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Adapting Urban Light-Rail Transport to the African Context: A Process Conducted by Transport Authorities and Chinese Rail Corporations in Addis-Ababa, Abuja, and Lagos

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Abstract: A contextual approach to Light-Rail Transport (LRT) needs to be tailored towards specific contexts, in terms of situations or contingencies, such as socio-economic and environmental factors. This research intends to discuss the societal benefits comprised of well-informed contextual factors for policymakers and urban transport authorities, to enable them to be able to formulate objective policies for a city's socio-economic development. The aim of this article is to analyze the contextual factors in three cities which are responsible for the contextualization of infrastructural innovations of urban light-rail transport from China. The methodology that has been used is a qualitative method using multiple case studies, which includes a pilot and semi-structured interview. The analysis compares the similarities and differences within Nigeria, and between Nigeria and Ethiopia. The most perceptible contextual factors which influence infrastructural innovations in Nigeria include an electric energy supply, modernization of LRT and their stations, Transit-Oriented Development (TOD), and seamless integration of LRT with other transport modes. The most conspicuous factors in Ethiopia are emergency ticket shops, seamless integration of LRT with other transport modes, and Non-Motorized Transport (NMT). Nigeria and Ethiopia both share the seamless integration of LRT with other transport modes. Therefore, academically analyzing contextual factors helps to unravel the poly-contextualization and context-specific decision-making processes in LRT implementation.

Keywords: infrastructural-innovation; innovation-adaptation; contextual-factors; poly-contextualization; urban light-rail transport; context-specific decision-making

1. Introduction

Research has shown that a contextual approach is required in the implementation processes for Light-Rail Transport (LRT). This is based on contextual factors which contend with the new innovations in LRT [1]. This method requires a tailor-made process towards its specific context, in terms of particular situations or contingencies, such as the organizational structure of the various participating firms [2], socio-economic and environmental factors, culture, procedure differences, travel demand gaps, city governance, and the technical capability gap [3–5]. The various methods of contextualization for LRT innovations from China used for adaption to the specific characteristics of Addis-Ababa, Abuja, and Lagos are key elements of this research. At the organizational level, researchers have generally defined innovation as the development or generation and adoption of new ideas or behaviors [6,7]. Organizational and process innovation [8] supports the use of a novel method to generate or commercialize products or services [9]. The idea or actions may relate to product(s), service(s), technology, system(s), or practice(s). The adoption of innovation is a process that results in the assimilation of product(s), process(s), or practice(s), because it is new to the

adopting organization [7]. In addition, using a contextual approach introduces the theory of a context-specific decision-making process, between experience-based local knowledge of local transport authorities and expert knowledge from Chinese rail corporations, which is used to adapt to practical situations at-hand, along with their demonstrated capacity for learning and imitation [10].

This research provides an academic approach to identify new contextual factors in rail transport sciences and it relates the already known factors in literature to present events during LRT implementation in the three cities. It also explicates how multi-actors are able to implement a Light-Rail Transport system using context-specific decision-making processes, despite the innumerable challenges faced due to city level contextual factors, through poly-contextualization and re-modification. An attempt has also been made to provide societal relevance benefits by making sure that policy makers and urban transport authorities are well-informed of local contextual factors, enabling them to formulate objective policies for a city's socio-economic development, which will consequently provide a sustainable LRT and satisfaction to the LRT users.

In this regard, the research aims to analyze the contextual factors in these three cities, showing who is responsible for the contextualization of infrastructural innovations of an urban Light-Rail Transport. The LRT innovations have been imported from a Chinese context, to an Addis-Ababa, Ethiopian city context, and to the Abuja and Lagos contexts in Nigeria. The importing of the LRTs was made possible with some modifications in order to suit the different contexts of these three cities.

Therefore, this article aims to answer the research question: What are the factors influencing the contextualization of infrastructural innovations in an urban Light-Rail Transport, from a Chinese context to Addis-Ababa, Abuja, and Lagos city contexts? The significance of this study can be further visualized as a case study research which incorporates practical examples of innovation management, making it possible to comprehend how and reveal the reasons why it should be done in practice in a certain way. Although a remarkable amount of empirical research has been conducted, there is still further investigation that is necessary to decipher conditions for and consequences of innovation [11].

Section one presents the introduction. Section two explains the theoretical framework, which describes the relationships between infrastructural innovation, contextual approach, and contextual factors. Section three focuses on the research method. Section four entails the empirical results and discussion. Section five contains the conclusions, added values to academic research and the transport industry, recommendations, and further research areas.

