solutions plus

This project has received funding from the Europeans Union Horizon 2020 research and innovation programme under grant agreement No. 875041

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Working Paper: Impact Assessment - Dar es Salaam

Background and context

Geography and the social/urban context

Dar es Salaam, with a population of around 4.3 million (Data for 2012, annual growth rate 4.96% since 1988, Source: United Nations/un-.org, unofficial estimations for 2020: approx. 6 million), is the largest city in Tanzania. In 2017 Tanzania's GDP per capita amounted to $2,945. CO2 per capita in Tanzania was estimated at 0.221 metric tons in 2014 with the transport sector contributing 57% of the total CO2 emissions from fuel combustion. With renewable electricity output currently at 43 % of total electricity output, the country's aim is to increase its share of renewable energy production through increased use of hydropower, solar and other renewable energy sources.
City: Dar es Salaam
Population: 4.3 million (2012)
GDP per capita: $2,945 (2017)
CO2 emissions (per capita): 0.221 metric tons in 2014

The images below show ongoing, rapid population growth in Dar es Salaam, that increases the urban sprawl and density.

Urban transport

Dar es Salaam has introduced a Bus Rapid Transit System called 'DART' in 2016, that starts in the CBD / city center. DART comprises two lines of a total length of 21.1 km (Source: brtdata.org). Data indicate a daily ridership of 180.000 passengers (ibd.). While DART public transport system run by a public authority, a large fraction of public transport ridership is still being delivered by the informal transport sector: a large number of mini- and midi-size buses called 'dala-dala' run throughout the cities streets, that a growing number of 2- ('boda-boda') and 3-wheeler taxis ('bajaji' - named after the most indian company bajaj who import three wheelers to TZ/Dar es Salaam) complements. Two- and three-wheelers have become increasingly common since the mid of the 2000s and are being used by passengers for shorter trips and also feeder-trips towards the BRT and dala-dala.

Overall, the mode share of public transport modes (including BRT and dala-dala) is high, however numbers vary between studies and sources, ranging between 43% of all trips in Dar es Salaam (Source: DART, taken from brtdata.org) and 68 % (Source: Mkalawa & Haixiao, 2014). Mkalawa & Haixiao also give a complete estimation of the modal split in Dar es Salaam for the year of 2014, as can be found in the table below. However, due to the lack of a recent census and a household travel survey, all these numbers should only be considered as approximations. Also, since 2014, when the total number of 3-wheelers was estimated to be around 50.000 (Bishop & Amos, 2015), they grew above-average due to rising imports since then.

Public Transport	68 %
Private cars / motorized individual transport	12 %

2-wheelers (bicycles and motorbikes)	2 %
Walking	17 %
Employer transit	1 %

Source: Mkalawa & Haixiao, 2014, p. 426

At the time of writing this report, information on overall VKT of cars in the city, and the number of cars in the city was unavailable. However, these information are highly needed for the baseline scenario.

Identification of main problems

Passenger transport services

The rapid population growth of Dar es Salaam in the past 2-3 decades has imposed many challenges on the development of the city. As the population continues to increase, people make more trips within a city over a long distance(Kanyama et al,2005). The supply of an adequate public transport system and infrastructure are one of these main challenges today.

- Increasing private car ownership due to increased wealth/income
- Increasing transport demand due to the population growth and increasing economic activities
- Longer distances travelled resulting from urban sprawl
- Increasing number of 2- & 3-wheelers since mid of the 2000s

All of the above points increase negative externalities from transport as well as increased congestion. All motorised modes rely on fossil fuels, thereby leading to increased CO2 and particle-emissions. Additionally, noise and safety externalities result as well as increased travel times due to road congestion.

