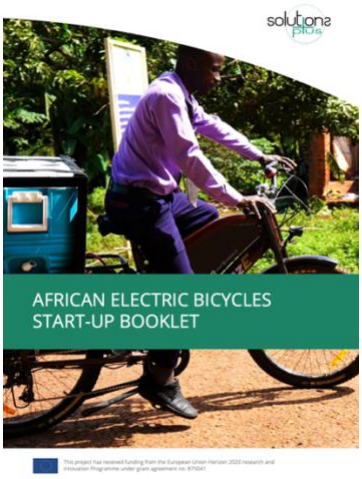


Figure 2 African electric bicycles start-up booklet

SOLUTIONSplus documented the rise of electric bicycles on the African continent in its 'African Electric Bicycles Start-up Booklet' (2023). This booklet gave a voice to 18 selected pioneering start-ups engaged in designing, manufacturing, assembling, and deploying electric bicycles within African urban and rural landscapes.

The booklet showed that electric bicycles represent a **tangible reality in Africa**, not just wishful thinking or an innovation present in the Global North. The numbers speak for themselves: some of the 18 start-ups featured in this booklet experience very dynamic uptake rates, sometimes significantly higher than companies concentrating on other vehicle types, such as electric motorcycles or electric cars.

Significant market potential and growth of e-bicycles in Africa

In Africa's electric mobility landscape, electric two- and three-wheelers currently dominate, constituting a remarkable 79% of the electric fleets, while electric light-duty vehicles make up 20%, and electric buses account for 1% (AfEMA, 2023a).

Identifying the proportion of electric bicycles in the overall fleet of electric two- and three-wheelers is challenging due to the common absence of specific tax regimes or incentives and the lack of separate registration categories for electric bicycles, often resulting in them being categorised as standard goods.

However, according to the AfEMA e-mobility companies database, which tracked 159 electric mobility companies in Africa as of December 2023, **19% of electric mobility companies in the continent offer a variety of electric bicycles.**

This figure may be taken with caution as the database is a dynamic product regularly updated, and as the market is rapidly evolving.

Figure 3 E-bicycle companies in Africa

Significant market potential and growth of e-bicycles in Africa

37.8% of the companies are in a market expansion phase: 16.7% of the 18 featured companies in the booklet have deployed more than 400 e-bicycles each; another 11.1% are currently in a rapid market expansion phase, with fleets of 150 to 400 e-bicycles.

Half of the companies (50%) are in the development stage, with up to 150 e-bicycles each. Lastly, 22.2% are testing various models in the R&D stage.

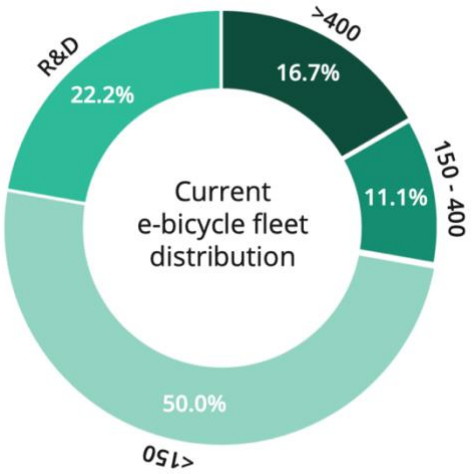


Figure 4 Current e-bicycle fleet distribution

Versatility of applications

E-bicycles in Africa serve a **variety of purposes**, from rural goods transport to last-mile and urban food deliveries. They also play a growing role in personal commutes, shared mobility, and first and last-mile connectivity.

Urban & rural deliveries

In **logistics**, electric bicycles are instrumental in urban and peri-urban areas mainly for food delivery or e-commerce. In several growing and large African cities, electric bicycle companies offer deliveries by partnering with aggregator platforms, such as UberEATS, Takealot, Bolt and others. This also applies in rural areas, enabling the transport of goods to markets benefiting retailers, micro or small enterprises, and farmers. In both rural and urban areas, electric bicycles can serve gender inclusion objectives. For example, in Uganda, electric bicycles are used by women's groups in water transportation, replacing long walks, enabling faster access to water and saving time.

Credit: eBee

Credit: Karaa

Credit: Pick n Pay

Credit: eBee

Credit: eWaka

Credit: AfricroozE

Credit: Greenfoot Africa

Credit: Siemens Stiftung

Credit: Ebikes4Africa

Figure 5 E-bicycles for urban and rural deliveries

Passengers

For **personal transport**, various business models have been tested in Africa, including personal use, public bike-share, and closed community bike-share. Several companies featured in this booklet target commuters for their daily trips, particularly in highly congested cities. Cairo (Egypt) and Kigali (Rwanda) have implemented public shared schemes that already integrate electric bicycles or plan to do so in the near future. Additionally, in Morocco companies are piloting electric bicycle-sharing projects on university campuses.

In the health sector, e-bicycles are used for ambulance services in Uganda and Namibia, providing swift and efficient responses to health emergencies.

Credit: Little

Credit: CLOUD BIKE

Credit: GuraRide

Credit: AfricroozE

Credit: Baddel

Credit: Wattsc

Figure 6 E-bicycles for passenger transport

Several companies develop versatile electric bicycles that can be used in rural and urban areas for both the transport of goods and passengers, therefore increasing their value proposition.

Design adapted to the application and local needs

E-bicycles come in many shapes, sizes and specifications catering for the variety of use cases, for instance with a very sturdy frame, rear carriers or larger carriage space in the front or back to transport goods.

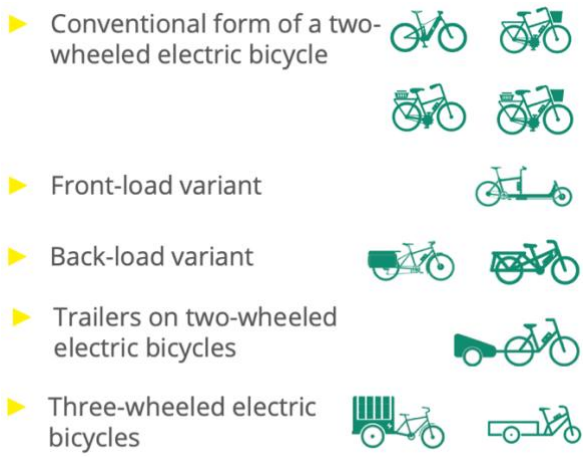


Figure 7 Types of e-bicycles

The booklet predominantly features companies engaged in the design and inhouse manufacturing of electric bicycles, less the battery. This strategic local design and manufacturing approach enables them to tailor and adjust their products to meet unique local requirements and conditions.

Table 2 Possible elements of a tailored-made e-bicycle design

Needs	Possible elements of a tailored-made design
Need to transport heavy loads (goods or passengers)	› Large and sturdy rear carrier › Strong braking system › Strong motor
Need for a robust vehicle to navigate through unpaved or bumpy terrains	› Sturdy frame › Suspension › Wide tyres that can resist punctures
Need to cover long distances, e.g. in peri-urban and rural areas	› Sufficient battery capacity › Double battery system › Battery system that can be charged on a regular socket or swapped › Several levels of electric assistance
Need to be able to maintain and repair the electric bicycle locally	› Standard spare parts that can already be found in the country or the region › Training of mechanics as an integrated activity of several companies

Wide-ranging benefits

The companies showcased in the booklet place a similar emphasis on these primary benefits:

- **Enhancing spatial accessibility by offering a new mobility option** that is more affordable than petrol motorcycles while enabling longer and faster trips than regular bicycles.
- **Expanding modal choice in cities**, enhancing access to public transport, and improving convenience in hilly or hot environments.
- **Providing economic savings and opportunities for users** through cost-effective options for purchase, leasing, and operation, as compared to conventional and electric motorcycles.

- **Having the potential to reduce GHG emissions and air pollution** when replacing petrol vehicles.

Additional benefits are contingent upon the specific focuses and characteristics of the companies: job creation when manufactured locally, enhanced quality of products transported with refrigeration systems, gender inclusion when proactively involving women, community and participatory design, health benefits, vector for digital integration, and convenience.

The need for increased policy support:

Despite their potential, e-bicycles have been largely absent from e-mobility policies and incentives in African countries. Only one of the four East African countries with e-mobility incentives covers e-bicycles.
In Kigali, SOLUTIONSplus partners advocated for the following recommendations.

- Apply current electric mobility incentives to electric bicycles.
- Plan safe cycle networks.
- Scale up the current bike-share areas.
- Facilitate the development of the electric bicycle sector.
- Expand the scope of the incentives to cover all micro-mobility modes.
- Extend fiscal incentives to all bicycles.

3 The SOLUTIONSplus electric bicycle pilot in Dar es Salaam

3.1 Description of the pilot

Why?

Identifying the wealth of applications of electric bicycles and the benefits that electric bicycles can provide as found at global level and in sub-Saharan Africa, SOLUTIONSPlus decided to support their uptake in Dar es Salaam, to enlarge the range of mobility options and assess the opportunity to shift from larger, faster motorised two-wheelers to safer, resource-efficient electric bicycles.
In 2022, 16 electric bicycles were shipped and assembled in Dar es Salaam. They are used to perform a variety of urban deliveries, including medical supplies and tools on behalf of the Aga Khan Hospital.

Who?

As in all SOLUTIONSplus demonstration actions, this project was implemented in a collaborative approach, bringing together partners with complementary expertise.

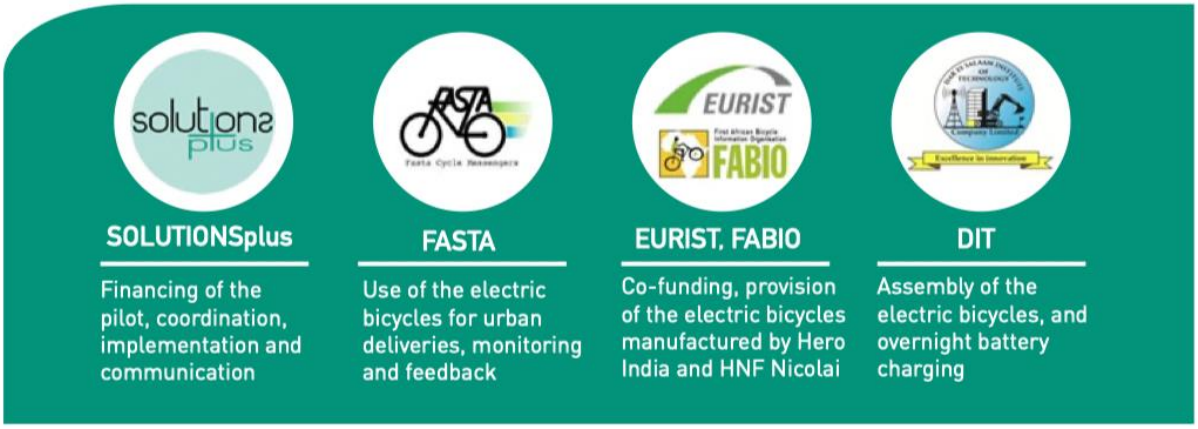


Figure 8 Partners collaborating in the SOLUTIONSplus e-bicycle pilot

What?

EURIST partnered with the First African Bicycle Information Organisation (FABIO), HERO Cycles and HNF-Nicolai designed the AfricroozE. The AfricroozE bicycle was designed to address the specific needs of several sub-Saharan African countries, not specific to Dar es Salaam.

Figure 9 AfricroozE – The African E-Bike

Transport heavy loads (goods or passengers)	• A 280W hub motor with pedal assistance • Disc brakes installed on both the front and rear wheels for enhanced safety. • Sturdy bicycle rack seat to transport packages or ferry people, with a maximum payload capacity of 100 kg.
Enable long distances	• A 460Wh lithium-ion battery, delivering a range of 30 - 40 km on a single charge to facilitate longer trips, e.g. in peri urban or rural areas.
Offer convenient rides	• Electric assistance until 30 km/h. • A 7-speed chain transmission to ensure smooth rides

How?

	2021 – October to December	The SOLUTIONSplus partners **selected EURIST**, a Germany-based organisation to introduce 16 pedal-assist electric bicycles in Dar es Salaam. EURIST, FABIO, HERO Cycles and the Germany-based e-bike company HNF-Nicolai jointly design these electric bicycles.
	2022 – January to March	The SOLUTIONSplus team in Dar es Salaam collectively mapped needs and stakeholders to **identify the most promising use case for the electric bicycle**s. Urban deliveries were selected as the application having the highest potential to scale and compete with two-wheeled motorised vehicles.
		SOLUTIONSplus partners identified FASTA Cycling Cooperative as receiver and **established partnerships** with FASTA and the Dar es Salaam Institute of Technology (DIT).
	2022 – October	16 electric bicycles along with 5 additional batteries were **shipped in completely knocked down (CKD) condition** from India to Mombasa (Kenya), then transported to Dar es Salaam. The initial intension to deliver 20 electric bicycles had to be reduced due to high taxes on electric bicycles, but a reasonable fleet size for testing was enabled with 9 electric bicycles funded by SOLUTIONSplus and 7 funded by EURIST. The decision to ship to Mombasa, and not Dar es Salaam, was due to the fact that the 16 e-bicycles were part of a larger consignment with 84 e-bicycles proceeding to Uganda.
	2022 – November	A three-day **training and assembly workshop** was held at the Dar Institute of Technology (DIT), training DIT staff, students, cyclists of the cooperative FASTA and a number of local mechanics on the assembly and use of electric bicycles. Participants assembled the electric bicycles before the official inauguration ceremony at the Aga Khan Hospital.

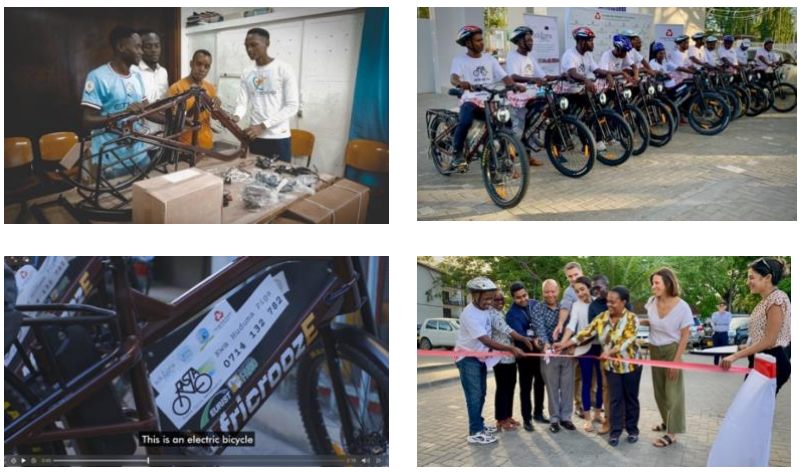


Figure 10 SOLUTIONSplus pilot training and assembly workshop

2023 – January to July

The initial six-month **testing and monitoring phase** took place. The batteries are charged every night at DIT and the electric bicycles stored at DIT, as parking at home was not deemed safe by the cyclists. The DIT facilities are available for the FASTA cyclists for 24 months, until the end of 2024. Cyclists pick up the e-bicycles including charged batteries in the morning. Two electric bicycles stayed with DIT for research purposes.