2. Theoretical Framework

This section presents the conceptual model used to describe the LRT infrastructural innovation and contextual approach based on contextual factors that have been used by multiple actors from Nigeria, Ethiopia, and China. Furthermore, the relationships are explained between contextualized infrastructural innovation, contextual factors, and the process of contextual approach by the three African cities and China. Abuja Light-Rail Department (ALRD), Lagos Metropolitan Area Transport Authority (LAMATA), and the Ethiopian Railway Corporation (ERC) were the LRT Rail Receiving Authorities (RRAs) from Abuja, Lagos, and Addis-Ababa cities, respectively. The China Railway Engineering Corporation (CREC), Shenzhen Metro Group (SMG), and the China Civil Engineering Construction Corporation (CCECC) were the Multi-National Corporations (MNCs) and Rail Providing Corporations (RPC) from China.

As seen in Figure 1, the dependent variable is contextualized infrastructural innovation and independent variable(s) are the city contextual factors. The contextualized infrastructural innovation depends on several specific city contextual factors, which were common to each city, to deliver the LRT to the cities. These were the independent variables.

Re-modification, as a process, occurred after the first phase of contextualized infrastructural innovations took place, which then needed to be re-modified at the second phase, which was based on prevailing city contextual factors. An in-depth analysis was also performed regarding the relationships between infrastructural innovation and the process of contextual approach by the multiple actors involved. Both cities in Nigeria dealt with only one Chinese corporation, namely

CCECC. ERC of Addis-Ababa city worked with two Chinese MNCs, namely CREC who dealt mainly with the light-rail construction and SMG who dealt with operations.

Contextualized infrastructural innovations were based on contextual factors, a contextual approach process involving Chinese MNCs providing the light-rail (RPC), and LRT city authorities in Nigeria and Ethiopia receiving the light-rail (Rail Receiving Authorities (RRAs)) in a collaboration to deliver LRT.

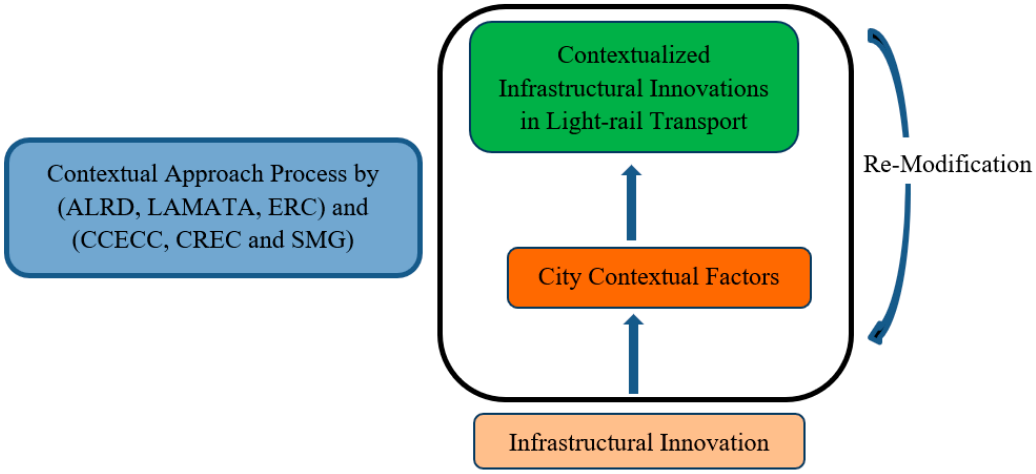

Figure 1. Concept relationships in theoretical framework

2.1. Infrastructural Innovation as a Non-Technological Innovation

Infrastructural innovation is often referred to as non-technological innovation [12]. However, infrastructural innovation in transport can be approached from technological and non-technological innovation viewpoints. This research has focused on the latter. The study of non-technological innovations has been minimally analyzed compared to the study of technological innovations. In high-tech prediction and social modification literature, many scientific papers emphasize the function of technological inventions within transport's broad spectrum [13–15], and particularly with regard to sustainable transport [16–18]. Very little has been documented regarding non-technological innovations from a sustainable transport point of view [19].

The role of institutional innovations that assist in generating public support to support the creation of extra ecological forms of transportation is also important [20]. Sustainable transport leverages non-technological innovation as a foundation to position the transport industry not only in the manufacturing sector, but in addition as a service providing industry [21]. Non-technological innovation is a significant component within organizations' infrastructure adoption actions, which together adds more value, complementing technological innovation. Non-technological innovation is mainly related to marketing and organizational innovation, which has been defined as the introduction of fresh organizational techniques or the incorporation of new marketing procedures [22], and the bottom-up effects provided by context-specific decision-making processes [10] conducted by city transport authorities and rail corporation experts, which foster frugality in time, expenses, and human resources.

Non-technological innovations are characterized into three main groups [21] for sustainable transport: pricing, infrastructure, and regulation. This research focuses only on the infrastructure innovation aspects of light-rail public transport, because they were common features in the three cities during the design and construction phases of the LRT adoption by the RRAs, while the operation phase had only commenced in Addis-Ababa during the time the research was carried out.