The development of an integrated public transport system has to be considered as the main priority in terms of urban mobility, as private individual transport will further increase the externalities and congestion. Besides the further development and construction of a high-capacity rapid transit system such as BRT, the feeder modes for fine distribution also need to be addressed. Especially 3-wheelers have proven to be suitable for the context of Dar es Salaam, as their rapid increase shows. The following are noted for the urban transport system in Dar es Salaam:

Numbers on emissions (CO2 and pm 2.5 / pm 10)
Total emissions for Dar es Salaam from household energy, buildings and Industry, all road transportation and solid waste was estimated at 8,065,907million tonnes of carbon dioxide equivalent (CO2e) with 1.3 tonnes CO2e per capita in 2016. Contributions from the transport sector was reported at 32% being the second largest contributor of GHG (gases included CO2,CH4 and N20) after waste (Dar es Salaam GHG Emissions Inventory Report, 2016).

- The current public transport system in Dar es Salaam is composed of approximately 6820 registered daladalas owned by 3,700 owners with 362 licenced routes for public transport (ESIA, 2015). The city is increasingly witnessing an increased number of motorcycles and tricycles as an important means of transport running parallel with the dala-dalas and also serving the outskirts of the city as a major means of transport servicing the last mile connectivity aspect. There were 4,432 registered bodaboda as of May 2014 and an increasing number of tricycles which provide the much-needed employment opportunities, to-date the market had already created an estimate of about 50,000 direct jobs (Bishop, 2015). The city is also traversed by a few bicycles most of which are privately owned, the ferries that serve the population in the southern part of the city and the Dar es Salaam commuter train running through the city centre.
- The existing BRT system is still being developed, currently there are ongoing constructions of phase two and the consequent phases to follow(Phase 2 - 4).
- The new BRT fleet from phase 2 alone is expected to conform to the Euro III emission standards achieving an offset of 104.243 metric tons of pollutants per day (BRT ESIA, 2015).

Average levels of PM2.5 and PM10 recorded in Dar es Salaam City study by Njee et al in 2016 were 48.8 µg/m3 and 152.9µg/m3 from traffic with major contributers being old diesel engines commuter buses, congestions and the general rapid increase in the number of vehicles.
Currently, there's a growing number of 3-wheelers operating in Dar es Salaam as on-demand taxi ser-

vices ('micro-informal' transport, see Goletz & Ehebrecht, 2020). They can be characterized as a semi-legal, yet unorganized mode of transport and are part of Dar es Salaam's informal transport sector that also includes the dala-dalas. These 3-wheelers serve for a set of different trip types, with feeder services into the BRT and dala-dalas being very common (ibd.). It frequently happens that many three-wheelers mainly run between the BRT stations along Morogoro-Road into the settlements lying north and south of it. The Figure below show's such a typical situation: Shown are the trips that have been derived from GPS tracks. One 3-wheeler was tracked throughout a whole day, thereby frequently making trips southbound from the Kimara BRT station and likely already serving as an informal BRT feeder. Goletz & Ehebrecht also measured the average trip distance of 3-wheelers being 2.8km, while Czeh (2019) states 2.98km as the average trip distance. Czeh also identifies the number of daily trips averaging at 21.5km for three wheelers in 2018, with 64.1 km per day or 448.6 per week, respectively.