Aga Khan was intended as the primary user of FASTA's delivery service to transport medical supplies. Aga Khan had a strong interest in this project, which fits into their current global net-zero strategy. In addition, other use cases were tested included the delivery of groceries, food, and various shopping items. All e-bicycles were equipped with GPS to enable trip tracking.

Figure 11 FASTA communication campaign via WhatsApp

2023 – March

A **focus group** was led to receive intermediary feedback on the pilot and suggestions from the FASTA cyclists, with participation from UN-Habitat, UEMI, the Wuppertal Institute and ITDP Africa.

Figure 12 SOLUTIONSplus pilot focus group

2023 – March to August

The SOLUTIONSplus partners Urban Living Lab Center and ITDP Africa conducted on-site **data collection to better understand the urban logistics system** in Dar es Salaam. This study was a cornerstone to understand the role that electric bicycles could play with the delivery ecosystem in comparison with vehicles currently used. The methodological approaches used in the SOLUTIONSPlus urban logistics pilot projects in Latin America were tailored to the local context by the Urban Living Lab Center Africa Team. A threefold process was designed to survey residents, establishments and drivers in Dar es Salaam. A first phase focusing on testing the questionnaires began in March 2023, while the data collection took place in August 2023. The Urban Living Lab Center also analysed the financial and environmental impacts of shifting from motorcycles to electric bicycles.

Figure 13 Surveys with boda boda delivery drivers

	2023 – July to October	EURIST **evaluated the extensive data collected during the electric bicycle pilot phase** (January 1-July 30 2023). The study included a single baseline data collection for reference purposes (baseline data collected for October 2022), followed by monthly data collection on user characteristics through questionnaires conducted by EURIST, as well as monthly GPS monitoring.
	2023 – October to present	SOLUTIONSplus partners identified the need to further study the various types of electric bicycles (two and three-wheeled) found in sub-Saharan Africa and published the **Africa E-Bicycles Start-Up Booklet**. This booklet gives a voice to 18 African companies providing a wide range of electric bicycles coming with different shapes and types of passenger or delivery applications. Continuous discussions between FASTA and the Urban Living Lab Center explored possibility to improve FASTA's operations, for instance by using an online booking and tracking app.
	2024 – March	A **workshop on scaling-up, business improvement and digital literacy** was held between FASTA, DIT and the Urban Living Lab Center at DIT. In a first part of the workshop, the Urban Living Lab Center presented this study to the partners. Cyclists and DIT students and staff brainstormed on pathways to scale up FASTA's operations and to support the uptake of electric bicycles in Dar es Salaam. Their recommendations are integrated in Section 6 of the study. In the second part of the workshop, the Urban Living Lab Center presented recommendations to FASTA on options to improve the cooperative's operations and revenues. Thirdly, the Urban Living Lab Center initiated the training on how to use the digital booking application developed by Paschal Giki, ULLC Research Fellow, which is deemed to provide significant opportunities for business improvement. This training was continued over regular follow-up meetings. Lastly, ten smartphones were handed over to cyclists without smartphones to enable them to use the booking application.



2024 – June

A final one-week long further **training on the maintenance, basic repair skills, and the safe use of e-bicycles in various weather and traffic conditions** was held at DIT, provided by FABIO to 15 selected participants among FASTA cyclists, fundis, and DIT students. Further trainings are considered.


3.2 Results of the pilot

Data was collected through a diversity of quantitative and qualitative approaches, to capture an encompassing picture of the e-bicycles and FASTA's operations. This included six components: (1) a baseline data collection for reference purposes, (2) monthly questionnaires on FASTA's operations, (3) monthly GPS monitoring, (4) focus group on qualitative feedback from cyclists, (5) final questionnaire with the project partners, and (6) an environmental analysis of the impacts.

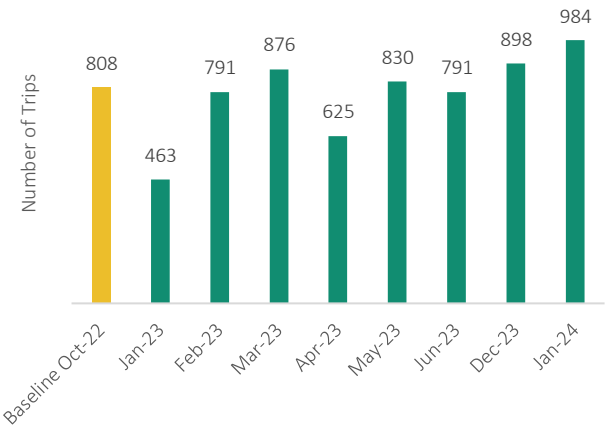
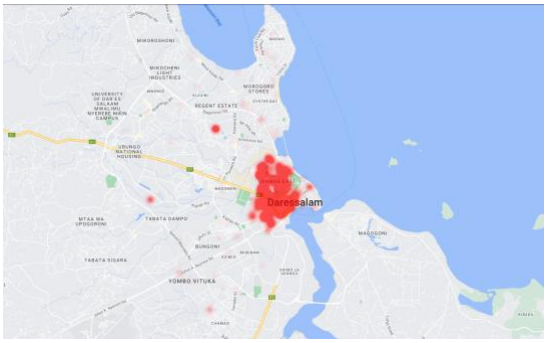
Equipment	16 pedal-assist electric bicycles deployed
	5 extra batteries
	10 smartphones
	1 booking application
	Promotional material, e.g. FASTA business shirt

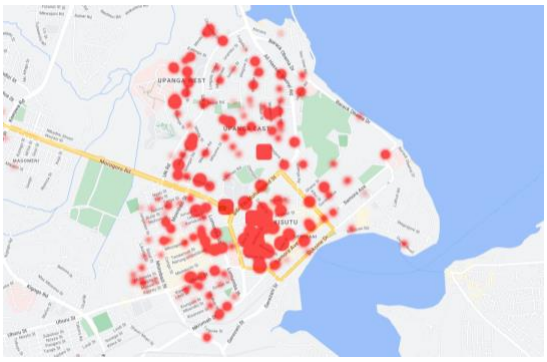
Training	
	45 people trained in the assembly, use, maintenance and repairs of electric bicycles (components and technical details of the AfricroozE, battery instructions, safety and maintenance instructions, usage of fleet management software from Fleetx, assembly of the AfricroozE)
	15 people trained in the use of a booking application
	3 training weeks on assembly, repair, maintenance, operation and business models disseminated over the 19 months of the project's implementation

Equipment evaluation	
Satisfaction of cyclists with the e-bicycles	During the focus group in March 2023, FASTA cyclists stated to appreciate the ability granted by the e-bicycles to deliver faster, to travel further, and to create trust and credibility with increased punctuality. At conclusion of the first pilot phase after six months, a survey of cyclists indicated that the adoption of e-bicycles was successful. Results indicated high satisfaction and enthusiasm among cyclists, encouraging more FASTA cyclists to use e-bicycles. These resulted in significant improvements to delivery services, with success rated at 8.5 out of 10. The e-bikes facilitated greater precision and punctuality, allowing riders to plan delivery speeds and cover longer distances efficiently, earning trust and credibility from customers for timely deliveries. Cyclists recommended the continued use of e-bicycles for their efficiency and convenience, particularly for older cyclists.
Impact of e-bicycles on customers and orders	FASTA indicated during the focus group and final survey that the increased punctuality enabled by e-bicycles positively impacts payments from customers. Being able to deliver orders on-time more often, is estimated by cyclists as very important since some customers do not pay when they receive the orders late. The e-bicycles are seen by customers as an innovative vehicle. According to FASTA, the e-bicycle itself has become part of their advertisement as they receive a lot of attention. However, this has not been translated into a higher number of customers as of March. The continuous monitoring will be key in that perspective.

	 People are very intrigued and interested in the e-bike; every day we receive requests, they want to know what kind of bicycle it is. The bike itself is part of our advertisement. The electric bicycles are good promotion for us. (Filbert, March 2023) *Figure 14 Member of the cycling cooperative FASTA* Lastly, an environmental benefit of electric bicycles for deliveries, as compared to larger motorised two-wheelers is identified by the Aga Khan Hospital. The environmentally friendly aspect of e-bicycles is a core reason to opt for them, as stated by the Environmental Manager at Aga Khan. *"For me, I see a very great potential for the FASTA bike. Many organisations are now moving to more environmental sustainability in the future many organizations are going to use the service"*. While this dimension may not play a large role for individual customers, it could for larger, institutional customers and will be further explored as a business improvement option for FASTA.
Number of repairs	During the six-month pilot with monthly monitoring, 17 repairs were carried out on the e-bicycles. The majority of these were minor, and no major issues were encountered. The three most frequent repairs were related to the brakes (6 repairs), the stand (4 repairs), and the front light (2 repairs). Wear and tear on brake pads was identified. The repairs could be carried out either by the local fundi or, with regard to electrical problems with the lights, by an experienced FASTA cyclist. Monitoring one year after the start of the pilot showed additional repair needs with regards to bottom bracket, chain, brake cables and hoses, pedals, that will be addressed by the Urban Living Lab Center and AfricroozE.
Battery charging	All e-bicycle batteries are charged at the DIT at the end of a working day. Each battery absorbs an amount of energy of 0.28 kilowatts during the charging process. The charging process takes place during the night so that the e-bicycles are ready for use the next morning with sufficient energy for the entire working day. At the end of the pilot, it was not possible to make a definitive statement about the longevity of the batteries, since the batteries are always charged at the end of a working day and have never been used until they are completely discharged. The exact range of the batteries also cannot be accurately stated, as they were never used until completely discharged.
Challenges identified	Challenges were also encountered, including: > A few items originally not shipped by the Indian manufacturer (2 grommets, 2 mudguard holders, 2 faulty sensors, 2 missing brake washers, etc.). Essential missing parts which could not be found at the local market were sent by FABIO after the training. > The costs of some spare parts.

	> Safety issues in wet conditions and heavy traffic.

FASTA trips and orders	
Number of trips	729 trips per month on average during the six-month pilot phase (January-June 2023).  *Figure 15 Total number of trips by FASTA cyclists per month*
	The number of trips was marked by considerable fluctuation from one month to another, in particular, lower demand during or after festive and religious seasons. Rainy seasons were not found to have an impact. This monthly reported data is consistent with the focus group results, indicating 20-25 deliveries per day for all cyclists, working 7 days/week.
Impact of e-bicycles on the number of trips	The first six-month pilot phase (January-June 2023) did not identify an increase in trips with the introduction of the e-bikes, as compared to the baseline in October 2022. Analysing the impact was not possible due to this limited period and the monthly fluctuation (see supra). However, continuous monitoring after this first phase provides encouraging signs, with an increase to 898 trips in December 2023. The Urban Living Lab Center together with FASTA and volunteers supporting FASTA will continue monitoring the monthly trips.
Average distance driven per day	On average, drivers covered 21.7 km every day. This limited distance per day is due to a low number of delivery orders (see below, business considerations), not due to technical limitations – the batteries have never been fully depleted at the end of a working day.
Geographical focus of FASTA's operations	The majority of trips are concentrated in the core area of Dar es Salaam. A few exceptions are Regent Estate, Tabata Dampo, Masaki and Morogoro Stores, Yombo Vituka and Bugoni, suggesting recurrent engagements 

	with specific customers in these areas. Apart these exceptions, most of FASTA's activities take place in the Central Business District of Dar es Salaam. An approximate triangle of 3 x 3 x 3 km can be identified.  *Figure 16 Trip patterns observed during the pilot phase* In this triangle, a concentration of trips is identified in the south-west area of Kisutu. In this area, there are frequent and repetitive occurrences of markers that suggest a pattern of regular customers contacting Fasta to pick up their products. Upanga East and Upanga West have both a lot of individual and regular markers, indicating diverse frequent trip activities within these areas.
Conditions of operations	FASTA cyclists reported road safety issues linked with cycling – regardless of electric of conditional -, especially when cycling in the rain or in heavy traffic. Another concern expressed by cyclists was the fear of potential theft or robbery, as e-bicycles are costly, and in the absence of safe parking places. The cyclists highlighted the need for security measures, such as parking spaces to lock bicycles.

Business	
Limitations to current business and recommendations for improvements	Monitoring the project enabled to identify challenges for FASTA's business. In particular, the absence of a booking app facilitating orders, tracking and payment, was identified as a large barrier to attract and retain larger customers, such as the Aga Khan Hospital. Other limitations to FASTA's business include an atomised customer base of individual customers, and fluctuation of orders during festive seasons, which translated into a low number of orders and low revenues for cyclists, who often have a side job. The Urban Living Lab Center identified two main pathways to improve the business of FASTA: > Need to ensure higher order convenience for customers by developing a booking app, which will facilitate order distribution between cyclists, enable customers to track their deliveries, and add an option of mobile payment. > Need to expand FASTA's customer base to ensure sufficient and stable revenues for riders. Larger or institutional customers should be targeted in priority to receive a higher number of orders and mitigate the impact of seasonal fluctuations. These recommendations were broken down by the Urban Living Lab Center into activities, facilitated (e.g. provision of 10 smartphones to cyclists to

	enable the use of the Nibebe booking app), and were submitted to FASTA in March 2024.

Partnerships	
Evaluation of the partnership between FASTA, DIT, EURIST & Urban Living Lab Center	The partnership between FASTA and DIT was seen by cyclists as yielding several benefits, including secure parking, free charging, enhanced security, and capacity building. The project was perceived to have a positive impact on FASTA's access to resources, publicity, and partnerships with organisations such as DIT, EURIST, and the Urban Living Lab Center.

Impact	
Impact for customers of using e-bicycle deliveries instead ICE motorcycles	Larger customers of FASTA such as the Aga Khan Hospital used larger motorised vehicles, such as motorcycles or cars, for their deliveries before using FASTA's services. To quantify the benefits of using FASTA services with electric bicycles instead of ICE motorcycles, the Urban Living Lab Center modelled these environmental impacts.