Infrastructural innovation is defined as supportive infrastructure, provided as components required to aid the passenger service use of public transport, such as infrastructure for multi-modal integration, park and ride, pedestrian accessibility infrastructure, public transport measures (priority, increased frequency), information provision to passengers [12], etc., thereby increasing the level of

usage of the LRT public transport. Infrastructure innovation entails the innovative availability and positioning of infrastructure, style of provision and its components, the availability of different types of information facilities, and what type(s) of method(s) or style(s) have been provided. This includes electronically provided information using electronic boards on platforms and up-to date online trip information provided in the LRT vehicles during trips. Infrastructure innovation aids the safe flow of passengers, providing high travel demand, better accessibility, and proximity to LRT platforms, provides near real-time and real time trip information to passengers, reduces congestion, and supports modal change from private to public transport, etc.

2.2. Contextual Factors and Contextual Approach Process

Context is defined as specifics involving the political climate, organizational-setting, peculiar challenges at hand, etc., that can affect innovation adoption [3]. The authors in reference [3] further explained context as the flexibility of interventions during the process. Due to varying contexts, similar innovation(s) can be adopted in different ways by diverse organizations. Understanding the various innovation management methods, from the view point of the organization, the governance of innovation processes, and their corresponding advantages and disadvantages is necessary for choosing the most suitable method in a specific context [1].

In general, it appears that more corporations are integrating a contingency style to innovation management by adjusting their innovation management procedures to their business context, which is known as contextual innovation [1]. In literature, contextual factors are defined as the political and legal system(s), culture, history, ecology, geography, the stage of economic development, and the economic system(s) used at a specific period of time, including all emerging contexts within a frame of time and space, which has shaped the components and reasons why a certain context is currently present [5]. In addition, contextual factors also include technological environment, economic environment, and social influence [4]. Contextualization is defined as integrating the context into relevant processes by understanding, defining and hypothesizing about the phenomena within it [5]. Consequently, due to the diversity of contexts, poly-contextualization has been introduced [23] to define the procedure of integrating various scopes of a context to facilitate comprehensive and valid knowledge of its phenomena. Cross-cultural relationships are not only necessary but indispensable for success in the contextualization of Light-Rail Transport [5].

A contextual approach in this research means the adaptation of certain components of the LRT, such as the infrastructural innovation which has been adapted to suit the context setting of the three cities. It also involves the commercial activities associated with the LRT being produced and provided by another country, which is China. A contextual approach in technological and non-technological innovations is important for suitability and a sustainable long run operation of the LRT. This is because when large infrastructure like a light-rail system does not suit the context of the receiving city, huge amounts of money are wasted, there is extra money spent to make it fit the system, or it poses maintenance problems, leading to extra costs and time wastage (which is less frugal).

Furthermore, it is pertinent to state that these city transport authorities value their long term goals and the sustainable operation of the LRT, meaning the use of a context-specific decision making process is crucial, involving the exchange of practical city context knowledge from the RRAs and light-rail expert knowledge from the RPC [10]. This context-specific knowledge fosters a bottom-up approach implementation of the LRT, providing necessary knowledge support from the RRAs to the RPCs during all stages of the implementation. A re-modification of the infrastructural innovation processes occurs when a negative outcome is observed in the contextualized infrastructural innovations and needs to be re-modified.

2.3. Relationship between Contextualized Infrastructural Innovation, Contextual Factors, and the Process of a Contextual Approach used by RRAs and RPCs

China's RPCs produced the LRT rolling stock for Nigeria and Ethiopia, and interacted with their RRAs to design and construct (build) the LRT. However, there was a strong need to use a contextual approach, considering the different city contextual factors in these cities, since they are different from

cities in China. In this regard, the specific types of contextual factors found at certain areas along the LRT routes determined the ways in which infrastructural innovations were contextualized to suit any areas of concern. The multiple actors went through this contextual approach process, which mostly tried to leverage the value for money for citizens while providing LPT to the three cities. This involved innovatively contextualizing the infrastructural innovations together with other city authorities who were linked to the implementation of the LRT, such as ministries of transport, water authorities, electric and telecommunications companies, ministries of lands and their relocation/compensation departments, etc.

Thus, the infrastructural innovations, such as type, style, and the positioning of the provided infrastructure, also went through the process of a contextual approach, which involved modifying different areas of infrastructure to individually suit the three cities. The contextual approach sometimes led to complete or partial modifications in infrastructural innovations used, which required extra cost, time, and additional technical personnel.

3. Methodology

In this section, the concepts and their core variables have been defined with indicators that have been operationalized, as shown in table 1. Furthermore, the qualitative research strategy that was used has been explained in detail. The pilot interviews, in-depth semi-structured interviews, sampling method(s), sample size(s), and different respondent groups are fully described.

3.1. Operationalization of Concepts

Table 1. The concepts, variables, and their respective indicators [3–5,12].

