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Original Article

Integrated Transportation Case: Planning of Future Transport Infrastructure/Connectivity In Dar es Salaam

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ABSTRACT

Urbanization poses significant challenges to transportation systems in rapidly growing cities like Dar es Salaam. This paper examines the potential of Bus Rapid Transit (BRT) and Intelligent Transport Systems (ITS) to address transportation issues in the Ilala municipality. Despite ongoing infrastructure projects, the city lacks a comprehensive master plan to support its projected growth. The research underscores the importance of integrating infrastructure improvements and ITS to optimize the BRT system in Ilala. The study begins with an analysis of the current transportation landscape, highlighting deficiencies in road networks and public transportation that lead to severe congestion and unreliable commutes. Key stakeholders are identified, and the necessity of their involvement in transportation planning is emphasized. The research questions focus on enhancing stakeholder engagement, integrating ITS, and improving road infrastructure design. A mixed-methods approach is employed, including literature reviews, case studies of successful BRT implementations worldwide, and primary data collection through interviews, surveys, and focus groups with various stakeholders. This comprehensive approach provides actionable insights for enhancing urban mobility in Ilala. Future recommendations include upgrading the BRT system to a Level 3 configuration, incorporating elevated BRT sections to separate bus lanes from other traffic, and optimizing the design of lanes, stations, and vehicles to improve efficiency. Additionally, the paper discusses the potential benefits of a well-implemented ITS, providing real-time information to commuters and enhancing overall transportation experience. By addressing these challenges, the research aims to improve the quality of life for Dar es Salaam residents, stimulate economic growth, and contribute to a more sustainable urban environment. The findings and recommendations offer a strategic framework for future transportation planning in Ilala and beyond.

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INTRODUCTION

Urbanization poses significant challenges to transportation systems in many large cities worldwide, impacting economic growth, social development, and overall quality of life. Among these cities, Dar es Salaam, Tanzania's principal economic and governmental hub, grapples with pressing transportation issues stemming from rapid urban expansion, burgeoning private vehicle ownership, congestion, and inadequate public transportation infrastructure. This paper delves into the planning and improvement of transportation infrastructure in Dar es Salaam, with a particular focus on the pivotal Ilala municipality (World Bank Group, 2022).

Dar es Salaam stands out within Tanzania due to its disproportionate concentration of trade, services, and manufacturing, attracting a significant portion of the country's workforce (African Development Bank Group, 2014). Despite housing only 10% of Tanzania's population, the city serves as a primary source of employment for nearly half of the nation's populace (Todd et al., 2019). However, the city's mobility infrastructure faces numerous challenges, characterized by insufficient road networks, deficient public transportation systems, and severe congestion issues, exacerbating as urbanization persists (Bonsu, 2023).

Notably, mobility is fundamental for urban residents in sub-Saharan Africa, closely intertwined with livelihoods. Nevertheless, Dar es Salaam grapples with an underdeveloped transportation infrastructure, hampering accessibility and exacerbating travel times and reliability issues for commuters (Rodriguez et al., 2017). Although the government has initiated efforts to enhance the Bus Rapid Transit (BRT) system—a leading transport solution lauded for its efficiency—the city's local roads remain in poor condition, contributing to congestion and hindering overall accessibility.

The Ilala municipality, as the most densely populated district and the epicenter of governmental and business activities, emerges as a focal point for transportation improvement initiatives (Smith et al., 2015). Despite ongoing road network expansions in phase 3, solely focusing on increasing road capacity may not address the city's multifaceted transportation challenges comprehensively (Ilala Municipal Council, 2017). Hence, this research aims to shape future infrastructure projects in Ilala, integrating BRT systems and Intelligent Transportation Solutions (ITS) to enhance accessibility, efficiency, and stakeholder engagement (Hermoso, 2022).

The overarching problem lies in the lack of high-quality infrastructure for both motorized and non-motorized transport in Dar es Salaam (Matey et al., 2017). This deficiency impedes access to public transportation networks and exacerbates congestion, resulting in prolonged and unreliable commutes for a significant portion of the population (Mkalawa & Haixiao, 2014). Moreover, the absence of reliable transportation data further compounds these issues, hindering informed decision-making for both commuters and businesses.

To address these challenges, this paper sets forth several research objectives, including improving stakeholder involvement, integrating ITS systems,

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and enhancing road infrastructure design within the Ilala municipality (Mushule, 2010). By answering specific research questions related to stakeholder engagement, ITS integration, and road infrastructure enhancement, this study aims to provide actionable insights for future transportation planning and development (Masaoe, 2017).

The significance of this study extends beyond Ilala municipality to the broader context of Dar es Salaam and its inhabitants (Kasanda, 2014). By improving transport infrastructure and ITS systems, this research seeks to alleviate mobility challenges, enhance the quality of life, and stimulate economic growth within the city (Robert Kiunsi, 2013). Moreover, by reducing BRT travel times, increasing reliability, and improving infrastructure design, this study endeavors to optimize transportation efficiency and customer satisfaction, ultimately contributing to a more sustainable and resilient urban environment in Dar es Salaam (Sheuya & Burra, 2016).

The first step in this study will be to determine the present transport challenges that Dar es Salaam is facing by examining the collected information and analyzing the secondary data found in the literature. The objective of this research is to show how Transport Infrastructure, Intelligent Transport Systems, and Stakeholder involvement can be ameliorated in other to improve the BRT transport infrastructure of the Ilala municipality in the future. This directly brought us to our general research question, which is How can improving Transport Infrastructure, Intelligent Transport Systems, and Stakeholder involvement improve the BRT transport infrastructure of the Ilala municipality in the future? The study seeks to:- Bring out the project's potential stakeholders and how improving these stakeholder involvement procedures can help improve the BRT transport infrastructure in the Ilala district in the future. Show how the inclusion of an up-to-date adapted ITS system(s) in Ilala can improve the BRT transport infrastructural designs in Ilala district in the future. Show how the design and quality of the road infrastructure in Ilala district can be improved to ease BRT movement in the future and also to reduce travel time and increase transport flexibility.