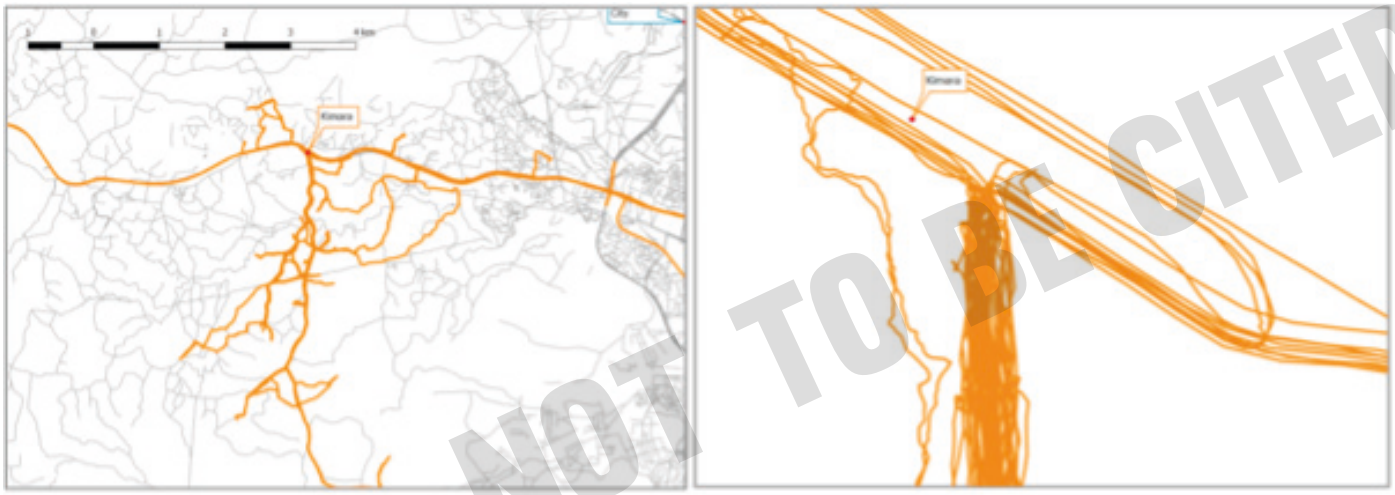

Figure X: GPS tracks of 3-wheelers in Dar es Salaam, at Kimara BRT station (Goletz & Ehebrecht, 2020)

Czeh (2019, p. 18+) also calculated emissions for combustion fuelled three wheelers, based on assumptions that have been drawn for the same type of vehicles operating however in india. He assumes emission factors of 0.1135kg CO2 per km for petrol and 0.1322 for diesel fuelled vehicles. Looking at a total of 105 vehicles in the year of 2018 in Dar es Salaam, Czeh finds only 2 being fuelled by diesel while 103 being fuelled by petrol.

Challenge: BRT will be expanded (Phase 2 - 4 outrolling) - how to get the passengers sustainably along the last mile (access and egress). electric 3-wheelers to fill this gap, reflecting challenging road conditions and need for flexibility. Integrating such sustainable feeder modes into the BRT scheme is challenging from multiple perspectives: tarif and fare integration, physical / built integration, electricity demand, operational challenges, maintenance, availability of suitable vehicles, institutional and regulatory challenges.

Description of demonstration project

The demonstration in Dar Es Salaam focuses on e-mobility for last-mile connectivity and aims at integrating 60 electric 3-wheeler services with Dar es Salaam's BRT (DART) to support first/last mile connectivity. The deployment of e-3 wheelers is being planned around 5 DART stations considering urban locations: a) in the city centre, where fossil-fuelled 3-wheelers are currently banned for environmental reasons and where accessibility to/from the BRT stations can be limited due to longer distances; b) in peri-urban areas where combustion-fuelled 3-wheelers are currently very common as feeder-modes. The demonstration also involves the localisation and installation of charging infrastructure as well as the deployment of a Mobility-as-a-Service (MaaS) application to facilitate the integration of the BRT and the electric 3-wheeler services . The demonstration follows a systemic approach and includes the development of business models (vehicle ownership, rental schemes, and maintenance) and capacity building on electric mobility development to be offered to local stakeholders.

Relevant stakeholders and user needs

An assessment of the user needs with regards to electric mobility was carried out by the SOLUTIONSplus Dar es Salaam team in the months of November and December 2020 and in January 2021. The assessment involved online/face-to-face interviews with key local stakeholders, prioritisation of Key Performance Indicators (KPIs) and an online survey. Due to a very low response rate at the time of writing this report (n=2), the results of the online survey are not considered here. A total of ten (10) experts working in the field of urban transport were interviewed whilst four (4) responses were received for the KPIs prioritisation. Results and findings from the User Needs Assessment (UNA) are summarized in this report. The complete draft report of the UNA can be found here.