Concepts	Variables	Indicators
Infrastructural innovation	Type, style, and positioning of provided infrastructure in three cities	Accessibility support infrastructure Trip information infrastructure Ticket shop, ticket sale machine at platform, or inside Light-Rail Transport (LRT)
Modification of innovations	No, partial, or complete context modification in LRT support infrastructure	Types of context modifications at design or construction stages.
City contextual factors amongst the 3 cities of Abuja, Lagos and Addis-Ababa	City economic development City technological environment City culture Geography	Cost Operation and maintenance Transit Oriented Development (TOD) Safety Energy Supply Non-Motorized Transport (NMT) Seamless integration of transport modes Modern rolling stock Modern aesthetic stations Rocky deposit Swampy areas
Contextualized infrastructural innovations	Effects of contextual factors on different types of modifications	Types and extent of contextualization by re-modification

3.2. Research Strategy

The methodology used in this research was a qualitative method involving multiple case study research, using pilot interviews and two rounds of semi-structured interviews. This provided instruments for researchers to study complex phenomena within their contexts [24], which should encourage expert practices and serve evidence-based decision-making for policy settings. This affords researchers the opportunity to describe and explore an occurrence in context using various information sources. It also permits scholars to discover entities or establishments underpinned by multifaceted relationships, involvements, programs, and groups [25]. Furthermore, it provided the

deconstruction and successive reconstruction of several phenomena. The multiple case studies of Addis-Ababa, Abuja, and Lagos provided effective avenues for recognizing and collecting data from different contexts [26]. The multiple case study approach allowed for an in-depth study of variables and relationships between variables, due to the specific contexts of the different cases. This approach to research has been applied to actual settings [27–29]. In addition, for public transport institutional analysis, variables are better analyzed qualitatively, which requires in-depth methodologies [30], such as semi-structured in-depth interviews that can provide more comprehensive data and can take the specific contexts of the study into consideration. This approach made the collected data more comprehensive, as it was attained by the gathering of respondent views using various sources and concepts related to actors, their related clusters, and interactions.

The sampling method used was purposive sampling. It was selected because it is based on the characteristics of the population (LRT experts) and the objectives of the study. This enabled the respondents to relate their experiences on the ground with their expertise as engineers and managers. The population coverage included Nigerian, Ethiopian, and Chinese LRT experts. In Nigeria, the Abuja and Lagos LRT experts worked with ALRD and LAMATA, respectively, and in Ethiopia the Addis-Ababa LRT experts worked with ERC. The Chinese LRT experts worked with CCECC in Nigeria and with CREC/Shenzhen metro in Addis-Ababa. The coverage method used in collecting social context of survey respondents was mostly developed to estimate the respondent's network size [31]. There was a pre-test for three respondents, five respondents were involved in the 1st round of interviews, and nine respondents were involved during the 2nd round of interviews, providing a total of 17 interviews. The sample size in the semi-structured interviews in Lagos city was 11 LRT experts, comprising of nine Nigerians and two Chinese. The sample size in Addis Ababa in the two-step approach of pilot interviews and semi-structured interviews had a total of 22 respondents. There were five respondents in the pilot interviews in 2015, six in the semi-structured interviews in 2015, and 11 in the second round of semi-structured interviews in 2017. The data gathered was codified using the Atlas-TI software, which facilitated the categorizing of the various levels of data, generating a robust data sets capable of deducing categories from the data on design and operation phases of the LRT in the three cities. The unit of analysis was studying the processes and actions which involved many individuals [32], representing actors within RRA and RPC.

4. Empirical Results and Discussion

This section first discusses the similarities and differences within Nigeria, i.e., between Abuja and Lagos. Secondly, it discusses the similarities and differences between two countries, i.e., between Nigeria and Ethiopia, and their cities.

4.1. Similarities in Contextual Factors used During Contextual Processes between Abuja and Lagos within Nigeria:

These two cities in Nigeria both went through contextualization as a form of partial to complete modifications to suit the city contexts required. The following contextual factors that were responsible for their similar contextualization was analyzed and shown in table 2.

4.1.1. Seamless Integration of Transport Modes

In Abuja and Lagos cities, the need for seamless integration of LRT with other modes of transport was seen as the first contextual factor. Thus, in Abuja, there was a complete re-modification of the Abuja airport light-rail route, as a re-alignment with other existing transport modes, to provide seamless inter-modal transfer between air and rail modes of transport for passengers. In Lagos, seamless integration was the core consideration, as the LRT stations were designed to accommodate seamless integration and operation with other transport modes such as water and road transport, since an ample proportion of Lagos is surrounded by water. This design was meant to ensure that water and road transport passengers could easily access the LRT and would therefore be connected to other parts of Lagos. Furthermore, a flyover bridge was replaced by a tunnel for the LRT passage

at ring road one on the Nnamdi-Azikwe expressway, at the intersection of the national rail (Abuja to Kaduna) and the city light-rail (within Abuja city only). This was done during construction, as it was observed after the design stage that the national rail also needed to pass through the same intersection later when the national rail route was completed. This allowed for a seamless integration between the national rail and the city light-rail. In addition, the Abuja city later made inclusions of more access roads during the construction of the LRT, which were not incorporated in the initial design stage. These access roads were included to aid the seamless integration of private and public transport by allowing road users to have easy access to the LRT stations from different areas across the capital city of Abuja.