This paper serves as a comprehensive exploration of the transportation landscape in Dar es Salaam (Peter & Yang, 2019), with a focus on the transformative potential of infrastructure improvements and stakeholder engagement strategies in shaping the future of urban mobility in the region.

METHODOLOGY

This study explores the enhancement of Bus Rapid Transit infrastructure in Ilala municipality, Dar es Salaam, Tanzania, addressing urbanization challenges such as traffic congestion and inadequate public transportation. The research employed a mixed-methods approach, beginning with an exploratory phase that included comprehensive literature reviews and case studies of successful BRT implementations worldwide, synthesizing key lessons and best practices.

A descriptive study followed, analyzing the current transportation landscape in Ilala municipality. This phase involved examining traffic patterns, commuting behaviors, and infrastructure deficiencies to establish a baseline understanding of existing challenges and opportunities for improvement through BRT and Intelligent Transport Systems.

The study utilized a quasi-experimental design to assess the feasibility and effectiveness of proposed BRT and ITS solutions. Simulations and pilot studies were conducted to evaluate potential impacts, considering practicality and benefits for enhancing urban mobility.

Primary data collection involved structured interviews, surveys, and focus groups with a diverse range of stakeholders, including government officials, transport operators, commuters, residents, and businesses. This approach gathered comprehensive perspectives on transportation issues, preferences, and expectations. Secondary data sources, such as governmental reports and statistical databases,

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complemented primary findings, providing contextual background and facilitating comparative analysis.

Qualitative analysis of interview and focus group data identified recurring themes, challenges, and stakeholder perceptions. Quantitative analysis of survey data quantified commuting patterns, traffic volumes, economic impacts, and other measurable factors. Findings were visually presented through charts, graphs, maps, and qualitative excerpts to illustrate data trends, spatial distributions, and stakeholder sentiments.

Throughout the research process, ethical considerations ensured informed consent, confidentiality of participant data, and respectful engagement with stakeholders. This comprehensive methodology aimed to provide actionable insights and recommendations for enhancing urban mobility and transportation infrastructure in Ilala municipality and beyond.

FUTURE TRANSPORT INFRASTRUCTURE & INTELLIGENT SOLUTION IN TRANSPORTATION FOR DAR ES SALAAM

Future Bus Rapid Transit (BRT) Design for Ilala

Studies should be conducted, and infrastructure design for BRT should be studied by various experts and employ road construction and urban planning consultants (Akbar, 2020). Some of the characteristics of the drawings should include the following:

- BRT lanes should be proposed along different lines.
- BRT stations should be proposed near intersections with pedestrian bridges that can be accessed from all corners of the intersections.
- BRT lanes should be located along the curbside along the narrow roads.
- Right door BRT should be assumed, but left door BRT should be proposed at some sections.
- The solution to traffic conflict between U-turn and BRT lanes should be shown.

BRT Levels

There are a number of variations for BRT, and the boundary between BRT and conventional bus services is not clear as far as the physical appearance is concerned. A typical BRT is the bus transit service on exclusive lanes in road spaces.

As defined in Private/Public Partnership based Environmentally- friendly Public Transport System For Karachi (2006), there are three levels of BRT system commonly used for the classification of BRT.

- Level 1 Bus Lane
- Level 2 Busway
- Level 3 BRT

The Level-1 system usually provides a bus lane along the curbside. The bus lane is sometimes a priority lane which gives priority to using the lanes to buses, but other vehicles can use the lanes when the bus traffic is not heavy, and other times an exclusive lane (Akbar, 2020). In the case that this system is introduced in the urban street system where access demand along the roadside exists and there are intersections with crossing streets, the bus lanes are easily interrupted by other vehicles.

Figure 1 Seoul (Level 2) (Xu, 2014)

To avoid interweaves of buses and other traffic, bus lanes are located in the center of roads in Level 2 systems. The Busway system is usually a part of the network of general bus services. The improvement of bus services through the introduction of this system would be insufficient in case there are a number of operators (like

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Karachi) that are allowed to use the busway by many operators. The BRT systems in Seoul and Taipei are examples of this system.

Figure 2: Lima (Level 2) (The Observer Newspaper, March 11, 2018)

The Level 3 system is similar to the railway system. In most cases, buses are only operated on the dedicated lanes controlled by a single operator along the lanes. Since the BRT buses need not run on general traffic roads, advanced vehicle technologies can be used to increase capacity and speed. In addition, pre-board fare collection reduces dwell time at bus stations.

Metrobus (Istanbul) is an example of BRT of Level 3. Note that Level 3 does not necessarily mean a high-capacity system. For example, TransJakarta (Jakarta) is categorized as a Level 3 system, but the capacity is very small.

Figure 4: Jakarta (Level 3) (LiveJournal, May 12, 2012)

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TransMillenio (Bogota) is quite different from other BRTs in terms of capacity, speed, and quality. It is classified as "Full BRT". Therefore, we recommend the future BRT in Ilala, DES, be entirely upgraded to level 3, taking into account the different stakeholders and the financial budget (Burgess & Ordiz, 2010).

Figure 5: Istanbul (Level 3) (Di Pasquale et al., 2016)

Figure 7 shows the cross-section of a standard BRT as being 33 meters, and this space is available for most roads in Ilala. The road reserve in Tanzania is 90 meters (Building et al., 2012). So it will make the upgrade work easily and cheaply since there will be no need for land compensations.

Elevated BRT

To separate buses from other traffic, the future BRT of Dar es Salaam should cater to a section of elevated BRT. Since the low-cost urban transport system is the basic concept of BRT, it is not popular to use elevated structures, although elevated structures can segregate bus lanes completely from mixed traffic. The examples of elevated BRT are:

- Nagoya (Japan) introduced the "guideway" bus in 2001, having a 6.5km elevated section.
- Nagoya City subsidized 85 % of the cost of the infrastructure.
- Expresso Tiradentes is the elevated BRT system in Sao Paulo (Brazil), which was put into service in 2007 with a length of 8.5km.
- Xiamen (China) BRT is an elevated BRT system with three lines in a total length of 67.4km. The system was put into service in 2008.