Aims of the city to transform urban mobility

Dar es Salaam city experiences the fragility of the public transportation system where the majority of the residents heavily depend on the mini-buses(Balboni et al, 2020). The system provides poor service due to long waits, overcrowding, lack of fixed bus schedules and lack of comfort). With poor services offered by public transport and congestion other residents opt to use private vehicles.

With an estimated population of 12 million when it reaches 2030, the city agreed on a transport strategy in 2008 which is known as Dar es Salaam Transport Master Plan (2008-2030). The aim of the strategy is to cater for the needs of the expected population by making everyday life simpler in a large, competitive, close-knit city. The Transport Master Plan is implemented in action and investment plans, and will be the starting point for present and future plans and programmes for different modes of transport in Dar es Salaam City. The aim is to improve the quality of transport together with the mobility of the vulnerable citizens.

The coming years shall exhibit innovative time for urban transport. The Master Plan proposes the introduction of an appropriate traffic management system with advanced technology.
The concept of the transport is "Transit Oriented Mega City". Key strategy is to establish "Palm and Fingers' ' urban structure by applying TOD development, through improving capacity and service standard of the public transport by networking various transport modes, railway and BRT. The Concept shall be well known and shared among the stakeholders. In order to promote harmonization of a number of related plans and policies, it is requested for PO-RALG to ensure that M/P contents will reflect onto National, Regional and City plans and policies, specially to Dar es Salaam Master Plan (2012-2032, MOLHHSD), National Transport Policy (Transport -MOWTC), and the upcoming National Five-Year Development Plan (FYDP, MOFP).

Tanzania Electric Supply Company is responsible for power generation, transmission and distribution of electricity in Tanzania. Installed capacity is 1,602 MW out of which 48% is from natural gas, 31% from hydropower and 18% from fossil fuels. Tanzania is now implementing a massive project to generate over 4,000MW from the Nyerere hydro dam. All generated electricity will be fed into the national grid which is then distributed to all regions in Tanzania. The distribution system network voltages are 33kV and 11kV which serve as the distribution back-bone stepped-down by distribution transformers to 400/230 volts for residential, light commercial and light industrial supply.

The existing tariffs in Tanzania extend from $0.04 per unit for consumers who consume less than 75 units per month to $0.13 per unit for consumers who consume more than 75 units at voltages between 230V and 400V. The tariffs in PSMP2016 are predicted to increase 300–350 Tsh ($0.13–0.15) per kWh and might even rise up to 380 Tsh ($0.17) per kWh under the high case as per PSMP2016. Data from the Tanzania Investment Centre shows that the highest slab in the tariff structure was already 350 Tsh ($0.16) per KWh.

Dar es Salaam region is the main consumer of energy from TANESCO with estimated peak demand of over 1100 MW (TPSMP 2012) with electrification rate of about 90%. The power demand in Dar es Salaam in 2016 was estimated to be 3,539 GWh (DCMP). The average power consumption was 635 kWh per person per

month. Available data indicate that the amount of electricity generated has consistently exceeded the electric power consumption from 1985 to 2009.

Regulations

Vehicle regulations

There exists a strong legal framework guiding importation, registration operation and disposal of vehicles in Tanzania. Importation and registration of vehicles is governed by the Motor vehicle Act, and Regulations of 2006. Motorcycles are charged 15% of its value and vehicles with engine capacities up to 1,200cc are subject to import tax of 20% and value added tax of 18%. Tax payable for higher capacity vehicles ranges from 25 to 40% depending on the capacity of the engine. Vehicle transfer taxes are also described in the regulations. Registration of vehicles is done through the Tanzania Revenue Authority where the owner is required to pay registration fee and pay for the plate number. it is expected that the importation or assembly and ultimate use of the e-vehicle shall comply with existing laws and regulations eg. payment of relevant import tax and VAT. subsequently,e-vehicles shall be liable to follow applicable traffic regulations.