4.1.2. Transit Oriented Development

All the Abuja LRT stations were completely re-modified after their initial designs were proposed by the Chinese companies. This complete re-modification was intended to provide a better Transit Oriented Development (TOD) to all the stations and their connecting routes. This served as a policy to attract and encourage private developments near all the light-rail stations in Abuja, which provides the benefit of internally generated income for the Abuja city government. This internally generated income from rental charges of private development in the TOD arrangement augments the fare charges from passengers and budget commitments from the government. This augmentation from the TOD proceeds provided more support to the sustenance of operations and maintenance of the light-rail rolling-stock, since the public LRT is partially operated on a non-profit basis by the government. Thus, the number of floors were increased by one beyond an earlier proposed bungalow level, and other facilities were expanded to provide more business opportunities for the private sector, which fostered economic interactions. This was also evident in Lagos, as all stations were partially re-designed to accommodate more business activities, such as by constructing multi-story buildings for commercial carparks and other commercial facilities for private sector development.

4.1.3. Non-Motorized Transport

In Abuja city, another over-pass was added as a modification after the initial design. This Non-Motorized Transport (NMT) was intended to provide people living near the railroad tracks with better proximity and easy accessibility, as many people were not yet used to walking about one kilometer or more to be able to cross the road. This sort of NMT around the stations is also very evident in Lagos city, with the inclusion of a "Sky walkway" at some of the LRT stations, to allow passengers go from one mode of transport to another while walking within the same station.

4.1.4. Preference for a Modern Light-Rail for Good Aesthetics and Passengers' Satisfaction

After the initial design phase, the managers of the Abuja and Lagos city LRTs made a change from initial LRT vehicles being rolling stock, which was initially proposed by the Chinese, to a more modern LRT, with modernized facilities. Abuja city went through a complete change of type of LRT vehicle from a simple looking vehicle to a more modern looking LRT vehicle. Lagos city also changed to a LRT vehicle that included air-conditioning for better air quality for passengers during travel, and back-up batteries to save power during motion and avoid sudden power outages before moving the light-rail to its safe parking lot.

4.1.5. Inadequate Energy Supply

Abuja re-modified the design of stations by choosing staircases as a major priority over escalators, while also providing elevators for the passengers. This preference for the use of staircases was to avoid the breakdown of the escalators due to inadequate power supply. The Lagos city opted for a change in the LRT vehicle to one with back-up batteries to avoid stoppage of the LRT during operation, which may have affected the electrified LRT during operation, because of an inadequate electric supply.

Table 2. Summary of similar contextualization factors in Lagos and Abuja within Nigeria.

Contextual Factors	Abuja	Lagos
Seamless Integration of transport modes	Complete modification of the airport light-rail route and a re-alignment to other existing transport modes, for seamless inter-modal transfer, between air and rail modal transport passengers.	LRT stations designed to accommodate seamless integration and operation with other transport modes, such as water and road transport.
Transit-Oriented Development (TOD)	All LRT stations completely modified to provide TOD. Floors increased by one, other facilities expanded to provide more business opportunities for the private sector.	All stations partially designed to accommodate more business activities, such as multi-story buildings for commercial carparks and other commercial facilities for the private sector.
Non-Motorized Transport (NMT)	More over-passes added as a modification after the initial design to provide NMT, for better proximity and easy accessibility for people along the rail tracks.	Inclusion of a "Sky walkway" at some LRT stations, to allow passengers to go from one mode of transport to another, while walking within the same station with walk-friendly NMT infrastructure.
Modern light-rail for better aesthetics and passengers' satisfaction	Provided a complete change of LRT vehicle type from a simple to a more modern looking LRT vehicle.	Changed LRT vehicle to include air-conditioning for better air quality for passengers during travel, and back-up batteries to save power and avoid sudden power outages during operation.
Inadequate energy supply	Modified the design of stations by changing escalators to concrete staircases as a major priority and retaining the complimentary electric lifts and escalators in some stations, to avoid breakdown of escalators due to an inadequate power supply.	Opted for a change to LRT vehicle to add back-up batteries, to avoid stoppage during operation, which could affect the electrified LRT during operation because of any unforeseen interruption of electricity supply.

4.2. Differences in Contextual Factors between Abuja and Lagos within Nigeria

The contextual factors responsible for the differences in contextualization between Abuja and Lagos are analyzed and depicted in table 3.