Taxes and regulation	
Documents needed	**Diverse documents** are required regardless of whether the e-bikes are imported as CKD (Completely Knocked Down) Kits, as SKD (Semi-Knocked Down) Kits or as fully assembled e-bikes (situation in November 2022). > Invoice: provided by the manufacturer/supplier > Packing List: provided by the manufacturer/supplier > Bill of Lading: provided by the manufacturer/supplier or logistics operator depending on shipping terms > CoC (Certificate of Conformity): can be provided by the manufacturer/supplier or acquired locally. This certification is for single use and has to be done for each importation. It is calculated as a percentage of the import goods price. If one does not wish to go through the CoC process on each import - for instance in the case of frequent importation - one can process a yearly licence. However, the process to acquire a license is considered extremely strenuous (inspection of the e-bicycle factory in India, report back, shipment of a sample to the bureau of inspection, payment of a circa 8,000 USD yearly license fee).
Tax regime	The electric bicycles attracted a **total tax percentage of 58.4%**, made in the decreasing order of importance of import tax (25%), VAT (18%), Certificate of Conformity (CoC) done locally in Tanzania (10%), and other taxes (Custom Processing Fee-CPF of 0.6%, Road Development Fee-RDL of 1.5%, TASAC of 1.7% and wharfage of 1.6%). At the time of the project, it was not possible to benefit from tax exemption or reduction options (e.g. reduction for CKD units if going through a business entity; treasure vouchers to be received by a locally registered NGO; DIT tax exemption, etc.). This could be different for e-bicycle projects deployed now, due to learnings in the project or the recent evolution of taxation for CKD vehicles. In addition, it was not clear whether e-bicycle batteries could be imported as solar batteries, which are exempt from duties under as per EAC rules, and the exact conditions applying to these batteries.

4 Scaling the use of electric bicycles in Dar es Salaam: understanding better the logistics sector

4.1 Introduction and approach

To gain a comprehensive understanding of the logistics landscape in Dar es Salaam, three surveys were conducted: an establishment survey, a resident survey and a driver survey.

Establishment Survey

Surveys were conducted in person with a number of businesses, such as restaurants and retailers, to determine their specific delivery needs and openness to e-bicycle adoption. The sample size includes 219 responses.

Resident Survey

Surveys were conducted among residents to capture their perceptions of delivery services, usage patterns and shopping behaviour. Conducted online and in person, combined this survey reached 90 individuals.

Drivers Survey

A face-to-face driver survey was administered to delivery drivers using different types of delivery vehicles. The survey aimed to determine the current status of delivery operations and the acceptance of electric bicycles as delivery vehicle. The sample size amounts to 118 delivery drivers (after data cleaning).

The surveys were designed to gather insights from different perspectives within the city's urban logistics sector. They aimed to understand some of the key questions:

KPI	Type of questions	E	R	D
Characteristics	Socio-demographic information		X	X
	Locations & area types	X		X
	Employment structure			X
	Type of establishment, Nr. Employees, etc.	X		
Delivery activities	Vehicles used to deliver or receive goods	X	X	X
	Channels to order goods	X	X	
	Distances and trip patterns	X*		X
	Cost for delivery	X		X
	Operational costs			X**
Supply and demand	Types of products transported	X	X	X
	Delivery times	X		X
	Frequency of shopping, delivering or receiving goods	X	X	X
Perception & Awareness	Interest to hire, rent, buy or test (electric) bicycles	X		X
	Willingness to pay for (electric) bicycles	X		X
	Awareness of urban logistics		X	

** Between parking location and establishment*

*** Only Boda boda drivers*

4.2 Characteristics of the sample size

Establishments

85% of the respondents on the survey were solo traders, followed by wholesale businesses, accounting for only 8% of the establishments.

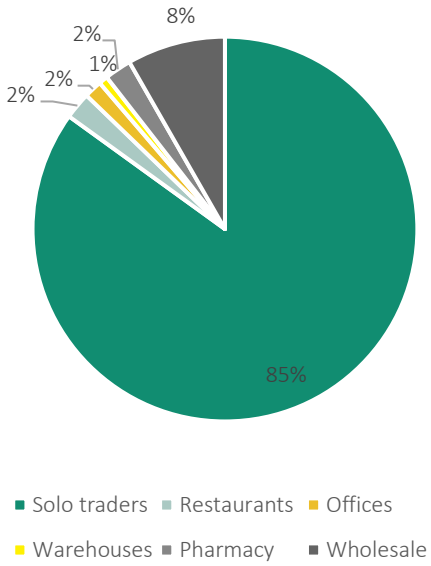


Figure 17 Types of establishments

Out of the 219 establishments surveyed, 64% were situated in commercial areas. These areas, integral to cities or towns, primarily host business activities like selling goods or services, renting offices, and offering entertainment.

Conversely, 20% of the establishments operated in central or city centre locations, particularly around Posta. A smaller proportion, 7% and 9%, were situated in high-density residential and high-income areas, respectively.

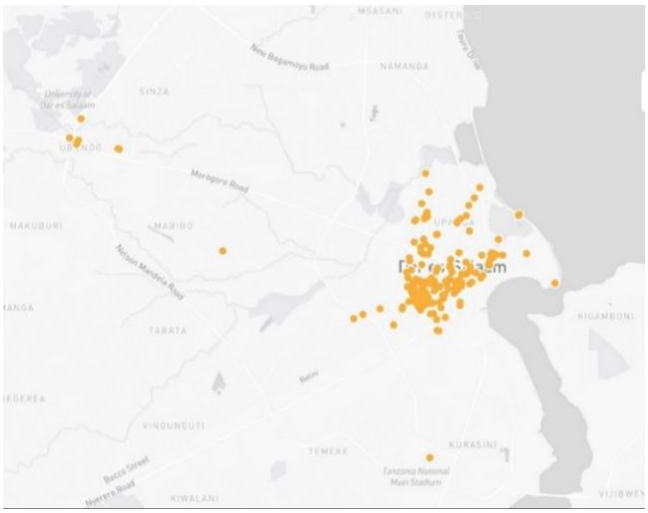


Figure 18 Geospatial distribution of the interviewed retail and wholesale shops in Dar es Salaam

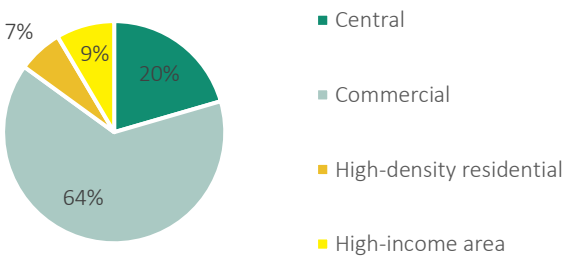


Figure 19 Classification of areas where businesses are located

In term of roles, 61% of the respondents were employees, 30% were owners and the remaining 9% were managers.

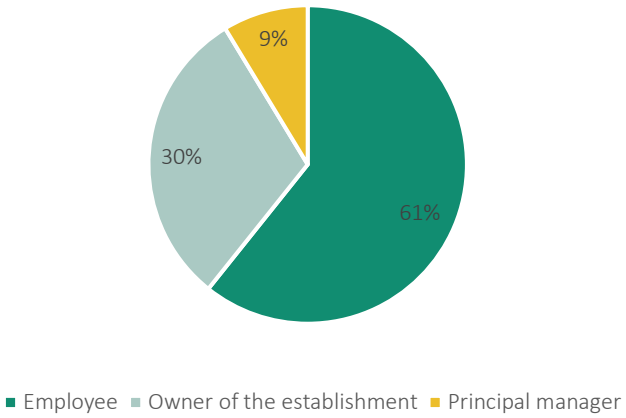


Figure 20 The type of respondents on establishment survey

Residents

A significant proportion of respondents, 51.65%, stated that they come in contact with the topic of urban deliveries in their daily lives. A smaller proportion, 16.48%, stated that they had extensive knowledge and experience in this area, which corresponds to the percentage of those who are merely familiar with the concept. Just under 15.38% of respondents had no experience with last mile delivery.

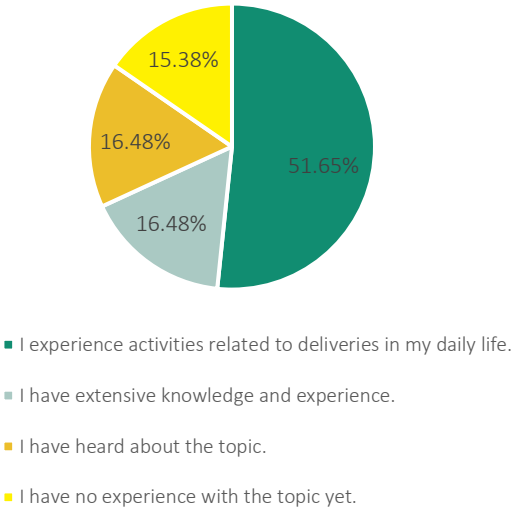


Figure 21 Experience with deliveries

Drivers

According to the survey results, there is a significant gender gap in the delivery market: 114 out of 118 drivers are male. All five female drivers surveyed drive bajajis. Most drivers, 78%, are between 24 and 39 years old. Five people stated that they were over 46 or older, with three of them over 50.

In addition, the extent to which delivery drivers have a second job was analysed. Out of the 116 people who responded to this question, 58% stated that they work solely as a delivery driver. In contrast, 41% have a second job, which indicates the necessity or desire for additional sources of income.

4.3 Delivery activities

4.3.1 Supply and demand

Establishments

Surveyed businesses are getting their supplies of goods from different types of suppliers. 51% of their supplies were coming from general traders followed by central distributor and direct sellers which were 19% and 18% respectively.

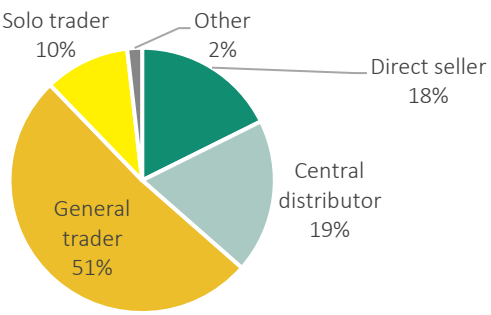


Figure 22 Supplier types

Drivers

The drivers survey revealed the dominance of self-employment among delivery drivers (66%). In contrast, the remaining 34% of drivers are employed by delivery companies or businesses such as restaurants, wholesalers and retailers, or are contracted by individuals.

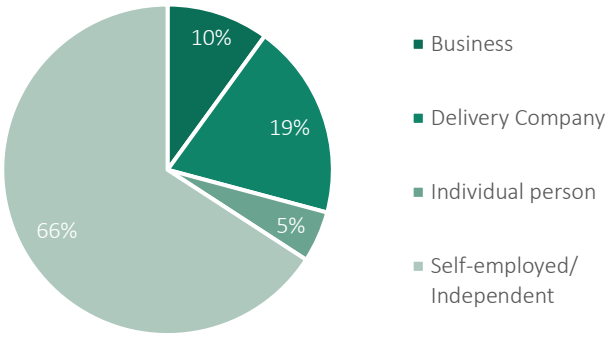


Figure 23 Employment situation

Average number of deliveries and customers per day

The results of the drivers survey show a pattern among drivers, with most making between 6 and 10 deliveries per day. This frequency is closely related to the number of customers the drivers typically serve, which is also between 6 and 10 customers per day.

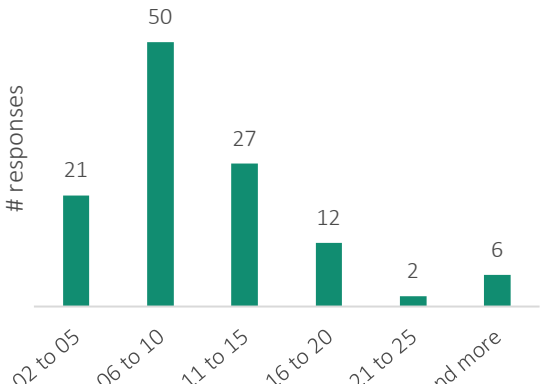


Figure 24 Average number of customers per day

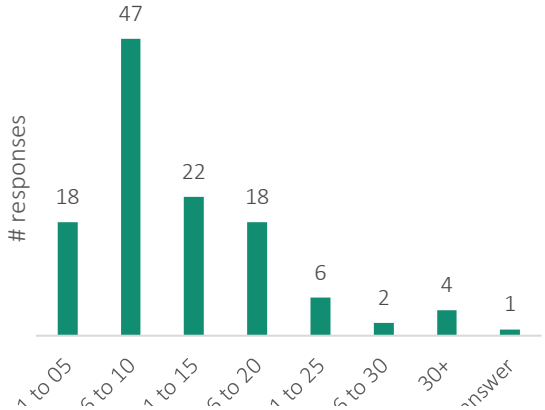
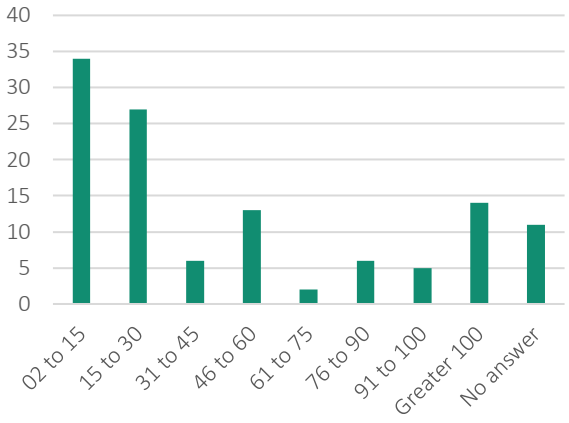


Figure 25 Average number of trips per day



Delivery costs

Drivers recurringly indicate is that delivery costs are influenced by the distance to the destination and the weight or size of the product delivered. After removing outliers from the data, the average cost per delivery for a boda boda lies at around 4,375 Tsh (eq. 1.58 EUR, conversion 3/02/24), for bajajis at around 4,140 Tsh (eq. 1.49 EUR) and for bicycles at around 3,290 Tsh (eq. 1.19 EUR).

Considerably higher fees are charged for vans/small trucks and gutas, set at 12,500 Tsh (eq. 4.52 EUR) and 7,400 Tsh (eq. 2.67 EUR) respectively. This however needs to be taken with highest caution due to the low response rate for guta and van drivers.