The Road Traffic Act No. 30 of 1973 and its numerous regulations prescribes motor vehicle pre-operation and operations to be followed by drivers in Tanzania. The Act focuses/guides the need for registration, having proper driving licence and use of motor vehicles; traffic control and enforcement and establishment of a national road safety council.

Land transport in Tanzania is regulated by the Land Transport Regulatory Authority (LATRA), responsible for licencing and regulating all land transport. It is therefore imperative that the e-mobility vehicles meets the prerequisites requirements and are run in accordance with laid down regulations

Roads and streets

In 2011, road density for the United Republic of Tanzania was 9.1 km per 100 sq.km. Since then, the government has implemented many road road projects in the country, hence the road density has increased substantially in recent years. In recent years there has been a concerted effort to build more roads to open up agriculture to the open markets in big cities.

The road network is 86,472 kilometres (53,731 mi) long, of which 12,786 kilometres (7,945 mi) is classified as trunk road and 21,105 kilometres (13,114 mi) as regional road. The rail network consists of 3,682 kilometres (2,288 mi) of track. Commuter rail service is in Dar es Salaam only. Part of the road network is the bus rapid transit system being implemented expected to cover about 160 kms of dedicated bus lanes.

Tanzania's Ministry of Works, Transport, and Communication through the Tanzania National Roads Agency (TANROADS) is managing the national road network of about 33,891km, comprising 12,786 km of trunk and 21,105 km of regional roads. The remaining network of about 53,460km of urban, district and feeder roads is under the responsibility of the Prime Minister's Office Regional Administration and Local Government (PMO-RALG).

Provision for road financing, development, maintenance , management and other related matters is governed by the Roads Act, 2007. The management of roads and streets assets is vested upon the road authorities - TANROADS for trunk roads and TARURA for urban and rural roads.

No electricity regulation barriers were identified in the UNA.

Obstacles, limitations and barriers for EVs

Import duties and other associated taxes may render the EVs very expensive and this could slow adoption of the same. Tax incentives (both subsidies and exemptions) may become a necessary measure just like in other sectors like fossil fuels. Affordability of the EV is an important factor for existing drivers of conventional three wheelers to venture into the EV business. Business models for the introduction of the EV

need to carefully consider how conventional bajaj owners, drivers and people along the chain are accommodated inorder to reduce resistance and allow for smooth uptake of the technology. The absence of regulation on EV may slow down the adoption and scaling up of EV in the country. Although there is no particular law or regulation that prohibits the use of such vehicles, it's important to set the regulations along use,management and disposal of EVs in the country.

Government and political support is imperative for success of any project. Stakeholder involvement at an early stage of project implementation will remove unnecessary obstacles and render support.

EVs are a relative new technology in the country, this brings technical limitations in terms use and management of EV. Like any other new technology EV may also be faced with reluctance to adoption.

The manufacturing sector in Tanzania is still at its juvenile stage thus may offer limited support to a new sector such as EV in the country. This may translate to importation of significant number of spare parts and inturn raise operational costs for EVs.

Business model

Current business models

It must be mentioned that there are currently no electric 3 wheelers operating in Dar es Salaam; as such, information on operations or business models relating to electric 3 wheelers do not exist specifically for Dar es Salaam. In this section however, a brief description of current business models used in the operation of conventionally fueled 3 wheelers (Bajaj) in Dar es Salaam is provided:

- Model 1: An individual buys a bajaj and runs the business as a driver and owner.
- Model 2: An individual buys a bajaj and gives it to a driver and the driver pays a fixed agreed amount of money to the owner every day or every week. Servicing of the Bajaj is also done by the Bajaj driver and the Bajaj remains the property of the owner throughout the business.
- Model 3: An individual buys a bajaj and gives it to a driver and the driver pays an agreed fixed amount of money to the owner every day/week and after two years the bajaj is owned by the driver.