The stations of these systems should be similar to that of elevated railway systems. A higher operational speed can be achieved compared to at-grade BRT systems because the intersection delay does not exist along the elevated section. However, the capacity of these systems is not necessarily high because passing lanes are not provided. As illustrated in *Figure 7*, there's enough space to apply this solution in Dar es Salaam. *Figure 6* shows Malaysia's first elevated BRT in Bandar Sunway, Subang. Similarly to Dar es Salaam, this practice can also be applied to DART in Ilala Municipality and Dar es Salaam at large.

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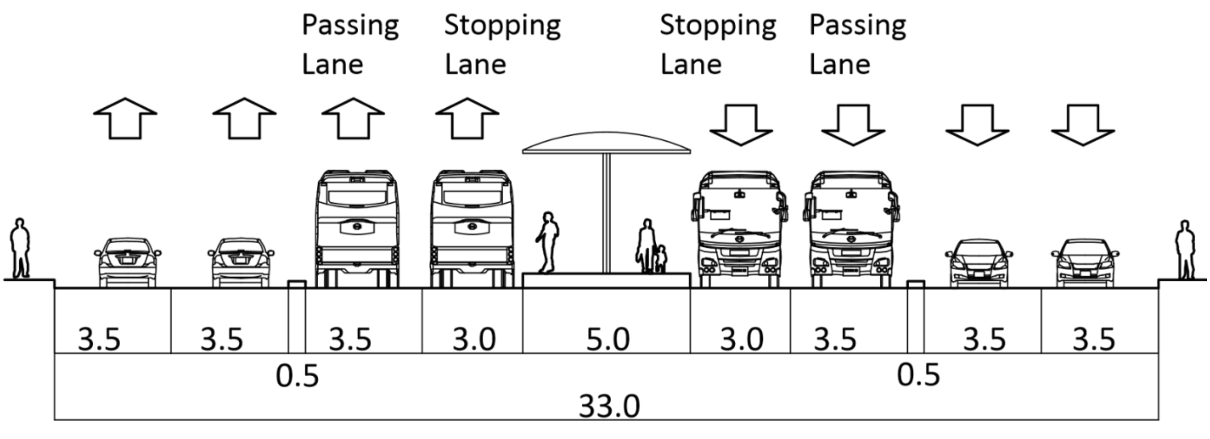
Figure 6: A 3D illustration of Malaysia's first elevated section of the BRT System in Bandar Sunway, Subang (Sunway City, 2014)

Future Configuration of Lanes, Station, and Vehicle

A typical BRT has stations between the exclusive lanes for both directions in the median of the road, and buses run in the same direction as other lanes. In this case, doors of boarding and alighting should be equipped on the right side of the vehicle, and due to this, existing buses cannot use BRT lanes. As an alternative, stations are provided on both sides of bus-exclusive lanes in the median, but this requires a wider width of the road. Providing lanes in opposite directions is also an alternative. Installing exclusive bus lanes along curbsides is also another alternative. *Figure 7* shows alternatives of the cross-section at a station in case of a 33 m width road (excluding sidewalk).

Figure 7: Cross-Section Alternative (Nippon Koei Co. & Yachiyo Engineering Co., 2012b).



Distance between Stations

Commercial speeds of BRT depend on the number of stations because buses need to spend time at each station for boarding and alighting. The longer the distance between stations, the faster the commercial speed of BRT. On the other hand, walking distance becomes longer if the distance between stations is longer. For passengers, total travel time is the sum of walking time, waiting time for a bus, and onboard time. There will be

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an optimum distance that minimizes the total passenger hours. In general, the optimum distance between stations is approximately 500 m considering the standard BRT systems in the world (Nippon Koei Co. & Yachiyo Engineering Co., 2012a).

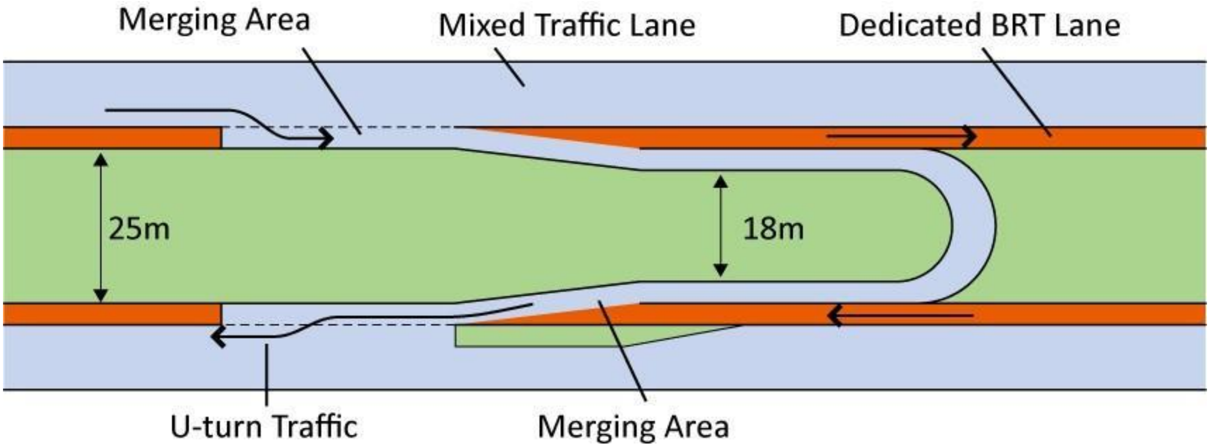
Although a better transport system usually increases the acceptable walking distance, there will be a maximum limit. Considering the law and order situation in DES, we propose walking distance should be as short as possible.

Solving the Problem of U-Turn Traffic along BRT Corridor

Since BRT lanes in Ilala are proposed in the center of roads, the crossing of BRT traffic and U-turn traffic will occur. To avoid the delay from the conflict between BRT and U-turn traffic, three alternatives should be considered. One is a grade separation of BRT lanes and U-turn lanes. In this case, BRT lanes will be constructed as flyovers because they can make use of the median area for new structures, while U-turn flyovers use the present carriageway for the structure (Nippon Koei Co. & Yachiyo Engineering Co., 2012b).