Residents' shopping behaviour and preferences

Residents were asked about their general shopping behaviours and preferences. This revealed that most of the shopping is done by one person within the household (62.64%), while 37.36% share this responsibility with one or two further persons. The frequency of weekly shopping trips varied (No distinction was made between in-person shopping and home deliveries). 29 respondents shop multiple times a week, while 14 do so daily and 12 once a week. In contrast to those who shopped less frequently, 11 people shopped twice a week: 10 every fortnight, 7 once a month and 8 less frequently than once a month.

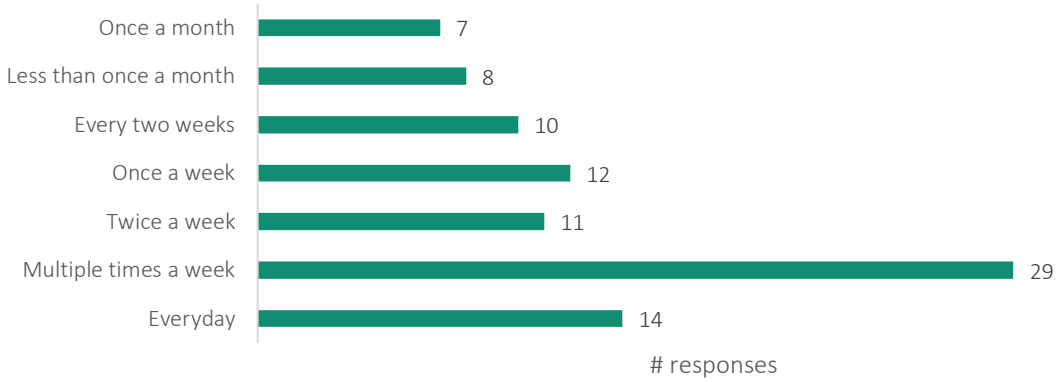


Figure 26 Frequency of shopping trips

The survey also asked about the use of home delivery services. To make the question more tangible, respondents were asked about their experiences in the last month. Only 30 out of 90 respondents said that they had never used a home delivery service, or at least not in the last month. When asked which channels are used to make orders for home deliveries, phone calls were the most popular (42). In addition, visits to the salesperson (31) also played an important role, while digital platforms were present but less utilised, with mobile apps (10) and websites (3) being the least used.

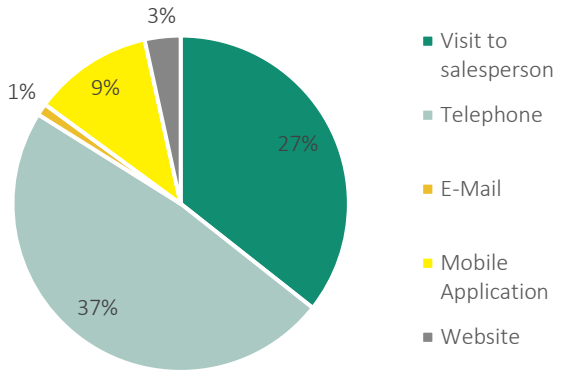


Figure 27 Channels used to order home deliveries

Overall, respondents expressed their interest in finding quick solutions to the needs of the community and emphasised the importance of efficient, organised and environmentally friendly delivery services.

Residents in Dar es Salaam mention two main issues for home delivery services: high delivery costs and unreliability in terms of timely delivery. One resident stated to often go to the shops in person to avoid the delivery cost, implying that the high delivery cost discourages them from using the service. In addition, it was mentioned that giving directions can be a challenge and drivers are often misdirected and have trouble finding the right location. Furthermore, they identify issues of dishonesty, misrepresentation of the quality or shape of products, i.e. not getting what you expect, as one of the biggest challenges.

4.3.2 Types of products transported

Residents

Restaurant or meal deliveries (35) are at the top of the list of goods ordered, followed by retail items such as clothing and electronics (24). Groceries were less common (13). Four respondents stated that they had certain household goods delivered to their home, such as furniture or cooking gas.

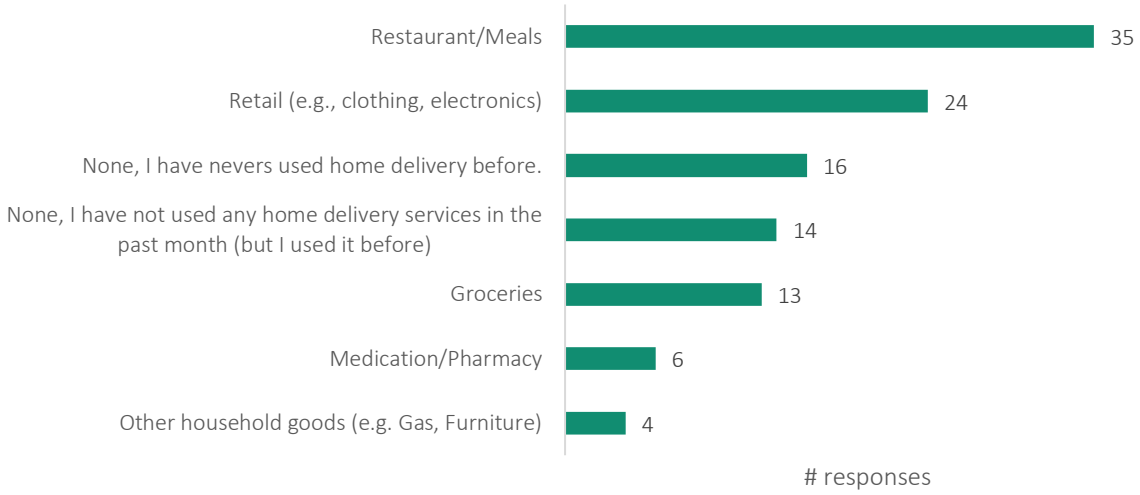


Figure 28 Types of products orders for home deliveries by residents

Types of products most ordered by establishments

As part of the establishments survey, the top 15 most selling items in the shops were light items such as cold drinks, sugar, drinking water and rice. The results showed that out of 464 products, the average weight for the delivery was estimated at 86 kg.

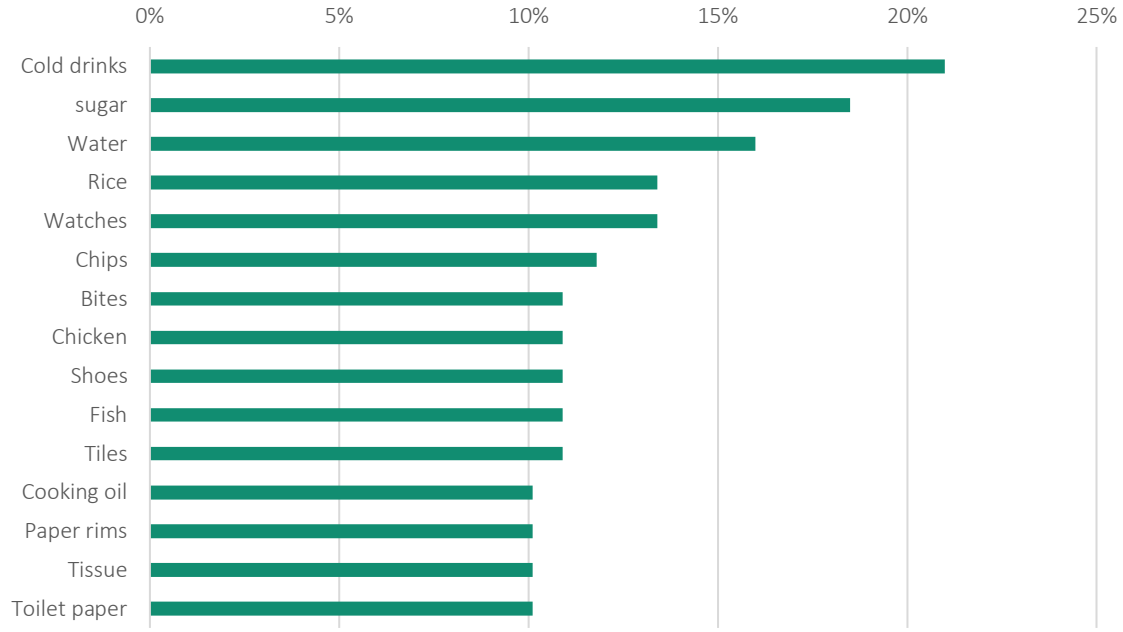


Figure 29 Top 15 most ordered products to be delivered to establishments (% of establishments)

Typical weight of products transported for establishments

Table 3 presents a summary of the transported products, with 464 products evaluated. The mean transported weight was 86 kg, the 75th percentile was 100 kg, and the minimum weight recorded was 0.5 kg. Additionally, three samples with values equal to or exceeding 1500 kg were identified as outliers and excluded from the analysis.

Table 3 Summary of mass (in Kg) of goods ordered by establishments.

sample	mean	std	min	25%	50%	75%	max
464	86.36	156.40	0.50	5	20	100	1000

Drivers

Delivery drivers transport a wide range of goods, with food products being the most important category (143 times). This includes fruit and vegetables (32 cases), meat, fish, poultry or sausages (35) and spices, sugar or coffee (22), to name a few. In addition, 67 times, drivers reported transporting beverages, in 50 cases prepared food or meals, in 48 cases clothing, textiles or linen and in 45 cases electronic devices (See Figure 30 Products transported by delivery drivers).

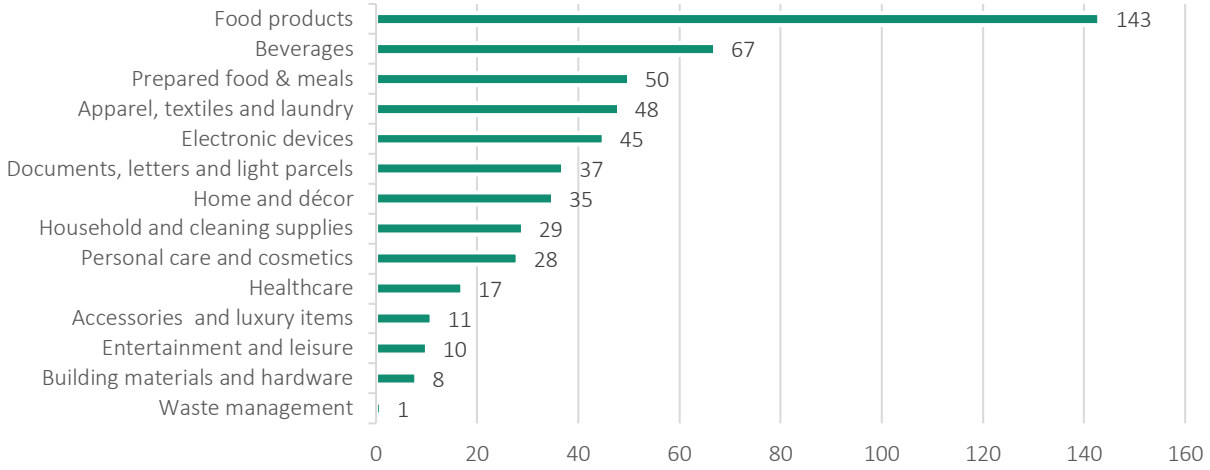
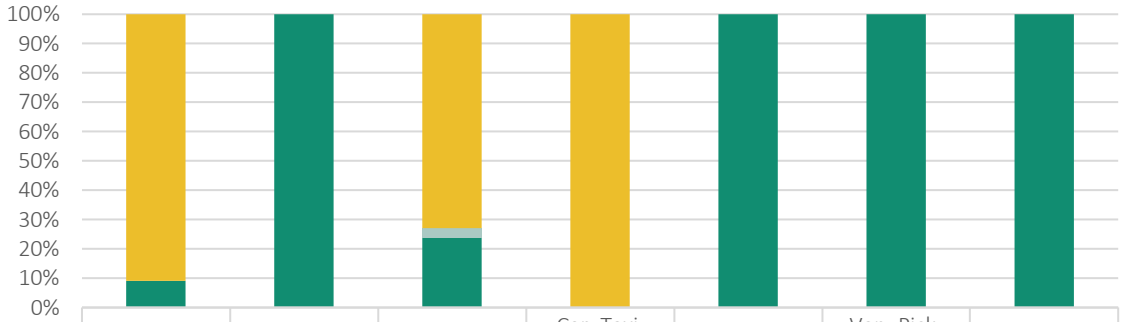


Figure 30 Products transported by delivery drivers

Beyond these most frequently transported goods, drivers mentioned specific goods. For instance, one bajaji driver indicated to transport waste. Drivers using bajajis, carts, gutas, vans or small trucks reported delivering furniture. In a single case, a boda-boda driver reported transporting vehicle spare parts. In addition, drivers of bajajis, boda bodas, carts and vans or small trucks reported delivering small building materials and hardware.

Another aspect of the survey concerned whether drivers carry only goods or both passengers and goods. The results were split evenly with around 50% of drivers stating that they carry both passengers and goods. Some vehicles are used to focus on one specific application (goods or passenger), while others typically transport both. Figure 31 shows that the surveyed bajajis, carts, gutas, vans and small trucks transport only goods, while bajajis, cars, taxis, daladalas and boda bodas predominantly carry both goods and passengers. These results based on the survey of drivers cannot however be generalised to all drivers in Dar es Salaam. For example, the FASTA bicycle couriers in the SOLUTIONSplus pilot indicated their desire, to have the option of installing a larger bicycle rack so that they could also transport passengers.



	Bajaji, Three-Wheeler	Bicycle	Boda boda, Pikipiki	Car, Taxi, Daladala/Mini bus	Guta	Van, Pick-up/Small Truck	Cart
Yes	10		46	4			
No answer			2				
No	1	17	15		6	6	11

Figure 31 Transport of passengers and goods

4.3.3 Types of delivery vehicles

Drivers

The data collected shows that a significant majority (53%) of drivers surveyed operates boda bodas.

This was followed by 14% who utilise bicycles, about 9% who use carts and 9% who use bajajis. The survey also included 6 drivers who used Gutas and six drivers who used vans or small trucks. In addition, the survey covered other vehicles including one car, one daladala and two taxis (See Figure 32). While the survey was not designed to target specifically boda boda and bicycle riders, knowledge of the purpose of this study may have affected the survey staff's choice in targeting riders of such vehicles.