Implications for Planning and Urban Development

Some of the issues identified during the needs assessment interviews in relation to planning and urban development implications of scaled up demo project include the following:

- The need for good roads to accommodate three wheelers (expansion of road infrastructure) will arise in the outskirts of towns, neighborhoods, and other regions in the country that use EV solutions and demand improved infrastructure. More EVs will influence provisions of either the roads or road reserves and other areas closer to roads, the charging stations on the road will drive new road designs to incorporate charging systems.
- The upscaling of the demo project also may result in the expansion of the energy infrastructure to other parts of the country, outside the towns. The government will be expected to improve the energy infrastructure in order to accommodate the needs of the electric three wheelers. The upscaled project may also mean an increase of renewable energy technologies and mix in the country's energy profile as a whole.
- Responsible authorities working with the private sector will have to start planning on management of a big chunk of e-waste generated from EVs.
- While low or reduced noise level is seen as a positive outcome from the use of EVs , on the other hand it may cause road accidents in communities where road users are accustomed to rather noisy transport modes. Interventions to make people aware of the introductions of such vehicles may deem necessary.
- As EVs operations are expected to become cheaper over time so will the movement of goods also. This may result in unexpected emergence of bigger markets in the outskirts of the city that require infrastructural changes.
- In an ideal vibrant EV sector where the private sector takes the pivotal role, charging

stations will likely be developed by the private sector or a public private partnership may be adopted in different areas. The positive aspect of this is the generation of new jobs along the EV value chain while the downside of things is the possibility of increasing land disputes especially in cities like Dar es Salaam where space for new infrastructure is already an issue.

Key Performance Indicators (KPIs)

Prioritization of KPIs addressing the specific city needs

The KPI tree was created in line with the SOLUTIONS+ project specifications. It is currently based on a number of 5 KPI weights (see Table 1) that have been carried out as part of the interviews during the user needs assessment. In the future, we aim to collect additional KPI weightings through our network in Dar es Salaam, while a significant boost is expected once the pilot phase has started and more stakeholders become actively involved in the project.