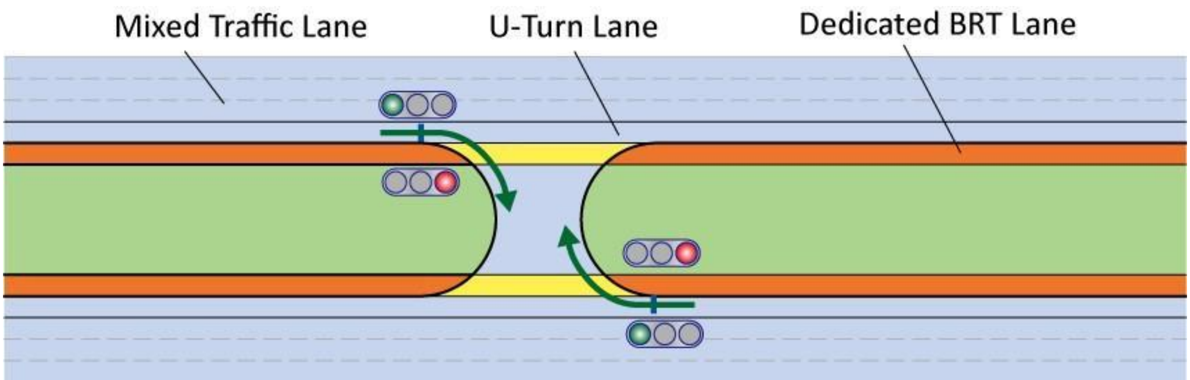
The second alternative is BRT lanes outside of U-turn lanes, as shown in *Figure 8*. There are merging areas of BRT lanes and U-turn lanes. In this case, the risk of traffic accidents becomes high if express bus services are introduced.

Figure 8: U-turn traffic and BRT lanes (Sharma et al., 2012)



The third alternative is installing traffic signals at U-turn locations, as shown in *Figure 9*. U-turn traffic and BRT traffic are separated by traffic signals. In mixed traffic lanes, U-turn lanes should be separated from straight traffic near the U-turn section so that the U-turn traffic can smoothly exit the U-turn area(ibid.).

Figure 9: U-turn traffic and BRT lanes (Sharma et al., 2012)



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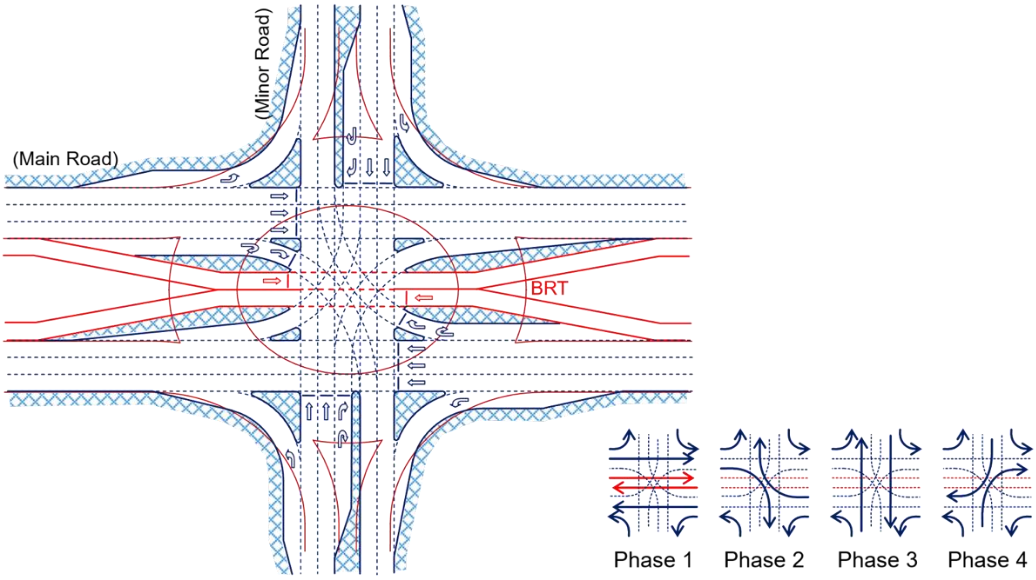
Roundabout Design

Roundabouts should be converted to standard 4-leg signalized intersections in principle. In case signalization is difficult due to the existence of monuments or fountains, traffic signals should be installed at the roundabout(ibid.).

Figure 10 shows the configuration of the basic type of a four-leg intersection based on signal control and fully channelized, covering all traffic movements from all four legs. A dual-direction busway is built into this intersection, located at the center of the main road next to the right-turn lane. A four-phase signal control, as given in *Figure 10*, is required to allow all traffic movements. The BRT bus will be given green time concurrent with the through traffic on the main road(ibid.).

Figure 10: Four-Leg Channelized Intersection (Lv et al., 2023)



Control of Right Turn Traffic

Right-turning vehicles will cause substantial delays through traffic and thus diminish the effectiveness of intersections. Therefore, it is believed beneficial, and so right-turn movements should be prohibited to relieve the traffic burden of the intersection and instead guide them to neighboring U-turns and intersections after passing through the intersection to reach their destinations by alternative routes. However, this indirect right-turn maneuver has disadvantages as well, such as fuel consumption will increase with unnecessary travel, and the additional U-turn and left-turn traffic will affect the operation of neighboring roads and intersections(ibid.).

It is generally desirable that right turns should be allowed as near as practical to the point at which drivers desire to turn right. It is proposed that U-turns should be removed from main roads, and instead, a large green time should be given to the right-turn traffic from the main roads at the intersections. In contrast, the right-turn traffic from minor roads should be prohibited to give green time to the main road, where BRT buses run. This right-turn control, as shown in *Figure 11*, BRT buses need not stop between intersections except at station stops, and the four signal phases of the intersection should be reduced to three phases by eliminating phase 4 (ibid.).