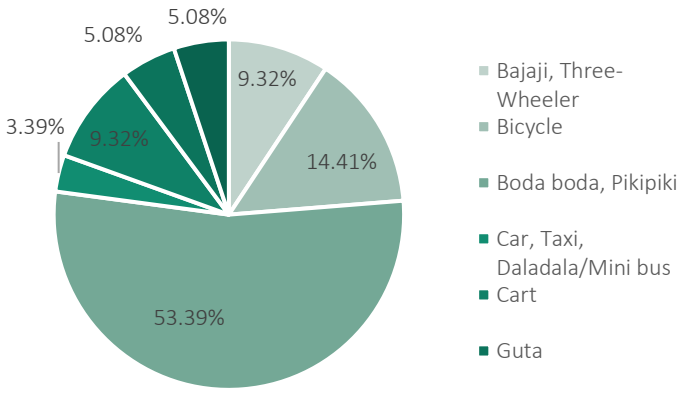


Figure 32 Delivery vehicle types

Figure 33 below gives an insight into the distribution of trips by vehicle type. Most drivers report driving between 2 and 15 kilometers, followed by 16 to 30 km per day in terms of distance travelled. However, as previous studies have shown, it is not always easy to obtain reliable distance data and perceptions from drivers can differ greatly compared to the kilometers recorded with GPS trackers (SOLUTIONSplus, 2023). Hence the distances obtained need to be taken with caution and will not be considered further in this study.

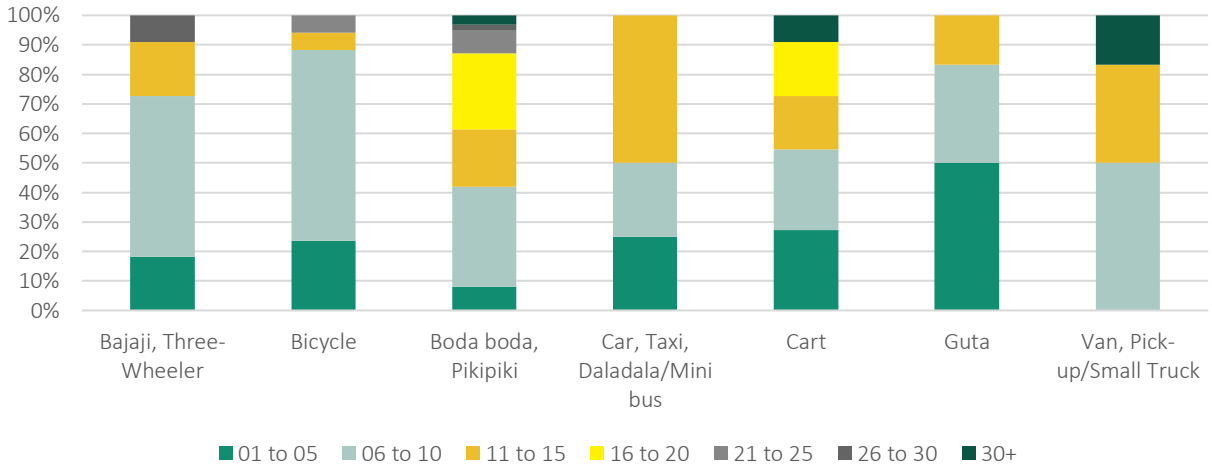


Figure 33 Trips per day by vehicle type

The survey results also show shed light on limited longevity of occupying a delivery occupation in Dar es Salaam. Remarkably, 93% of drivers have been in the profession for less than a decade. Of the 118 drivers surveyed, only 8 have been in the delivery industry for 10 years or more. This group includes three bajaji drivers with 16 to 20 years of experience and one driver who has been in the urban delivery market for over 20 years. Conversely, around 30% have started their career in delivery in the last 3 to 5 years, while around 29% have started in the last two years and 17.8% started working as delivery drivers in 2023 (See Figure 34 Working years as a delivery driver). These numbers capture a

dynamic and rapidly changing industry characterised by a steady influx of new drivers and a relatively small number of long-time drivers.

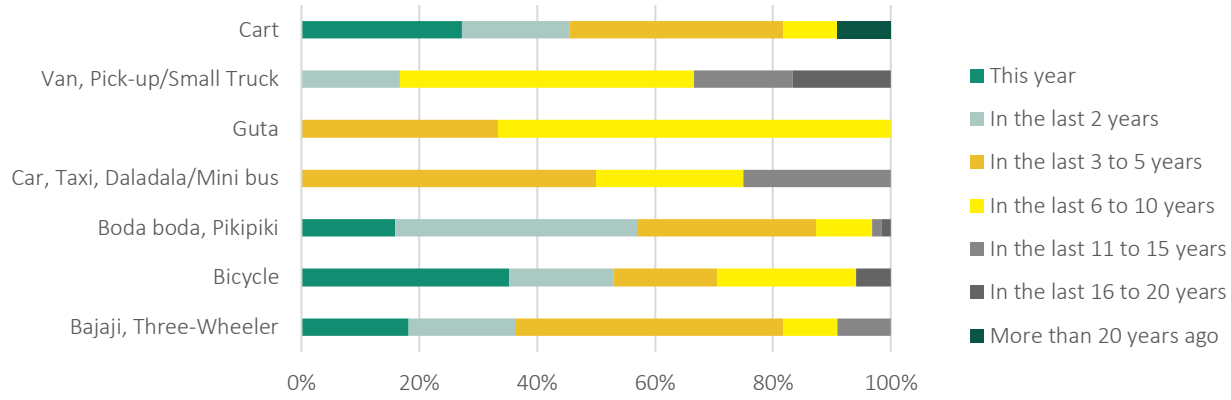


Figure 34 Working years as a delivery driver

Residents

In-person shopping and home deliveries were observed to have similar trends. For example, boda boda is the most popular vehicle used for in-person shopping and home deliveries indicated by 64 and 49 people respectively. Followed by walking, stated by 42 and 16 respondents for in-person shopping and home deliveries respectively.

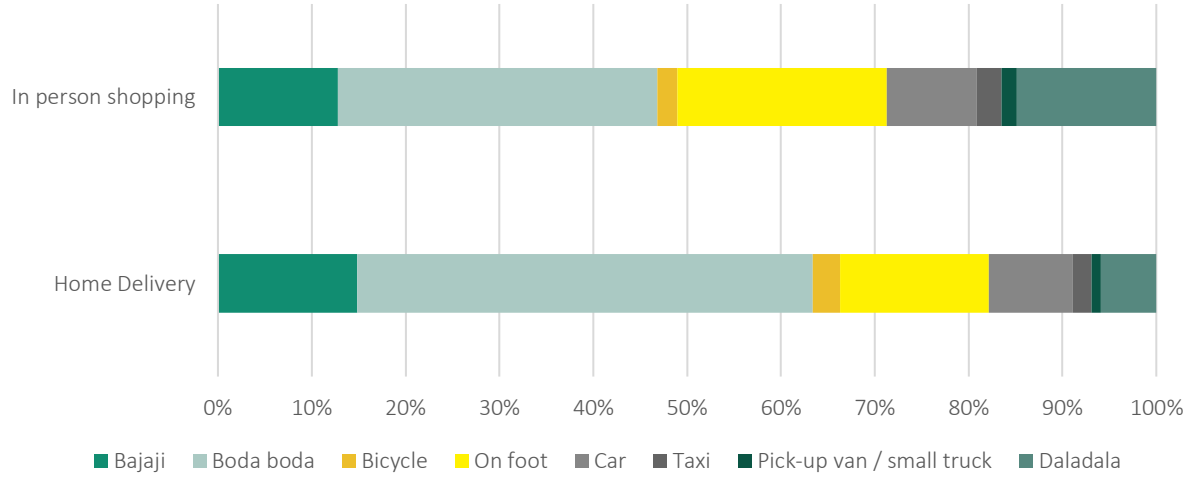


Figure 35 Types of vehicles used by residents for in-person shopping vs. home deliveries

The results show that boda-bodas are still the most popular option: 49 respondents said that they have had goods delivered by a boda-boda before. Deliveries with bajajis and on foot come next, mentioned by respectively 15 and 16 respondents. In contrast, deliveries by car are less standard, with only nine respondents choosing this option. The use of bicycles, taxis and daladalas for home deliveries is limited with three, two and six deliveries, respectively. A single respondent stated that a van or small truck had delivered something to their home in the last month. Although these results should be approached with caution due to the limited sample size and the potential risk of misinterpretation of the questions, the data points to the dominant role of informal modes of transport and boda bodas in the last mile ecosystem in Dar es Salaam.

Establishments

In terms of the means used to transport products, as shown in the figure below, the motorcycle is currently the most popular vehicle type which is used for the transport of goods (based on a question asking what vehicles are used for deliveries). According to the survey, 33% of the top three transported goods of the interviewed businesses were delivered using motorcycles, followed by cargo vehicles (12%), bajajis (10%), and by foot (8%).

Motorcycles, bicycles, on foot and with a cart together transport 55% of the goods.

It is assumed that most of the goods which are transported with these vehicles can also be transported using electric bicycles because as shown in **Error! Reference source not found.** (Section 4.3.2) the average mass of the evaluated products during the survey is 86 kg while the 75 percentile is only 100 kg. These masses are within the carrying capacity of the electric bicycle tested by the FASTA Cycling Cooperative where some electric bicycle models have up to 120 kg load capacity. This hints towards a large potential for the electric bicycle market in the city.

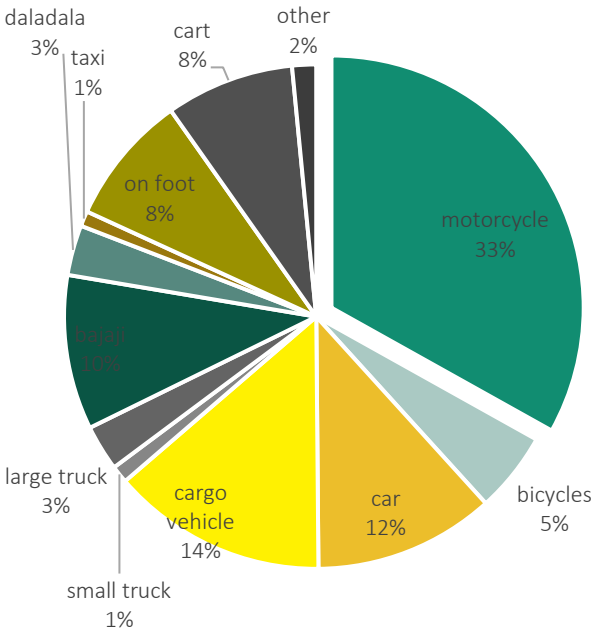


Figure 36 Means of transportation of products

4.3.4 Observations: logistics and transport infrastructure

Figure 37 provides an overview of the availability of parking lots (for any type of vehicle) in the locations where delivery drivers were surveyed, as observed by surveyors. The results show that there is a significant lack of dedicated parking bays in the different area types. At least 65% of observed locations lack parking infrastructure. Central areas have the highest proportion of parking spaces, where at around 35% of locations dedicated infrastructure for parking is observed. In contrast, surveyors did not identify dedicated vehicle parking facilities in high and low-density residential areas. However, locations in commercial areas, mixed residential areas and high-income areas do have a small percentage of dedicated parking facilities.

It is important to note that only one observation was collected for industrial areas, and the number of observations for high-density residential areas and low-density residential areas is limited to eight and nine, respectively. In contrast, 88 observations were collected in commercial areas, and 35 observations were collected in mixed residential areas. In addition, boda boda drivers were observed parking on sidewalks. Therefore, it is possible that the surveyors misidentified sidewalks as off-street parking infrastructure.

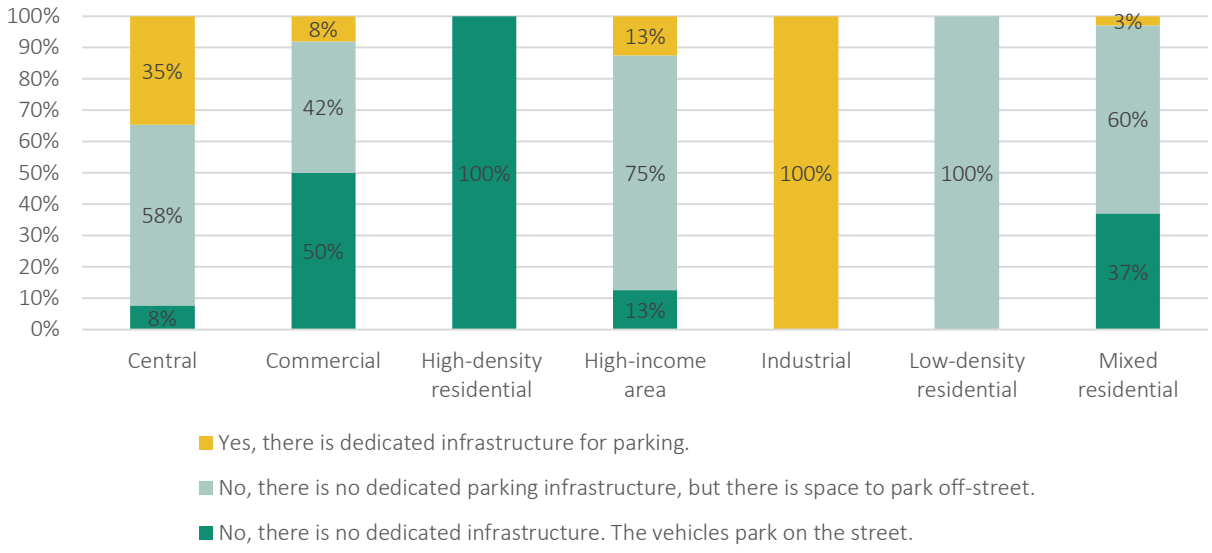


Figure 37 Availability of parking infrastructure

The availability of vehicle parking is critical, particularly in commercial areas which rely heavily on supply to meet customer demand. Adequate parking infrastructure plays a key role in ensuring that delivery traffic does not significantly disrupt the general flow of traffic.

4.4 Perceptions and willingness to pay for electric bicycles

4.4.1 Reason to transition to electric bicycles

According to the establishment survey, users would choose to purchase or use electric bicycles for various reasons. As indicated in the word cloud above, common motivations include the desire to expedite delivery processes – by being able to navigate narrow roads as shortcut, being portable, enabling load and offload good faster. Another motivation is to **reduce transportation costs**, and enhance efficiency in carrying goods. Many users appreciate the **cost efficiency** of electric bicycles, as they eliminate or significantly reduce the need for petrol, making them an economical choice.