Abuja city's construction choices have been characterized by its peculiar contextual factors, two of which are geographic and one of which is energy related. These are: the construction of an overpass (bridge) instead of the earlier planned underpass (tunnel) along the airport on the lot 3 LRT route, due to a barrier posed by a massive underground rock deposit; a bridge span being extended from 1 span to 26 spans, i.e. the length of the beam between two bridge supports, to provide multiple forms of support on a super structure bridge for a longer overpass for cars due to a lengthy swampy area. During the construction phase, the energy contextual factor was considered, which involved whether to use a concrete staircase or an electrified escalator in addition to the already included elevators. Due to the inadequate power supply in the city, a concrete staircase was chosen, which led to the modification during construction, while also incorporating an escalator in some areas that needed it in their LRT stations.

LRT construction in Lagos city was characterized by three distinct contextual factors. The first was its interest in achieving effective operations/maintenance and modernization; the second was its support for avoiding the extra costs of implementing LRT by re-routing LRT along areas with less third-party issues (private and public buildings and facilities along LRT routes); and the third concerned the safety of the LRT passengers. In achieving effective operations, the Marina station designed by CCECC with two tracks was later changed to three tracks, which was proposed by LAMATA. This was to provide a place to park all LRT coaches in case of a break-down of the light-rail during operation. The increased number of tracks at this location was also implemented to meet current best practices, thereby modernizing the tracks. To avoid extra costs when implementing the

LRT, one of the main routes was completely changed, by re-routing it from Iddo light-rail station through Ijora-Olopa to Marina. This was done to keep the cost within the expected Lagos city budget, due to the higher settlement of third parties needed along the earlier designed route of Iddo. As a safety measure, modification of the LRT doors was implemented to allow passengers to have control of the doors during emergencies. The initial design provided door control to the LRT driver alone.

Table 3. Summary of differences in contextualization factors between Abuja and Lagos within Nigeria.

Abuja	Lagos
Three distinct contextual factors: Two geographic factors and one energy related contextual factor. Geographic: • Construction of an overpass (bridge) instead of earlier planned underpass (tunnel) along the airport on lot 3 LRT route, due to barrier of massive underground rock deposit. • Bridge span extended from 1 to 26 for multiple support on a super structure bridge for a longer overpass for cars due to the extensive swampy area. Energy: • Modifications to augment electric escalators and elevators by constructing concrete staircases.	Three distinct contextual factors: • Effective operations/maintenance and modernization: Marina station with two tracks changed to three tracks to meet current best practices. • Choosing to avoid the extra costs of implementing LRT by re-routing LRT along areas with less third-party issues. • Safety of LRT passengers: Modification made to allow passengers open doors, to avoid accidents during emergencies.

4.3. Similarities in the contextual factors between Nigeria and Ethiopia

The contextual factors responsible for the similarities in contextualization between Nigeria and Ethiopia are analyzed and depicted in table 4.

4.3.1. Cost Effective LRT Route

The first similarity between the two countries was the need for a cost-effective LRT route, minimizing expenditure needed for relocating third party facilities. This was re-echoed during the Lagos interview as one of the top Chinese engineers mentioned, "Lagos city should tidy up all their third-party issues before constructing the LRT, to minimize the cost and waste of time".

4.3.2. Seamless Integration of the LRT with other Modes of Transport

The second priority was the need to provide seamless integration of the LRT with other modes of transport. This was necessary because major LRT stations are not far from public roads in all three cities and also close to water transport for Lagos city. Access roads and right-of-way were re-modified for seamless integration between other transport modes and the LRT.

4.3.3. Fostering TOD and NMT

The third similarity between the two countries was the need to foster TOD and NMT. This is very important for these countries because LRT was designed for the public and not intended for significant profit investment by the government. However, maximizing the benefits of LRT through the provision of TOD infrastructure, such as mega malls, office complexes, and other commercial activities along these routes, provides some profits to the government that assist with providing adequate maintenance of the rolling stock. In Abuja, NMT and the LRT were set up closer to the airport buildings to foster NMT between air and rail passengers, as well as the provision of more over-passes and walk-ways for pedestrians. In Lagos through, there was a modification of major LRT stations to accommodate the “Sky-walk” as a user-friendly pedestrian walkway within the LRT stations linking the road and water transportation methods. Addis-Ababa has modified its road networks to improve pedestrian accessibility to the LRT platforms, providing improved right-of-way

structures for pedestrians to walk on roads close to the LRT stations and to better link other transport modes, using walkways along such areas and linking them to the LRT platforms.

4.3.4. Safety

The fourth similarity is the need for safety across the board in the two countries. This priority was demonstrated as a decision to thicken the wall inside Lagos lagoon measuring 460 meters, to avoid city flooding, and a change of door use in favor of more passenger-friendly doors, which can also be opened by the passengers, especially during emergency periods. Abuja also provided more overpasses and underpasses for safe pedestrian and cattle movements. The Ethiopians also incorporated an intermittent automatic train protection system after the LRT was ordered during the operation phase to provide automated safety measures for the LRT drivers. Barriers were also built along the roads which shared the same level as the LRT to avoid accidents by vehicles from running into the LRT.