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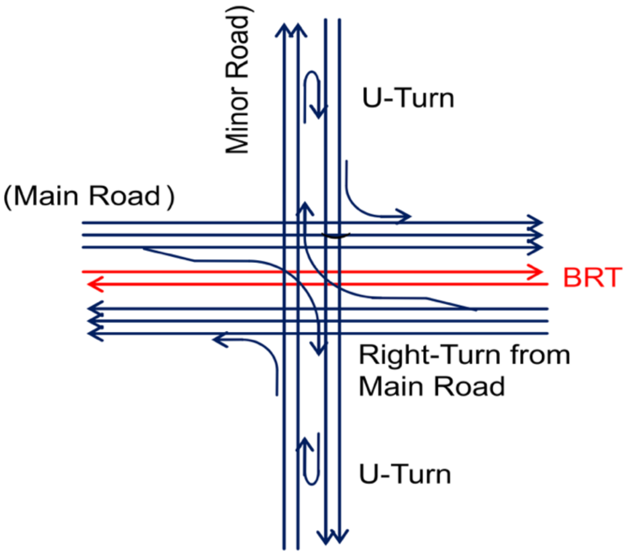
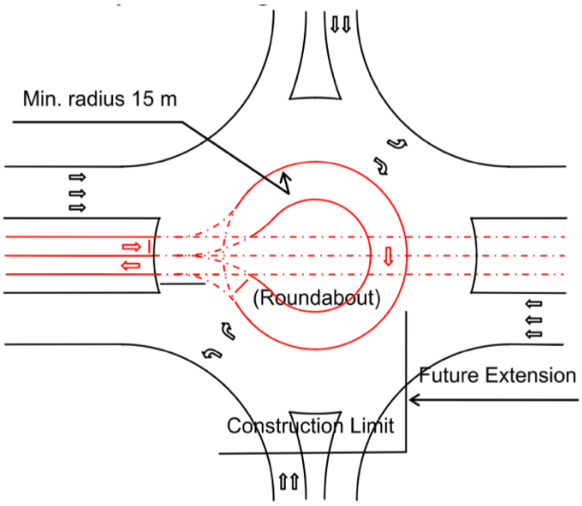
Figure 11: Elimination of Right-Turn Traffic from Minor Road (Siromaskul, 2022).



Design of BRT U-Turn Facility

The BRT U-turn facility is required at both ends of a BRT corridor and possibly at the middle point to turn the travel direction of buses. The design of bus U-turn facilities proposed here is only for bus-turning operations but does not consider station function(ibid.). At the end of a corridor in a suburb, buses can turn easily at an existing roundabout intersection, as shown in *Figure 12*.

Figure 12: At-Grade BRT Bus U-Turn (Siromaskul, 2022)



Speed

Experiences from throughout the world indicate that BRT is not always a high-speed system. While Transmillenio travels at about 30 km/h, the typical commercial speed of a conventional BRT in Dar es Salaam is about 20 km/h, ranging from 15 to 25 km/h. A typical BRT is anticipated to be able to travel at speeds between 25 and 30 km/h. The distance between stations, the number of junctions that must be traversed, and the amount of time spent at stations all affect the commercial speed. The maximum speed of a BRT without stopping at stations would be roughly 30–40 km/h, depending on the signal pashing given to BRT lanes due to the delay at crossings. As a result of the station stops, the speed would drop to 20 to 30 km/h (Nippon Koei Co. et al., 2012).

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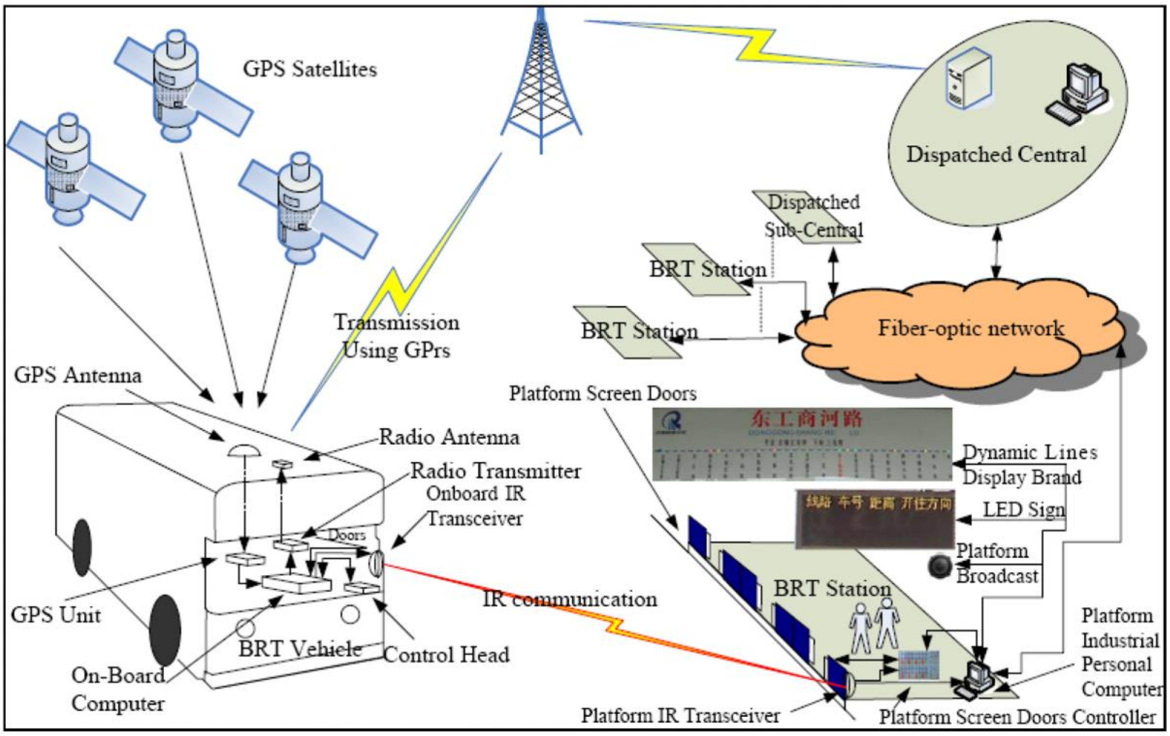
Since the average speed of existing mini buses in DES is approximately 8.5 km/h, the speed of 20km/h will produce a very small benefit from travel time-saving. Therefore, DES must design proper BRT plans to achieve higher commercial speed.