Figure 38 Word cloud indicating reasons to use electric bicycles

The **ability to carry large or heavy loads** is another key factor, with respondents highlighting the suitability of electric bicycles for transporting a variety of items, from small parcels to large cargo. Additionally, the **convenience** of electric bicycles, such as their portability, ease of use, and suitability for specific types of goods, plays a crucial role in the decision-making process. Overall, the

advantages, including cost savings, efficiency, and versatility, make electric bicycles an attractive option for individuals engaged in various delivery and transportation activities.

4.4.2 Willingness to pay

To assess the feasibility of electric bicycle adoption in Dar es Salaam, establishments and delivery drivers were queried about their preferences regarding various types of (electric) bicycles and their willingness to pay for different service options, including hiring a logistics service provider operating a vehicle, renting a vehicle, or purchasing the vehicle outright. The following section provides a condensed overview of these findings.

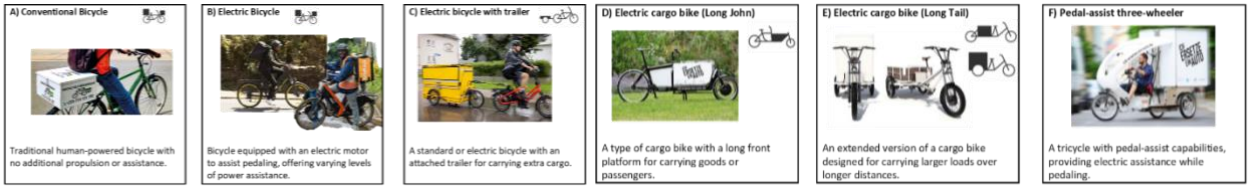


Figure 39 Types of bicycles shown to establishments and drivers during data collection

When establishments were surveyed about their interest in purchasing various types of vehicles for deliveries and transporting goods, 34% chose the Long John electric cargo bicycle. On average, they were willing to pay Tsh 732,000 (approximately USD 281[1]), with a range from Tsh 50,000 (19 USD) to Tsh 5 million (1921 USD). 13% of businesses were interested in the Long Tail electric cargo bicycle, while 15% were interested in pedal-assist three-wheelers. The highest average willingness to pay was identified for pedal-assist three-wheelers at Tsh 1 million (384 USD).

Establishments were willing to pay at least Tsh 40,000 (15 USD) for electric bicycles, with an average of around Tsh 368,000 (141 USD). Delivery drivers showed the most interest in electric bicycles, with their willingness to pay ranging up to Tsh 3.5 million (1345 USD), averaging around Tsh 384,000 (148 USD). The highest average willingness to pay among delivery drivers was for long tail e-cargo bicycles at about Tsh 540,000 (207 USD), and for pedal-assisted three-wheelers at around Tsh 589,000 (226 USD). Figure 40 shows the willingness to pay for the purchase of a bicycle by type (the red line indicates the baseline price for purchasing a boda boda).

Figure 40 Willingness to pay for purchase by bicycle type (Tsh)

[1] Conversion Rate: 1 Tsh = 0.00038 USD (02.06.2024)

The willingness to pay per day for renting different types of electric bicycles varied among establishments. Average rental prices ranged from Tsh 6,850 (2.6 USD) for electric bikes to about 11,500 (4.4 USD) for long-tail electric cargo bikes, indicating different financial considerations in this market segment. For conventional bicycles, although based on a small sample size of four, the average willingness to pay was Tsh 3,875 per day (1.5 USD). Figure 41 shows the willingness to pay per day for renting a bicycle by type (the red line indicates the baseline price for renting a boda boda per day).

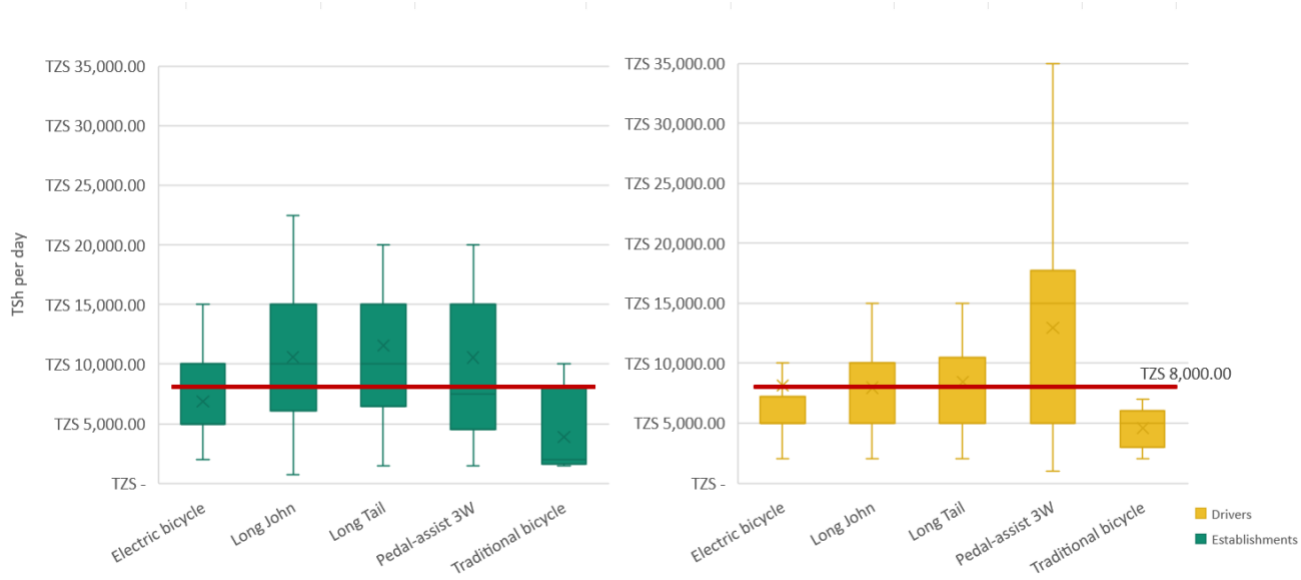


Figure 41 Willingness to pay for rental by bicycle type (Tsh)

Daily rental rates for various electric two- and three-wheelers, including the electric long john cargo bicycle, electric long tail cargo bicycle, and pedal-assist three-wheeler, were higher than for ICE motorcycles, which stand at Tsh 8,000 (3 USD) per day. The average willingness to pay per day among delivery drivers for electric bicycles, long john e-cargo bicycles, and long tail e-cargo bicycles was similar, at Tsh 8,150, Tsh 7,950, and Tsh 8,500 respectively. The highest willingness to pay was for pedal-assisted three-wheelers, averaging Tsh 12,900 (5 USD) per day, while traditional bicycles ranked last at Tsh 4,600 (1.8 USD). Although the purchase prices of electric bicycles are comparable to those of ICE boda bodas, the comparatively higher willingness to pay for rental prices suggests a potential for e- bicycle delivery services as an alternative to the ICE boda boda.

Furthermore, the data also reveals the preferences and financial considerations of establishments when hiring drivers using different vehicle types. The willingness to pay for hiring a driver showed similar patterns across all vehicle types, ranging from Tsh 7,000 to about Tsh 8,400. Long John electric cargo bicycles were popular among 82 respondents, with an average willingness to pay of Tsh 8,372. The average willingness to pay for electric vehicles ranged from Tsh 7,000 for electric bicycles to Tsh 8,375 for pedal-assist three-wheelers. This suggests that establishments do not have a strong preference for a particular vehicle type if it is operated by another party. However, these findings contradict the qualitative data from the FASTA SOLUTIONSplus pilot, where companies did not perceive delivery with an electric bicycle to be as valuable as delivery with a boda boda.

5 Scaling the use of electric bicycles in Dar es Salaam: assessing the feasibility to replace ICE motorcycles with electric bicycles

The opportunity assessment delves into the feasibility and potential impact of transitioning from ICE boda bodas to electric bicycles in Dar es Salaam. To this end, a number of Key Performance Indicators (KPIs) have been identified to determine the viability of this shift based on both technical and financial criteria, the potential environmental impact and the regulatory and institutional factors affecting this transition.

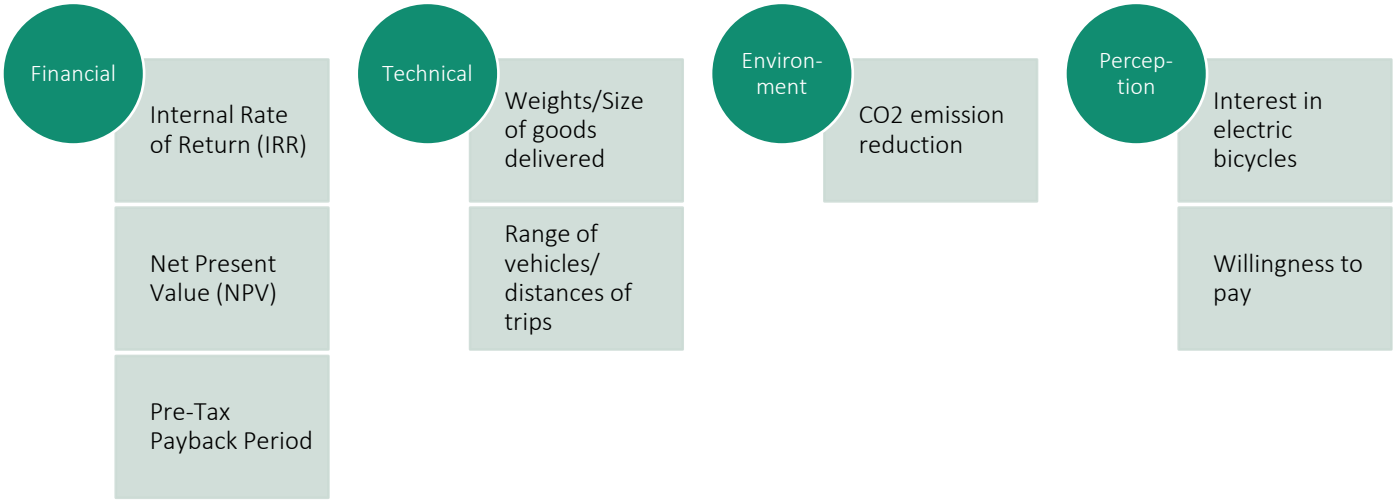


Figure 42 KPIs for assessing the feasibility to replace ICE motorcycles with e-bicycles

5.1 Financial Feasibility

The comparative financial analysis of electric bicycles and conventional ICE boda bodas, incorporates data from the SOLUTIONSplus electric bicycle pilot study, the driver survey and secondary sources. The analysis assesses the financial viability of pedal-assist electric bicycles compared to boda-bodas in three different scenarios:

- **Baseline:** Boda Boda Business as Usual
- **Scenario BAU:** Electric Bicycles Business as Usual (BAU)
- **Increase Scenarios:** Increase of Electric Bicycles Activities
  - **Scenario A:** Range and Trip Increase (Overnight charging)
  - **Scenario B:** Order Bundling and Optimization (Overnight charging)
  - **Scenario C:** Overnight Charging & Battery Swapping

The net present value (NPV), the internal rate of return (IRR), and the payback period are the three key figures used to assess the financial viability of the baseline and three scenarios. All values are considered before taxes. The NPV calculates the difference between the present value of the cash inflows (annual revenue) and the present value of the cash outflows (initial investment, annual operational costs) over the expected lifetime of the vehicle.

The NPV calculation is done with the following conditions and assumptions:

- The analysis was done for a period of four years.
- This period includes the battery's renewal after 3 years, based on its technical specifications (lifespan of 800 charging cycles) and the expected number of charges by cyclists.

- Other parts, such as the frame, have a longer useful lifetime of 7 to 10 years as per the information shared by suppliers of electric bicycles.
- Total annual operational costs are the sum of various categories such as driving licence certification/ renewal, night parking, electricity/ fuel costs, maintenance and other costs. Furthermore, personnel costs are included in operating costs - based on a monthly allowance for expenses during operations (e.g. food based on numbers obtained from FASTA drivers) and the minimum wage for jobs in the transport sector in Tanzania (ATE 2022). These values are used as proxies and may not accurately reflect the actual earnings of a delivery driver.
- An interim analysis was done based on the costs of the first electric bicycle prototype deployed in the pilot (Panagakos et al. 2024). Based on feedback from the drivers, the electric bicycle model has been further developed and adapted to meet the needs of its end users. The analysis in this study presents an update of the interim assessment, using a price closer to that of the forthcoming vehicle generations and factoring in the relevant taxes.
- The capital investment costs include the following components:
  - Updated prices: $680 for the bicycle and $270 for the battery (Landed price)
  - Taxes included: VAT (18%), Custom Processing Fee-CPF (0.6%), Road Development Fee-RDL (1.5%), TASAC (1.7%), wharfage (1.6%), CoC done locally in Tanzania (10%)
  - Taxes not included: Import tax (25%) was not included based on the assumption that the newly issued industry license for the import of vehicles will also apply to electric bicycles.

The IRR is the discount rate at which the NPV of all cash flows from the investment equals zero, it can be seen as the return generated by the purchase of the boda boda or electric bicycle and operation according to a typical operational profile analysed as part of this pre-feasibility study in Dar es Salaam (data obtained through desk research, driver survey and pilot study).

The payback period, on the other hand, indicates how long it takes for the initial investment to be recouped by the cash inflows from operating the vehicle. The estimates do not consider the income tax rate, hence the addition of “pre-tax” in the results' description.

5.1.1 Baseline: Boda Boda Business as Usual

The baseline scenario focuses on traditional ICE boda-bodas. These vehicles have an average purchase price of $1,121 and a residual value of 50% according to A2EI (2021). The annual operating costs amount to $3,877. For each of the presented cases, $1,869 of annual operating costs are attributed to personnel costs, meaning the salary of the driver. The annual revenue amounts to around $4,506. On average, a boda boda fare is $1.58 per trip, covers 11.88 kilometres per trip and makes around 9.7 delivery trips per day.
This results in a total daily distance travelled of around 115 km, with the boda bodas in use on around 294 days a year. The pre-tax NPV for the base case amounts to $1,251, the IRR lies at 47.96% and the pre-tax payback period at 1.79 years.

5.1.2 Scenario BAU: Electric Bicycles Business as Usual

Scenario BAU shifts the focus to the electric bicycles, in particular their financial feasibility without the support of the SOLUTIONSplus project. Here, the economic viability of the electric bicycles used in the pilot project is analysed using a range of parameters, including a Li-ion battery with a capacity of 0.46 kWh and a service life of 800 cycles. The electric bicycles have a range of around 40 kilometres per charge. The cost includes $680 for the bicycle body and $270 for the battery pack.