4.3.5. Modernization of LRT to Current Best Practices

Modernization of LRT to reach current best practices. Abuja completely changed its initially proposed LRT vehicle from a simple to a modern LRT vehicle with better aesthetics, while Lagos changed its LRT vehicle to a type that includes air-conditioning and back-up batteries. Addis-Ababa moved away from an earlier plan of using different entry and exit LRT doors for the passengers towards using all doors for entry and exit, since this is a more user-friendly option that avoids chaos, especially during peak periods.

Table 4. Summary of similar contextualization factors between Nigeria and Ethiopia.

Contextual Factors	Nigeria	Ethiopia
Cost effective LRT route	LRT route modified to avoid third-party issues and expenses beyond the government allocated budget.	Additions underpasses (LRT tunnel) and overpasses (bridges) initially not in the original design.
Seamless integration of LRT with other modes of transport	• LRT routes in close proximity to other transport modes. • Access roads added to allow for integration between public roads and water transport with LRT.	• Access roads and right of-way modified for seamless integration between other transport modes and the LRT. • LRT routes near other transport modes.
Foster TOD and NMT	• Modification of LRT route to be closer to airport buildings to foster NMT between air and rail passengers. • Provision of more over-passes and walk-ways for pedestrians. • Modification of major LRT stations to accommodate "Sky-walk" as user-friendly pedestrian walkways within LRT stations linking the road and water transport.	• Modification of road networks to improve pedestrian accessibility to the LRT platforms. • Provides improved right-of-way structures for pedestrians to walk on roads close to the LRT stations, for better linkages with other transport modes.
Safety	• The 460 meters thickening of the wall inside the lagoon to avoid city flooding. Change to passenger friendly LRT doors for emergencies. • Provision of more overpasses and underpasses, for safe pedestrian and cattle movements.	• Incorporated the use of intermittent automatic train protection systems during the operation phase. • Barriers built along the roads sharing the same level with the LRT, to prevent accidents involving vehicles running into the LRT.
Modernization of LRT to current best practices	• Complete change in the initial proposed LRT vehicles from a simple to a modern LRT with better aesthetics. • Changed the LRT vehicle to include air-conditioning and back-up batteries.	• Changed the earlier plan of using different entry and exit doors of LRT for passengers, to using all doors for entry and exit, which avoids chaos, especially during peak periods.

4.4. Differences in the Contextual Factors between Nigeria and Ethiopia

The contextual factors responsible for the differences in contextualization between Nigeria and Ethiopia are analyzed and shown in table 5.

4.4.1. Ticket Stations

The first difference is characterized by the construction of emergency ticket shops in Ethiopia. Nigeria in contrast has all of its ticket shops within the stations. This emergency plan by Ethiopia was the only option available, as they were not able to use the installed electronic ticket-validation system on board the LRT vehicle due to a high local population and the lack of barrier turnstiles at platforms. This created a need to build ticket shops at every light-rail stop. This in turn required extra expenditure for building the ticket shops close to each light-rail stop, employing ticket salespersons at each ticket shop in every light-rail station, and providing ticket officials inside the LRT. This use of paper tickets led to a significant level of around 30% fare evasion, according to a top ERC engineer. This significant fare evasion was because the few ticket officials were overwhelmed by the highly populated LRT, in which the passengers' tickets could not be adequately checked by the ticket officials during the trips on the LRT or before boarding at the station platforms. This led the free rides (fare evasion) by some passengers who sometimes traveled for long distances, but paid for short distances, or did not pay at all for the whole trip.

4.4.2. Energy

The need to prevent energy failure was prominent in Nigeria, characterized by the need for back-up batteries on the electrified LRT in Lagos and the preference for a concrete staircase over escalators in Abuja. Ethiopia has a more stable electricity supply, using a dedicated power supply for its LRT and in general having a more reliable electric supply than Nigeria.

4.4.3. TOD and NMT

Nigeria demonstrated more in-depth modification of its stations to improve TOD and NMT. This was mainly because all Nigerian stations are bigger, which means there was a need to maximize the space efficiency by integrating other transport modes with better NMT for pedestrian accessibility and improve economic activities at the LRT stations and routes. In Ethiopia, not all of the LRT stations could incorporate facilitates to support TOD, as some of the stations are only in-between roads and therefore possess less space to implement adequate TOD and NMT. However, some strategically selected stations with more space have improved TOD and NMT facilities in Ethiopia.

4.4.4. Modern Aesthetics of both the Rolling Stock and Station Areas

Nigeria had peculiar modern aesthetics for both the rolling stock and station areas, as its cities have bigger stations with more passenger facilities and a higher population. This is because Nigeria incorporated the LRT into its masterplan from the onset of Nigerian city planning, as opposed to Ethiopia who only developed LRT designs in recent years. Addis-Ababa is satisfied with the aesthetically electrified LRT provided by the Chinese, even though they have less choice to be able to enlarge all their stations, as only some strategic stations were enlarged to have TOD. Therefore, some LRT stations in Ethiopia share the road with vehicles on both two sides. The LRT has the major right of way. In the Nigerian cities, Abuja and Lagos are the present and former capital cities of Nigeria, which sought aesthetically beautiful rolling stock and station areas. This can be viewed as a cultural inclination for Nigerians to prefer not only functional but also aesthetic technology, which can be appropriate for capital cities.