Real-Time Information System for Future DART.

Modern BRT buses require more sophisticated methods in their operations. Challenges that passengers experience from commuting with BRT buses are due to reliance on manual procedures. For instance, queues during ticket booking can be resolved by the replacement of technology that can allow passengers to book a ticket at a distance using mobile smartphones (Alfred, 2020).

Using LED signs at stations, broadcasting announcements, or even a mobile application in the future that will assist passengers in getting real-time transit information such as bus arrival time, location, and speed of the buses can all help relieve overcrowding in stations or terminals. Knowing the bus arrival time may help passengers to arrive at the station with the assurance of the time at which the bus has to arrive and hence avoid unnecessarily long waiting for buses in bus terminals.

Figure 13: Architecture of the upgrade system for BRT in Ji'nan (Zhou & Gao, 2010)



The BRT upgrading system in Jinan is the best illustration of how this system works. Buses have computers that continuously determine their location by scanning satellites, and every 20 seconds, these computers use the GPRS network to send this information back to Dispatched Central (DC) computers (Zhou & Gao, 2010). In order to monitor operating buses, the central computers verify it and compare it to the GIS map. Additionally, it is sent every 20 seconds via the optical fiber connection network to the BRT stations.

Every BRT station's Industrial Personal Computer (IPC) gets the bus AVL datum and broadcasts it using at-stop technology such as LED signs, Dynamic Route Display Brands, and broadcasting equipment. The next two buses that will pass the stations in succession are listed on each at-stop LED sign, along with their route and destination. Additionally, the audio system will automatically announce the arrival time of the following bus,

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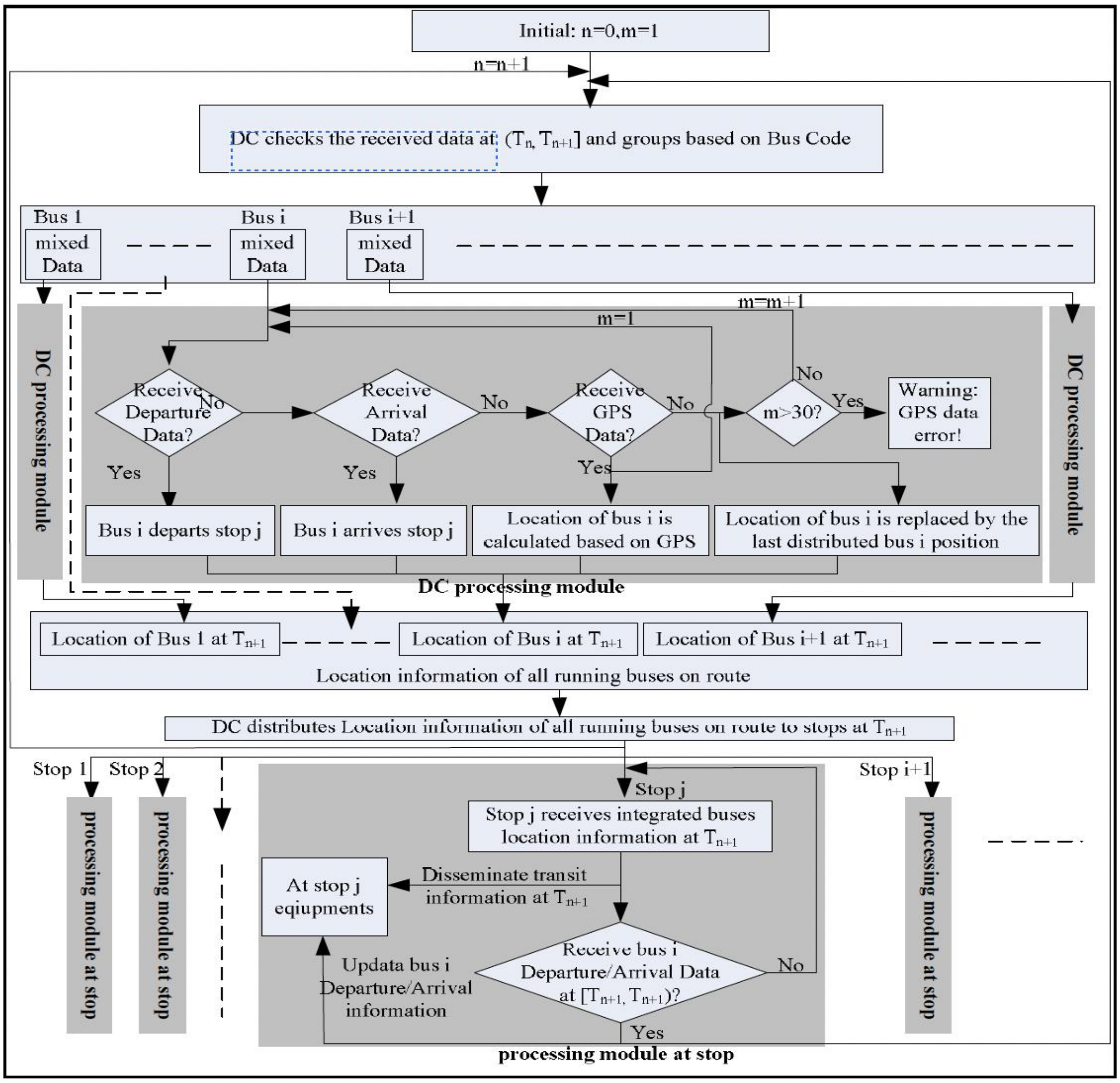
such as "To Quan'fu Overpass BRT Line 1 will be arriving, please passengers prepare for boarding"(ibid.).

The Dynamic Route Represent Brand (DRDB) is a sophisticated, intelligent technology that uses flashing yellow, red, and green lights to dynamically display the locations of all buses that are currently in motion at a station. Bus locations have two states: off stop, which is indicated by a yellowing light whether the vehicle has passed or not; and at the stop, which is indicated by red and green lights; the red light shows that the bus has passed the station, and the green light indicates that the bus has not yet left the station or arrived. Additionally, knowing how many buses will arrive and how far each bus is from the station is highly helpful information for commuters.