In this scenario, based on an interim evaluation of operation in the pilot project, the riders cover an average distance of 9.57 kilometres with an average of 2.3 trips per day, which corresponds to a total daily distance of 22.01 kilometres on 298 days per year. Given this operational profile and an average

delivery price per trip of $1.29 the total annual revenue amounts to $884. Over the expected useful lifetime of the bicycle over four years, this leads to a negative pre-tax NPV of -$5,137, strongly indicating that investing in electric bicycles under the given scenario is not profitable.

5.1.3 Increase Scenarios: Increase of Electric Bicycles activities

The Increase Scenarios build on the BAU scenario and analyse an increase in the operating capacity of the electric bicycles.

Scenario A anticipates an increase in both the number of daily trips and the distance travelled per day. This scenario is based on the assumption that demand will enable an increase in the FASTA customer base. This could be achieved, among other things, through partnerships with facilities and institutions in the city centre, as tested in the pilot project with the Aga Khan Hospital. FASTA drivers reported that on very good days, when demand is strong, deliveries per rider can be as high as six trips per day, which is why this number of daily trips is assumed in this scenario. At the same time, it is assumed that the utilization of the full battery capacity is realised and an increase from 22 to 40 km is achieved, which would lead to a doubling of the daily mileage of the electric bicycles and a significant increase in the number of deliveries. The increase in operating costs in this scenario only considers the change in energy costs due to the increase in charging frequency. In Scenario A there is a significant improvement in the key financial numbers compared to Scenario BAU. The pre-tax NPV improves significantly to -$646, the IRR to -31.33% and the payback period, i.e. the time required to recoup the original investment, is now estimated at 7.63 years. While still unfavourable, these figures represent a significant improvement on previous estimates as they indicate a much lower net loss over the life of the project, reflecting a slight improvement in the overall profitability of the investment, albeit still with a negative return.

Under the assumption that FASTA is able to grow its customer base to match the capacity of a conventional boda boda driver (9.7 trips or customers per day) under the same scenario, the financial results could be much more favourable. This revised scenario – Scenario B – assumes an increase in trips, albeit over shorter distances (9.7 trips/day on an average distance of 4km). Under these modified conditions, it is conceivable to achieve an NPV of $3,862, an IRR of 160.34% and a payback period reduced to 0.77 years, suggesting faster cost recovery and potential profits. However, it needs to be noted that this is a hypothetical scenario that does not consider market saturation and competition and a likely lower average revenue per trip for shorter trips. In addition, it may require operational adjustments, such as increased coordination and bundling of orders. Moreover, a possible faster wear and tear is not reflected in the operating costs.

Scenario C introduces the concept of battery swapping. This scenario aims to increase the operating capacity of electric bicycles to the level of ICE boda bodas, especially about the number of daily deliveries. Although it is assumed that the introduction of an additional battery doubles the maintenance costs and increases the capital costs by one additional battery, i.e. by $270, the operating efficiency of the e-bicycles is significantly increased. This scenario is particularly noteworthy for its financial impact, as it shows a significant increase in the IRR to 114.60% with the additional battery, as opposed to the IRR of -31.33% in Scenario A without the additional battery. The pre-tax NPV for Scenario C lies at $3,234 and the payback period is at 0.8 years.

Table 4 presents the results of the scenarios and baseline described above. To summarise, it can be said that under the given assumptions and constraints, the scenarios for the electric bicycle business with a high increase in trip frequency (Scenario B) and battery swapping (Scenario C) perform significantly better than the baseline scenario using boda bodas and the less ambitious electric bicycle scenarios (BAU and A). Scenarios B and C have particularly promising financial values that indicate good investment opportunities with quick returns, while Scenario BAU and Scenario A are unprofitable.

Table 4 Comparative financial impact assessment

Case	Description	Pre-tax NPV (USD)	Pre-tax IRR (%)	Pre-tax payback (years)
Baseline	Boda boda, 9.7 trips/day	1,251	47.96	1.79
Scenario BAU	Electric bicycle business as usual, low number of trips, and 22km/day	-5,137	-	-
Scenario A	Electric bicycle range and trip increase, increase to 6 trips & 40 km per day	-646	-31.33	7.63
Scenario B	Electric bicycle range and high trip increase, increase to 9.7. trips/day and 40 km/day	3,862	160.34	0.77
Scenario C	Electric bicycle battery swapping	3,234	114.60	0.80

To conclude, an impressive Internal Rate of Return (IRR) of about 115% IRR (investor's perspective) is achieved in a four-year scenario where ICE motorcycles would be replaced by pedal-assist electric bicycles equipped with a second battery to be swapped during the day to be able to perform the same number of daily deliveries as typical for motorcycles (9.7). The IRR is, however, negative (-31.33%) in the absence of this second battery, as only 6 daily deliveries would be possible.

While the initial investment in a boda boda ($1,121) and an electric bicycle—$950 with one battery and $1,220 with two batteries—is comparable, the electric bicycle offers significant financial benefits due to considerably lower operating costs over four years.

5.2 Technical Feasibility

- **Type of products**: establishments and drivers report similar items: mostly food products, cold drinks, sugar, drinking water, and rice, followed by apparel, textiles and laundry, and electronic devices on a less frequent basis. Residents mostly use deliveries for restaurant meals and retail shopping, e.g. clothing, electronics. These products can be transported by electric bicycles, especially in the cargo models with extra space in the back or the front.

- **Weight**: the average mass of the products evaluated in the establishment survey is 86 kg, while the 75th percentile is 100 kg. These masses are within the carrying capacity of the electric bicycle tested in the SOLUTIONSPlus pilot, as some electric bicycle models have up to a 120 kg load capacity. However, these results ought to be contextualized by pointing out a possible limitation related to the size of the goods transported, as observed during the field surveys in 2023 (see photos below).

- **Range**: to be able to offer a similar daily range as ICE motorcycles (circa 115 kilometers per day), electric bicycles with the same specifications as the pilot would need to proceed to two battery swaps. Our recommendation is to use e-bicycles equipped with two batteries.

- **Perception**: establishments have positive expectations towards electric bicycles, to reduce transportation costs and cost efficiency. While the willingness to pay is lower for purchase when comparing a regular e-bicycle with an ICE motorcycle, it is very close when asking about the willingness to pay for rental and for hiring an operator. In addition, cargo models with extra load in the front, in the back, or with three-wheeled, attracted higher willingness to pay.

Credit: SOLUTIONSPlus (2023)

Table 5 Comparison of product types

Product category	Product	Boda boda	Bicycle
Food & Beverages	Fruits and vegetables	X	X
	Meat, fish, poultry, sausages	X	X
	Dairies, Milk, yoghurt, cheese, Eggs	X	X
	Bread, toast, cakes, desserts	X	X
	Noodles, instant soups, rice, flour, nuts	X	X
	Spices, Sugar, coffee	X	X
	Prepared food and meals	X	X
	Soft drinks, water, juice, etc.	X	X
	Alcoholic beverages	X	
Personal care & health	Personal care & cosmetic	X	X
	Medicine	X	X
Household and cleaning supplies	Household cleaning products, Detergents, bleach, stain removers, laundry soap	X	X
Apparel, textiles and accessories	Textiles, Clothing, Laundry	X	X
	Watches, jewelry	X	X
Entertainment	Toys	X	
	Magazines, Newspapers	X	
Postal	Documents, Letters	X	X
	Light parcels	X	X
Home and décor	Home products (ornaments, vases, tableware, cutlery, etc.)	X	
	Furniture		
Other	Vehicle spare sparts	X	
	Building materials	X	
	Electronical devices	X	X
	Waste disposal and recycling materials		

Credit: SOLUTIONSPlus (2023)

5.3 Environmental impact

The environmental impact assessment shows, that the shift from ICE boda bodas to electric bicycles demonstrates significant potential for reducing CO2 emissions. As indicated in Table 6, an ICE motorcycle emits 2,875 kg of CO2e, while an electric bicycle only emits 152 kg of CO2e per year. Therefore, substituting an ICE motorcycle with an electric bicycle, under current characteristics of electricity generation, would result in an annual reduction of 2,723 kg of CO2e, equivalent to a substantial 95% decrease in CO2 emissions.

Table 6 Comparison between ICE motorcycle and electric bicycle energy consumption

Description	Unit	Motorcycle	E-bicycle
Petrol consumption	l/100 km	3.7	
Electricity consumption	kWh/100 km		1.15
CO2 emissions	kg of CO2e/litre	2.1602	

CO2 emissions	kg of CO2e/kWh		0.367
Annual distance	km	35,978	35,978
Annual consumptions electricity	kWh		413
Annual consumptions petrol	liters	1,331	
CO2 annual emissions	kg of CO2e	2,875	152

The CO_2e annual emission were calculated as shown in the table above with the following assumptions:

- The electric bicycles are charged from the grid with carbon intensity of electricity of 367 g of CO2e, per kWh.
- Bicycles and motorcycles travel same distances which is about 115 km for 6 days a week for a year which is roughly 35,978 km annually.
- The motorcycle has 150cc which emits about 2.16 kg of CO2e per liter.
- The electric bicycles have similar specification like the EURIST bicycle currently operated by FASTA which has a 460Wh lithium-ion battery with a range of 30-40km on a single charge.

Soon, opting for electric bicycles instead of ICE motorcycles for urban deliveries will contribute to even more CO2 savings. Presently, Tanzania's electricity installed capacity of 1,602 MW predominantly relies on natural gas (48%), followed by hydro (31%), petrol (18%), solar (1%), and biofuels (1%) (ITA 2021). With the impending launch of the Julius Nyerere Hydropower Project (JNHPP), boasting an installed capacity of 2,115 MW, this hydroelectric dam along the Rufiji River in eastern Tanzania, soon connected to the national grid, will not only double the national grid capacity but also elevate hydro as the primary source of electricity, constituting 60% of the national grid.

6 Scaling the use of electric bicycles in Dar es Salaam: learnings from the SOLUTIONSplus pilot and recommendations

6.1 Recommendations for the FASTA e-bicycle activities

AfricroozE electric bicycles, batteries, parts		
	Pilot findings	*Recommendations and actions*
Electric bicycles	Overall satisfaction, reducing risks of delays, increasing convenience, attracting attention from customers	
Battery	No issues were identified with the battery after one year of use. Although the battery was never found to be exhausted at the end of a working day, cyclists express the wish to have an additional battery in the case of longer trips.	> AfricroozE has been looking at the financial impact of adding an extra battery for longer trips. As seen in our assessment of e-bicycle versus ICE motorcycle, this is critical to be able to compete with the range enabled with motorcycles.
General design	Suggestions of improvements, such as adding a more comfortable saddle, options to attach cargo carts and footrests for passengers. Feedback was collected in two phases, in March 2023 and March 2024.	> Include louder bells to improve safety > Additional features such as two carriers (front and back), sliding cargo seats, passenger footrests, indicator lights when taking turns, water bottle carriers, and side mirrors. > Quick release seat clamp for adjustable saddle height on all e-bikes for smaller riders or women. > The design suggestions shared by cyclists in March 2023 have been incorporated into the subsequent model of the AfricroozE e-bicycle, e.g. saddle, attachment options e.g. footrests or for front carrier. Incorporation of the suggestions made in March 2024 are considered, e.g. side mirrors or louder bells.
Stand design	A kickstand, placed too low, broke off because hitting the ground when confronted by potholes or speed bumps. The broken stand was replaced locally.	> This issue has been addressed and resolved in the following AfricroozE models, positioning the stand higher.
Brakes	Wear and tear on the brake pads proved to be a common problem, also in other sub-Saharan African countries where the model is deployed, that needed to be fixed quickly. It is assumed to stem from braking at fast speeds, and without making use of mechanical gears or reducing speed before braking.	> AfricroozE worked on technological improvements to the brakes to minimise this problem in the future, including the introduction of a brake lever kill-switch when braking. > The training in June 2024 insisted on progressive reduction of the speed, to reduce wear and tear, and to reduce

		road safety risks when braking in the rain.
Spare parts	Some spare parts are difficult to come by, for instance, brake pads spare parts as they differ slightly from those most commonly used on a standard bicycle. In addition, replacement parts are expensive due to the bike's complex design compared to current market options. Finding trustworthy retailers for spare e-bicycle parts is crucial, to avoid makeshift solutions for repairing damaged components	> It is critical to establish a reliable spare parts supply chain to overcome challenges related to component availability and affordability. > It is recommended to partner with reputable e-bicycle parts dealers to ensure timely repairs and maintenance.

Charging modalities		
	Pilot findings	*Recommendations*
Battery charging and e-bicycle storage at night	Communication between DIT and FASTA was smooth, as well as the overall process of getting and charging batteries at DIT.	> Extend the cooperation beyond the agreement on charging at DIT until November 2024. In Mach, DIT provided a larger space for FASTA to charge and conduct office activities. > Explore partnerships with current distribution chains and solar charging infrastructure services.

FASTA operations		
	Pilot findings	*Recommendations*
Customer base and order volumes	The absence of a booking app facilitating orders, tracking and payment, was identified as a large barrier to attract and retain larger customers, such as the Aga Khan Hospital. Other limitations to FASTA's business include an atomised customer base of individual customers, and fluctuation of orders during festive seasons, which translated into a low number of orders and low revenues for cyclists, who often have a side job.	> Recommended use of a booking app, to facilitate order distribution between cyclists, allow customer to track their deliveries, and add an option of mobile payment. In March 2024, 10 smartphones were handed over to cyclists to enable the use of the Nibebe booking app. > Recommended expansion FASTA's customer base to ensure sufficient and stable revenues for riders, targeting larger or institutional customers through a customer slide deck, and marketing improvement.
Ability to transport parcels	While most deliveries were smooth, delicate items like cakes require extra care during transportation, leading to riders holding the boxes with one hand during rides. Certain goods, such as waste glass bottles, posed logistical challenges due to their size.	> Explore the possibility to be equipped with larger, stable, backpacks, refrigerated bags to transport meals, or improve the rear carrier. > Explore the possibility to be equipped with phone holders for easier orientation.