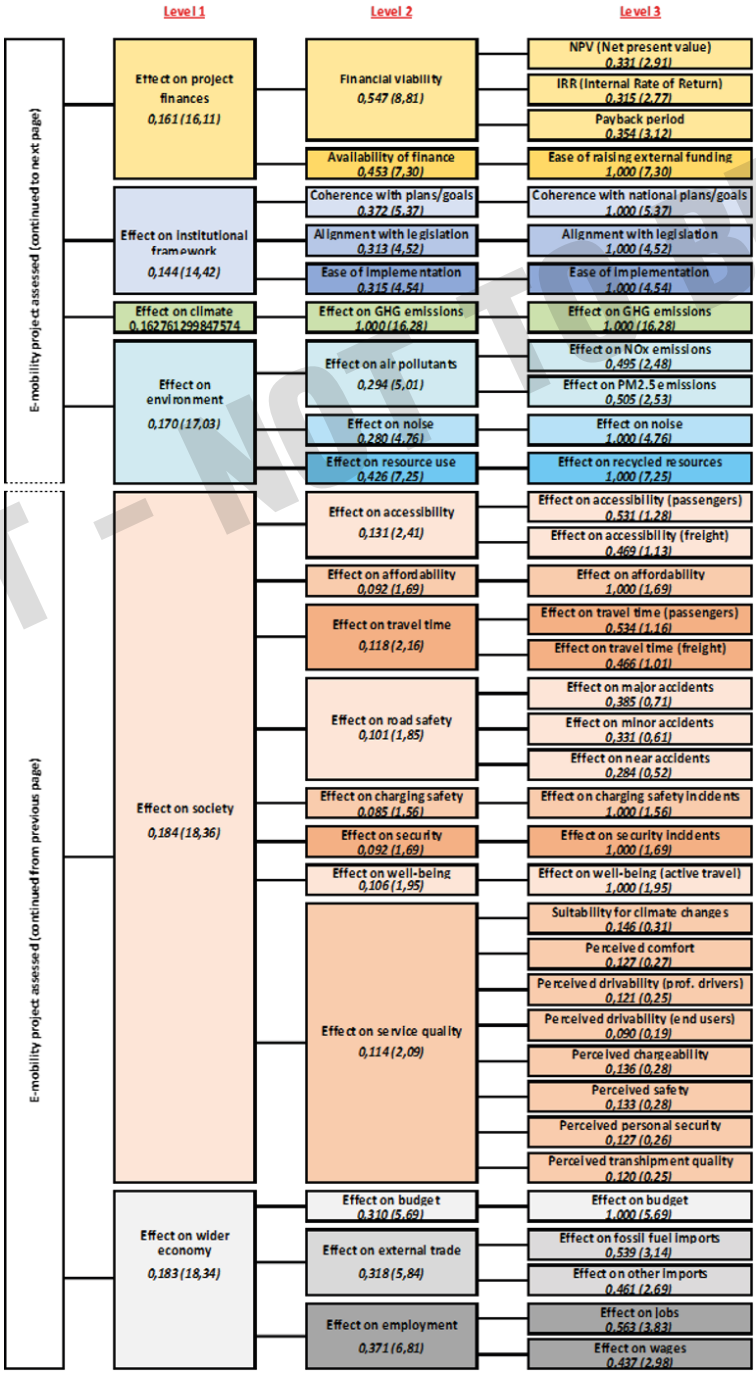

Figure 7.2 Attribute weights indicated by the Kathmandu stakeholders (tentative)

Figure 7.2 shows the mean values of the weights received from the 5 stakeholders. Both relative (in black) and cumulative (in red) weights are shown. Relative weights indicate stakeholder priorities within a family and sum to 1. Cumulative weights at each level are determined by applying the relative weights of that level to the cumulative weight of the parent attribute. To minimize potential mistakes, the sum of all cumulative weights at each level is set to 100. The cumulative weights of L1 are identical to the corresponding relative ones, only expressed at a different scale.

For L1, the "Effect on the wider economy" is seen as the most important aspect of the project (0,183), followed by effects on society, environment, climate, project finances and the institutional framework (in this order). For the subsequent Levels (L2, L3), the importance per category can be read from the table, for instance that the effect on employment (0,371) was rated highest amongst the L2 category for the effect on the economy, accessibility in the category society (0,131).

KPI estimation methods and data needs

The KPI estimation method was followed in line with the description provided in the introduction of Deliverable 1.6.

Table 3: Data category, description and data source for the city of Dar es Salaam (taken from D1.4)

Category	Description	Source of data
Vehicles number / share	- Fleet of 3 wheelers - Engine share (ICE, electric) - OR number of ICE 3 wheelers, number of electric three wheelers	Vehicle Registration numbers from Tanzania Revenue Authority (TRA)
Emissions	for different drive train types for 3 wheelers - Daily kilometres driven, if appropriate distinct by engine types - Electric energy mix (carbon based, hydro, solar etc.) and resulting emissions	- Czeh (2019) - For ICE Goletz/Ehebrecht (2020), for electric t.b.d in the project - Ministry of Energy, TANESCO (official reports)
Economic effects/ impacts	- Comparison of revenue figures such as daily average income of 3w-drivers, using a) ICE b) electric engine - Business models and market structure: institutional economic analysis and associated economic benefits	- a) Czeh (2019) & Ehebrecht (2018), b) internal analysis empirical study - project internal analysis, empirical study & field work
Impact on Accessibility	- Impact on SDG 11.2: Accessibility to PT - optional: What is the impact on the accessibility for the population to reach certain locations (t.b.d) Accessibility analysis using UrMoAc (provided by DLR in WP 1 toolbox), requiring data wise input information on: - Population information - Routable road network & information on modes - Locations	- Population: Census 2012 + projections, or DLR WSF 2015 or National Bureau of Statistics - Routable road network: OSM or similar - Public transport network (GTFS data for BRT) - optional: Locations: OSM or similar
Integration and MaaS App	- Information on overall number of trips using electric 3-wheelers - Information an overall trips with electric 3-wheelers using the MaaS App	- Internal Data from MaaS App, DART