A DRDB is displayed on a wall at the Donggongshanghe station, and it reveals that nine vehicles are operating on the entire BRT Line 1 from Huang'gang to Quan'fu Overpass, four of which are off the station as indicated by a yellow light, two of which are at the station and have passed it as indicated by a red light, and three of which are at the station but have not yet arrived or left as indicated by a green light(ibid.).

Figure 14: Data processing flow in the upgrade system (Zhou & Gao, 2010).



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The proposed solution for DART is to enable a real-time information system for future DART in Dar es Salaam that will significantly upgrade the commuter's experience and comfort, reducing waiting time and overcrowding at stations by providing this real-time data update through LED signs, broadcasting announcements at stations and also through a mobile application for smartphone users.

Stakeholder Involvement

Stakeholder involvement is a critical aspect of any project, initiative, or policy, particularly in the realm of transportation infrastructure development (Karlsen, 2002). In the context of improving the transportation infrastructure in Dar es Salaam, Tanzania, various stakeholders play pivotal roles in shaping the project's outcomes and ensuring its success (International Business Publication, 2011). These stakeholders can be broadly categorized into internal and external groups, each with distinct interests, responsibilities, and impacts on the project.

Internal Stakeholders:

Tanzanian Government: As the primary authority overseeing infrastructure development and governance, the Tanzanian government holds significant influence over transportation projects in Dar es Salaam. Through legislative frameworks, such as the Constitution and various acts related to land acquisition and urban planning, the government provides the legal and regulatory framework for infrastructure initiatives. Additionally, government agencies like TANROADS (Tanzania National Roads Agency) are directly involved in project implementation, funding, and management (Smith et al., 2015).

TANROADS Regional Agency: TANROADS, operating under the Ministry of Works and Transport, is tasked with developing, maintaining, and managing the trunk and regional road networks (Mativila, 2021). With its extensive infrastructure portfolio and workforce, TANROADS plays a crucial role in executing road projects, including the construction and maintenance of roads and highways in Dar es Salaam (TANROADS, 2022).

Ilala Municipal Council: As the local administrative body responsible for Ilala municipality, the council plays a key role in coordinating and facilitating infrastructure projects within its jurisdiction. From urban planning and land management to service delivery and stakeholder engagement, the municipal council serves as a vital link between the government, communities, and other stakeholders.

Citizens of Ilala Municipality: The residents and businesses within Ilala Municipality are directly impacted by transportation infrastructure projects. They are both beneficiaries and stakeholders in such initiatives, experiencing the benefits of improved mobility while also facing potential disruptions and challenges during the construction and implementation phases.

External Stakeholders:

World Bank: As an external stakeholder and funding partner, the World Bank plays a significant role in providing financial support, technical expertise, and policy guidance for transportation projects in Dar es Salaam. Through its various institutions, including the International Bank for Reconstruction and Development (IBRD) and the International Development Association (IDA), the World Bank supports initiatives aimed at reducing poverty, promoting shared prosperity, and advancing sustainable development.

Effective stakeholder involvement requires proactive engagement, communication, and collaboration among all parties throughout the project lifecycle. This entails identifying stakeholders' interests, concerns, and expectations, as well as incorporating their feedback into project planning, decision-making, and implementation processes. By fostering inclusive and transparent stakeholder engagement, transportation projects can achieve greater buy-in, legitimacy, and ultimately, success

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in addressing the mobility needs and challenges facing Dar es Salaam and its residents.

ACTION PLAN AND FEASIBILITY

Land acquisition will be necessary for improving DART; there are various social and economic activities in the location where the BRT will pass, necessitating DART's compensation for individuals impacted and assurance that the project won't negatively affect those impacted by forcible resettlement (International Finance Corporation, 2021).

The following project activities will influence resettlement due to the development and improvement of the DART project:

- Upgrading and improvement of Dart Road
- Construction of Fly-over
- Turning Radiuses
- Upgrade bus stations
- Provide the link to connect DART with feeder stations
- Construction of walkways
- Unforeseen impact

Compensation for Damage to other Utilities within the Project Area

Utilities and other infrastructures need to be moved to complete the proposed improvement of Bus Rapid Transit; institutions that own the utility will need compensation from the project developer for any harm or relocation caused by the project developer (Hill & Lindner, 2010).

Budget

The law will cover the total compensation costs in the construction of BRT in Dar; expertise and property valuation will be conducted by experts so that the affected population interacts during all stages of the project implementation. The meeting will be organized and led by the government. Municipal levels to educate stakeholders about the project, its effects, the methods used to alleviate them, and how they will benefit and be compensated for their property.

Limitations

The feasibility of upgrading and improving Bus rapid transit requires a deep study; this research was based on secondary data. The technical study and cost feasibility are not discussed in this report. Dar es Salaam's financial capacity was not taken into consideration when developing the proposed solutions. Time constraint was a challenge in conducting a deep study for this paper. Not enough updated information about Dar es Salaam could be found to build up this report.

Recommendations

For achieving transportation connectivity in Ilala municipality in DES, the following recommendations are made considering the results of this project.

Recommendation for Planners

Considering the available space for BRT in the road network in Ilala and the difficulty of institutional reform, the following BRT scheme is proposed. Busways should be developed in the center of the road to ensure speed. Fare collection should be provided for the stable operation of BRT as buses should be reasonable, and significant intersections should be signalized to avoid the conflict of BRT traffic with right-turn and U-turn traffic. Existing buses providing reasonable fares for low-income people should remain for some years; therefore, transport fares should be set at a sustainable level. To do this, planners should consider the minimum wage in Tanzania and GDP per capita in planning a fair and affordable fare collection system. To establish a world-class intelligent transportation system, planners should ensure that the proposed intelligent systems are installed and maintained to have sustainable transport connectivity in Ilala, Dar es Salaam.