6.2 Recommendations for the uptake of electric bicycles in Dar es Salaam, in general

E-bicycle specifications and design		
	Pilot findings	*Recommendations*
Battery	One battery is sufficient to address the current volume of orders received by FASTA, but one would not be enough if the cooperative cyclists want to compete with motorcycles.	> Two batteries to swap if the e-bicycles are to be able to cover the same typical mileage as delivery motorcycles.
Vehicle design		> Sufficient space to carry goods in the back or front. > Ensuring a 100kg payload as the AfricroozE model, or more. > Gender-inclusive, lower-step frame.

Training, maintenance & repairs on electric bicycles		
	Pilot findings	*Recommendations*
Training	Feedback on the assembly and use fo e-bicycle training provided in November 2022 was positive. The training, although condensed in time, proved to be clear and beneficial, highlighting key technical aspects of bike use and safety. However, some riders emphasised the need for more in-depth training on certain technical issues. Timely technical support was sometimes a challenge when mechanics were otherwise engaged. The need for riding training was identified in March 2024, when identifying that cyclists typically use the maximum electric assist level - instead of modulating the level of assistance - and tend to brake abruptly.	> Further training on the optimal use of e-bicycles, for instance (1) on the alignment of gear and engine power, (2) on the progressive reduction of speed before braking, (3) on the safe use of e-bikes, particularly in adverse weather conditions, (4) on the navigation of the e-bicycles through various traffic situations safely, thereby reducing the risk of accidents. If possible, both of these scenarios should be practised through physical test rides. > This has been incorporated in the June 2024 training, e.g. the riding training, and needs to be sustained at intervals. Riding in rain conditions should be continued. > For like-minded projects dealing with innovative vehicles, regular training at intervals, e.g. every 6 months, is recommended to leave sufficient time to users to get familiar with the vehicle, especially in the first 2 years.
Maintenance & repairs	Two aspects are vital with regards to maintenance and repairs: on one hand, additional local mechanics need to be trained, to address the current difficulty in obtaining timely technical support from the trained local mechanics. On the other hand, the availability and affordability of	> Support the establishment of a network of local maintenance and repair centres. > Further train FASTA cyclists on bicycle repair basic skills (integrated in the June 2024 training). > Establish a reliable spare parts supply chain to overcome challenges

	spare parts is critical to ensure a smooth and quick fix of repairs.	related to component availability and affordability. > Partner with reputable e-bicycle parts dealers to ensure timely repairs and maintenance.

Operational, legal and regulatory environment		
	Pilot findings	*Recommendations*
Operations in traffic	Electric bicycles can present a viable alternative in Dar es Salaam to larger motorised vehicles, helping to address issues of traffic congestion, air pollution, and limited transportation options. They can also help improve the social perception of cycling and gain new customer groups to cycling. However, the absence of cycling lanes and of parking for bicycles does not allow for safe cycling. FASTA cyclists reported road safety issues, especially when cycling in the rain or in heavy traffic. A more decisive policy and planning support for conventional and electric bicycles is needed.	> A comprehensive network of bicycle paths and lanes must be created to interconnect residential areas, business hubs and main destinations, in order to ensure secure and efficient transportation. To upgrade the current cycle lane infrastructure, it is crucial to install adequate signposting, road paint and traffic calming measures. > It is essential to guarantee the safety of bicycles when they are not in use by implementing secure and convenient parking amenities for e-bikes at public transport centres, markets, and popular locations.
Taxes	The AfricroozE pilot attracted the highest total tax percentage of 58.4%, made in the decreasing order of importance of import duty (25%), VAT (18%), Certificate of Conformity (CoC) done locally in Tanzania (10%), and other taxes (Custom Processing Fee-CPF of 0.6%, Road Development Fee-RDL of 1.5%, TASAC of 1.7% and wharfage of 1.6%). It is assumed that the tax percentage is now lower with the new industrial license removing the import duty for vehicles locally assembled, but it has not been confirmed by Tanzanian authorities.	> E-bicycles companies should at least benefit from the recent HS code exempting CKD vehicles from the 25% import duty. > Advocate for a preferential tax regime for electric bicycles and bicycles to support this sustainable transport mode. > Discussions with the government to exempt e-bicycle batteries from duties as for solar batteries, and the conditions for their import > Ensure that electric bicycles are considered as light electric vehicles and included in any incentives adopted on e-mobility
Import documentation	Among all documents required (invoice, packing list, bill of lading, Certificate of Conformity, CoC), the CoC is due for each importation and attracts fees, representing a form of additional tax. Replacing it with a	> Discussions on trade facilitation to facilitate imports since key components of the e-bicycle (motor, battery) can not be produced locally for the time being.

	yearly license is a considerably strenuous and costly process.	
Batteries as e-waste		> Connecting with a company collecting, reusing or recycling EV batteries to ensure proper end-of-life management.
Further financial support	E-bicycles have a large potential but face bias with regards to their potential – seen as bicycles, which often a low social status – and are less known than other electric two-wheelers, such as electric motorcycles and mopeds/	> Consider financial support through subsidies, or grants, to curtail the cost of buying e-bicycles. > Partnering with microfinance, asset financing institutions and banks. > Explore schemes not requiring ownership such as bike sharing initiatives and short-term rentals.

E-bicycle applications		
	Pilot findings	*Recommendations*
Use cases	The e-bicycles have been found to be well adapted for urban deliveries in terms of the type of products, the weight, the range and perceptions. More stakeholders involved in urban deliveries should have the opportunities to experience e-bicycles, especially cargo models. Additional applications should be explored.	> Approach digital platform stakeholders to offer trial phases or partnership with e-bicycle companies. > Approach companies, highlighting environmental benefits and links to their Corporate Social Responsibility. > Approach Tanzanian government authorities for public fleet use, e.g. municipal fleet. > Experiment various further business models such as leasing, public sharing, and purchasing.

Awareness raising		
	Pilot findings	*Recommendations*
Perception of e-bicycles among the government	Discussions with government officials showed that e-bicycles are often confused with e-motorcycles, as both are called 'e-bikes'. There is little knowledge about e-bicycles.	> Increase awareness of the government and companies on the mobility and environmental benefits of e-bicycles through events allowing to test e-bicycles and communication campaigns.
Perception of e-bicycles among customers and citizens	On the one hand, cyclists indicate that e-bicycles attract interest from customers, identifying their specificity. On the other hand, they also indicate that customers still perceive an electric bicycle as a bicycle – often having a low social status – and compare them to a regular bicycle delivery method. The feedback from	> Increase awareness of cities through media awareness, community events, advertisement on billboards, workshops, and demonstrations on e-bicycles, safe cycling practices, and maintenance. > Explore collaboration opportunities with other companies to promote mutual growth and competitiveness.

	cyclists is consistent with experiences reported in other sub-Saharan African countries, where testing an e-bike has a strong impact on changing the perception. Furthermore, the surveys of establishments and drivers revealed a significantly lower willingness to pay for the bicycle types, both in comparison to the average baseline price of a boda boda and the actual value of the AfricroozE electric bicycle. This discrepancy highlights a gap between market expectations and the perceived value of electric bicycles among potential users.	> Organise car-free days to promote the use of safe, environmental-friendly and inclusive mobility. > Mobilise university student networks, with WhatsApp and Instagram groups. > Mobilise influencers and organisations such as Uwaba. > Participate to events and exhibitions.

7 Conclusion

The adoption and scaling of electric bicycles in Dar es Salaam present a promising opportunity to address urban delivery challenges. The SOLUTIONSplus pilot has demonstrated the benefits of using e-bicycles, showing high satisfaction among riders and significant potential for reducing CO2 emissions. However, for widespread adoption, key challenges must be addressed, including improving cycling infrastructure, ensuring the availability of spare parts, and raising awareness among government officials, the public and the private sector.

This pre-feasibility study concludes that with the right support, e-bicycles can be an effective alternative to ICE motorcycles, offering similar services with notable environmental and financial benefits. The recommendations provided aim to create an enabling environment for e-bicycles, including enhancing infrastructure, simplifying fiscal policies, and conducting awareness campaigns.

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Appendices

Appendix A: Method and data collection approach

Data collection approach

Secondary and primary research was utilised to gather a comprehensive overview of the urban logistics ecosystem. The primary data obtained during the data collection process for the study include:

- Impact Assessment during electric bicycle pilot conducted with FASTA Cooperative and EURIST
- Urban Logistics Profile Analysis: Driver Survey, Establishment Survey, Resident Survey

A local team of the ULLC, UEMI, ITDP Africa, and DART coordinated and conducted the data collection. Over ten days, they actively conducted surveys among delivery drivers, businesses, and residents in Dar es Salaam city centre.

On-Ground Observations & Surveys

On-site data collection was a cornerstone of the pre-feasibility study, which aimed to explore the intricacies of the urban logistics system in Dar es Salaam. The data collection was conducted in two methodologically planned phases, each critical to the robustness and granularity of the findings from the study. Based on the methodological approaches used in the SOLUTIONSPlus urban logistics demonstration projects in Latin America, the survey design of the study was tailored to the local context. The first phase began in March 2023 and focused on testing the questionnaires, while the second phase took place in July/August 2023.

Phase 1: Testing the questionnaires and preliminary data collection

The first phase was dedicated to the development and testing of the surveys. Collaboration with students from the University of Dar es Salaam (UDSM) was instrumental in developing questionnaires that resonate with the target groups - delivery drivers, businesses and residents. This phase was critical to ensure the relevance and clarity of the questions that would provide the necessary insights. The feedback received was crucial in refining the survey tools and formed the basis for a streamlined and effective data collection process in the subsequent phase.

Phase 2: In-depth data collection

With the questionnaires refined, the second phase was conducted with the help of hired research support to expand the survey to a broader participant base. This phase was designed to collect comprehensive data from each identified stakeholder group to provide a comprehensive data set for subsequent analysis. Six surveyors conducted the survey for ten days between the end of July and early August 2023.

Observations

The local team, UDSM students and surveyors conducted field observations to gain an initial understanding of delivery operations, traffic conditions, and the potential for electric bicycle integration. These observations were strategically scheduled at different times and locations to gather various data on delivery operations and the compatibility of the urban environment with electric bicycles.

As part of the driver and establishment surveys, surveyors were instructed to make observations at the beginning of each questionnaire. These observations included the type of area in which the survey was conducted (e.g. city centre, commercial area, residential area, high-income area, etc.) and the availability of parking infrastructure. The question on area allowed for multiple responses, i.e. an area

could be both residential and commercial. In order to aggregate the data in the graph, such responses were split and included in the results for mixed residential and commercial areas separately.) In the survey, respondents could indicate whether there is dedicated infrastructure for parking, no dedicated infrastructure for parking but space for off-street parking or no dedicated infrastructure for parking leaving vehicles to park on the street.

Drivers Survey

A driver survey was administered to a selected group of delivery drivers using different types of delivery vehicles. The survey aimed to determine the current status of delivery operations and the acceptance of electric bicycles as delivery vehicles.

Establishment Survey

In-person surveys and interviews were conducted with owners, managers, and employees of various establishments, including retail and wholesale shops. The survey aimed to identify the prevailing modes of transportation used for deliveries, the types of goods frequently transported, and the frequency of such deliveries. Additionally, respondents were asked to rank alternative modes of transport as potential substitutes for ICE powered vehicles, providing insights into their preferences and the reasons behind their choices.

Resident Survey

The aim of the resident survey was to gain a comprehensive insight into the experiences and views of the local population regarding last mile delivery. The survey was intended to cover a broad spectrum of the city's population and was not differentiated by age, social background or education to ensure a broad and representative sample. However, it should be noted that the majority of respondents have a university degree, resulting in a biased sample. The following results can, therefore, be seen as an insight into the situation but must be treated with caution.

Appendix B Capital & Operational Costs Financial Assessment

In assessing potential e-bicycle business models and addressing the study's focus on replacing ICE motorcycles with electric bicycles for urban deliveries, a 150 cc ICE motorcycle, a commonly used motorcycle model, was considered as the baseline. Information regarding purchase and rental prices for the motorcycle was gathered from a single key informant.

Parameter	Base	S 1	S 2.1	S 2.2	S 3	Unit
Capital costs						
Market value (***Interim results***)	1,121	620	620	620	820	USD
Market value (***Updated results***)	-	950	950	950	1,220	USD
Expected useful life	4	4	4	4	4	years
Residual value	560	150	150	150	150	USD
Operating profile						
Average length of trip	11.88	9.57	6.7	4.12	6.7	km
Paid trips/day	9.7	2.3	6	9.7	9.7	trips/ day
Total distance/day	115.24	22.01	40	40	64.99	km/ day
Operating days/year	294	298	298	298	298	days/ year
Annual operating costs						
Total operating cost	3,877	2,141	2,147	2,147	2,196	USD/ year
* Licencing/ renewal	36	0	0	0	0	USD/ year
* Vehicle road tax	26	0	0	0	0	USD/ year
* Night parking	146	146	146	146	146	USD/ year
* Technical inspection	-	72	72	72	72	USD/ year
* Insurance	30	22	22	22	22	USD/ year
* Personnel cost	1,869	1,869	1,869	1,869	1,869	USD/ year
* Electricity cost	-	7	13	13	42	USD/ year
- Energy consumption	-	0.012				kWh/ km
- Electricity tariff	-	0.094				USD/ kWh
* Fuel cost	1,272	-	-	-	-	USD/ year
* Maintenance	440	20	20	20	40	USD/ year
- General Maintance cost	170	7	7	7	7	USD/ year
- Tires	-	6	6	6	6	USD/ year
- Brake shoes	-	2	2	2	2	USD/ year
- Dent paint	-	2	2	2	2	USD/ year
- Head- & tail-lights	-	2	2	2	2	USD/ year
- Fuses	-	0.4	0.4	0.4	0.4	USD/ year
- Motor service	270	-	-	-	-	USD/ year
* Vehicle cleaning	21	5	5	5	5	USD/ year
* Other (e.g. Cooperative membersship)	42	-	-	-	-	USD/ year

Glossary

Wholesale business	Wholesale businesses are companies that buy large quantities of goods from manufacturers or distributors and resell them to other businesses, usually retailers, at a higher price
Solo trader	Self-employed person who runs their own businesses
Fundi	A Kiswahili term designating a mechanic or repairer
Footrests	Extra attachments on the e-bike to support the feet of a passenger carried on the back carrier
Quick-release seat clamp	A mechanism that allows for easy adjustment of the seat post height without the need for extra tools
Kill-switch	This function immediately cuts the flow of electricity to the engine upon braking which helps to improve the braking distance, reduce brake pad wear and has a slight impact on reducing battery drain.

This project has received funding from
the European Union's Horizon 2020
research and innovation programme
under grant agreement no. 875041