Baseline scenario

Existing trends in passenger/freight transport

The need to provide public transport in Dar es Salaam grew as the city outgrew the colonial structure built by the Germans, and then the British, which now corresponds to the city centre. As distances increased within the city, so did rates of private motorisation. Thus the predominance of the private car over other modes of transport, already apparent in 1979, became acute in the decades since, and today Dar es Salaam is notorious for its constant traffic jams. However, the majority of people in Dar es Salaam do not travel by car. 42.9 percent of people travel by bus and about 10.5 per cent walk. They all share the same road network.

Road transport remains the main means of transport in the city of Dar es Salaam. The share of walking and public transport use is 86% among all travel modes in DSM. By trip purpose and by travel mode, use of BRT to work is 4%, or 280,000 trips per day. by travel mode, use of BRT to work is 4%, or 280,000 trips per day. BRT started its operation in 2016 and already provides a versatile transport system in DSM. Private cars contribute about 8% to the existing transport modes. Improved public transport will definitely have an impact on other modes of transport as many people will leave their cars at home. Depending on the affordability of the bus fares, the walking category will also decline.

According to the transport survey conducted in 2017, total trip generation is 8.7 million per day in DSM. Compared to the traffic survey conducted in 2007, it is more than a tripling increase. While the population growth rate increased by 1.9 times in the last decade, traffic demand increased more than the speed of population growth rate. Accompanied by the economic growth in DSM, car ownership also increased by 2.4 times compared to the previous survey. Trips generated in Dar es Salaam city are basically for work, school, shopping and social activities like visiting relatives.

The Dar es Salaam Transport Master Plan is silent on 2 and 3 wheelers as means of transport, yet it advocates for introducing flexible transport systems responding to additional traffic demand. It also has a target of flexible supply responding to transport demand change and fluctuation.

However, the Dar es Salaam City Master Plan states, one percent of the Dar es Salaam City population work in their neighbourhoods within a range of 500 metres. It further elaborate; the modes of transport used in the city include the private car, public transport, motorcycle, Bajaj, bicycle, walking and others. Private cars, motorcycles and Bajaj modes of transport contribute about 11.05 per cent, 16.75 per cent and 13.27 per cent respectively.

Most residents use non-motorized means of transport by walking or cycling to work. Some do use motorbikes and motor tricycle-bikes (Bajaj). A large proportion of workers (62 percent) live at a distance to workplaces located 1-2 kilometres from their workplaces. They mainly travel to work using mini-buses (Daladalas or bus rapid transit). About 10 per cent travel more than 10 kilometres to work.

Baseline values

Demand forecast from JICA analysis:
According to the Transport Master Plan,in 2040, it is projected that the number of trips generated will be 19.2 millions trips(per weekday) which is more than 2 times of the trips made in 2017. Based on results of sub-centres and the satellite cities,it is projected that the share of the city center trips to the entire city will also fall from 19% in 2017 to 12% in 2040.
Private car tips will decrease with improved public transport, if nothing will be done the share of cars and motorcycles will increase up to 14.3%.
Again, it is estimated that the railway passengers will increase from 42,000 to 55,000 per hour per direction(DHPDDP) at peak hour if the Master plan will be realized.
ALong that, the Bus Rapid Transit passenger will increase from 14,000 to 26,000 per hour per direction at peak hour.

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