Recommendations for Policymakers & Stakeholders

Significant investment is required, particularly in developing proper BRT system facilities. The

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national government's financial support can be beneficial. The city should invest in BRT infrastructure to address sustainable transportation concerns and perceptions of safety; this will necessitate the creation of a network of BRT lanes of high quality, as described in our solutions. Improved connectivity may encourage more people to use public transport, significantly mitigating the congestion and easy, rapid movement of people to their businesses. The government cannot achieve this project alone; other stakeholders are recommended to be flexible in financial investment. A law about mass transit development should be enacted so that the transit authority can take necessary actions without legal challenges.

RESULTS AND DISCUSSION

Results

Transportation challenges in Dar es Salaam: The study identified several key transportation challenges in Dar es Salaam, particularly in the Ilala municipality. These include severe traffic congestion, inadequate public transportation infrastructure, and limited stakeholder involvement. Traffic patterns and commuting behaviors were analyzed, revealing significant bottlenecks and inefficiencies in the current system. The analysis indicated that improving the BRT infrastructure could alleviate many of these issues by providing a more reliable and efficient mode of transport.

Stakeholder involvement and ITS integration: A significant finding of the study is the importance of stakeholder involvement and the integration of Intelligent Transport Systems (ITS). The primary data collected through interviews and focus groups highlighted the need for better communication and collaboration among government officials, transport operators, commuters, and residents. The study found that stakeholder engagement is crucial for the successful implementation of BRT systems. Furthermore, the incorporation of ITS, such as real-time information systems and adaptive traffic control, was shown to enhance the efficiency and user satisfaction of the BRT system.

Economic and social impacts: The implementation of a robust BRT system is projected to have substantial economic and social benefits. By reducing travel times and improving accessibility, the BRT system can boost local businesses and enhance access to education and healthcare services. The study's simulations and pilot studies demonstrated that the proposed BRT and ITS solutions could significantly improve urban mobility, leading to increased economic activity and improved quality of life for residents.

Discussion

Effectiveness of BRT systems: The case studies analyzed in this research, such as those of Curitiba and Bogotá, support the effectiveness of BRT systems in diverse urban settings. These systems have been successful in increasing ridership and promoting economic growth. The findings from Dar es Salaam are consistent with these global examples, indicating that a well-implemented BRT system can transform urban transportation dynamics.

Challenges and recommendations: Despite the potential benefits, the study also identified several challenges. Land acquisition and resettlement emerged as significant issues, with potential socio-economic impacts on affected communities. The study recommends comprehensive planning and stakeholder engagement to address these challenges effectively. Additionally, securing financial investment for the development and maintenance of BRT infrastructure remains a critical concern. The study suggests that a combination of government funding and private sector investment will be necessary to achieve sustainable development of the BRT system.

Policy implications: The findings underscore the need for supportive policies and regulatory frameworks to facilitate the development of BRT systems. Policymakers should focus on creating an enabling environment for investment, ensuring fair compensation for affected individuals, and establishing clear guidelines for the integration of ITS. The study also highlights the importance of setting affordable and sustainable fare systems to encourage public adoption of the BRT.

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Future research: The study opens several avenues for future research. One area is the long-term socio-economic impacts of BRT systems on urban development. Another important aspect is the exploration of innovative technologies and their integration into urban transport systems. Future studies could also investigate the scalability of BRT solutions in other Tanzanian cities and similar urban contexts in developing countries.

CONCLUSIONS, RECOMMENDATIONS AND LIMITATIONS

The study examined the transportation challenges in Dar es Salaam, specifically within the Ilala municipality, with an emphasis on enhancing the Bus Rapid Transit (BRT) system through improved infrastructure, the integration of Intelligent Transport Systems (ITS), and increased stakeholder involvement.

The findings indicate that:

Infrastructure deficiencies: The current road networks in Ilala are insufficient to handle the demands of urbanization. The poor road conditions and lack of dedicated BRT lanes contribute significantly to traffic congestion and inefficiencies.

Benefits of ITS integration: Integrating ITS can greatly enhance the efficiency and reliability of the BRT system. Real-time information systems can better manage traffic flow, reduce travel times, and improve commuter satisfaction.

Stakeholder engagement: Effective involvement of stakeholders is crucial for the successful implementation of transportation projects. The research shows that engaging local communities, transport operators, and governmental agencies leads to better-informed decision-making and increased support for infrastructure projects.

In conclusion, addressing the transportation challenges in Ilala requires a comprehensive approach that includes improving road infrastructure, integrating advanced ITS, and fostering active stakeholder participation. These measures are essential for enhancing the BRT system's efficiency, reducing congestion, and supporting the city's economic growth.

Based on the findings, the following recommendations are proposed:

Infrastructure development: Prioritize the construction and maintenance of dedicated BRT lanes to ensure uninterrupted bus services. Implement elevated BRT sections where feasible to segregate bus traffic from general traffic and reduce delays.

ITS implementation: Deploy ITS solutions such as traffic signal prioritization for BRT buses, real-time passenger information systems, and automated fare collection to improve operational efficiency and user experience.

Stakeholder engagement: Establish a robust framework for stakeholder involvement, including regular consultations with local communities, transport operators, and government agencies. This will help address concerns, garner support, and ensure the successful implementation of BRT projects.

Policy and regulation: Develop and enforce policies that support sustainable urban transport solutions, including regulations that prioritize public transport and discourage private vehicle use in congested areas.

The study acknowledges several limitations:

Scope of study: The research focuses on the Ilala municipality, and the findings may not be fully applicable to other regions of Dar es Salaam or Tanzania.

Data availability: The study relies on both primary and secondary data, and the accuracy of findings depends on the quality and completeness of available data. Some data limitations may affect the generalizability of the results.

Implementation feasibility: The recommendations may face practical challenges during implementation, including financial constraints, political opposition, and technical difficulties. Further studies are needed to explore the feasibility of these recommendations in detail.

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Technological adoption: The integration of ITS requires significant investment and technical expertise. The readiness of the local infrastructure and workforce to adopt these technologies is a potential limitation.

Addressing these limitations in future research will help develop more comprehensive strategies to improve urban transportation in Dar es Salaam and similar urban environments.

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