Table 5. Summary of differences in contextualization factors between Nigeria and Ethiopia.

Nigeria	Ethiopia
All ticket shops are within enclosed ticket shops inside the stations.	Construction of "emergency" ticket shops, based on not being able to use the installed electronic ticket system on-board the LRT vehicle, due to a high population and a lack of barrier turnstiles at platforms.
Need to prepare for energy failure. Seen in the use of back-up batteries on electrified LRT and the preference for concrete staircases over escalators.	More stable electricity supply, using dedicated electric power supply for its LRT.
More in-depth modification of stations to improve TOD and NMT. Mainly because all Nigeria stations are bigger, which allows integrating other modes with better NMT for pedestrian accessibility and improved economic activities at LRT stations and routes.	Not all LRT stations can incorporate facilitates to support TOD or NMT, as some of the stations are only in-between roads and therefore possess less space to implement more TOD. However, some strategically selected stations with more space have improved TOD and NMT facilities.
• Need for modern aesthetics for both rolling stock and station areas, with bigger stations and more passenger facilities to serve more populated cities. • LRT plan present in the city master plan.	• Both electrified LRT and station areas are already aesthetically adequate. Only strategically selected stations were expanded for TOD. • LRT plan absent in the city master plan until recently. Therefore, use of middle of road areas for some of the LRT routes, giving priority and right-of-way to LRT.

4.5. Highlight of Congruent and Divergent Contextual Factors between Nigeria and Ethiopia

The congruent contextual factors in Abuja and Lagos highlight the major and similar contexts in both cities due to their peculiar challenges and situations at hand. These are evident in the inadequate electric energy supply in Nigeria; modernization of the light-rails and their stations because the two cities prefer more aesthetic-looking light-rail with modern features, as compared to the light-rail and stations proposed by the Chinese rail corporations; TOD as a means to promote business activities for the private sector and support government finances for operations and maintenance through rent charges at TOD designated areas along the LRT routes, which is partly due to the more spacious areas in the light-rail stations; NMT within the TOD areas and along the LRT routes to facilitate pedestrian movements; seamless integration of LRT with other modes of transport, which was mainly due to the presence of the LRT in their master plan, to support its integration with their national rail systems, Bus Rapid Transit (BRT), water transport, and other private and public road transport modes.

In Addis-Ababa, the contextual factors were different to those in Nigeria, including having emergency ticket shops due to non-functioning electronic ticket machines on-board the LRT and over populated peak-hour travel by passengers; less capacity for TOD as they were only present in some designated light-rail stations due to having less space to develop the TOD; NMT are mainly along the LRT stops to provide better safety due to right-of-way issues on the roads and safer accessibility into the LRT, as the light-rail and other motorized transport share the roads in more than half of the light-rail stops.

5. Conclusions

The conclusion reveals lessons learnt from the poly-contextualization between the three cities of the two countries. These lessons learnt unravel sets of stronger contextual factors; answers the research question; shows the benefits of filled gaps in the academic literature and benefits for the transport industry; provides key recommendations for the transferability of research findings to other local contexts; and indicates towards areas for further research.

Lessons Learnt from Contextual Factors as a Benchmark to Poly-Contextualization between Nigeria and Ethiopia

The eminent contextual factors with a stronger influence on the contextualization of infrastructural innovations in Nigeria are the electric energy supply, modernization of LRT and their stations, TOD, and seamless integration of LRT with other transport modes. Out of these four factors

in Nigeria, modernization of LRT rolling stock and their stations is the strongest out of all the factors, as various re-modifications were made on the LRT rolling stock and LRT stations to modernize them with best practices to suit the former and present capital cities. The prominent contextual factors with more effect on the contextualization of infrastructural innovations from Ethiopia were emergency ticket shops, seamless integration of LRT with other transport modes, and NMT. NMT was specifically used to improve safe pedestrian accessibility to LRT in Ethiopia, since a significant amount of LRT is in the middle of roads, sharing these roads with other modes of transport, such as public transport and private busses and cars. Out of these three factors in Ethiopia, emergency ticket shops stand out as the strongest factor, as it was the most unexpected event, due to non-functional electric ticket-validation machines inside the LRT, leading to fare evasion. The seamless integration of LRT with other transport modes stands out as being common to both Nigeria and Ethiopia. This answers the research question: What are the factors influencing the contextualization of infrastructural innovations in urban light-rail transport, from the China context to Addis-Ababa, Abuja, and Lagos city contexts?

Furthermore, from the insights of this research and observations during fieldwork in both countries, it can be argued that an effective contextual approach to implementing a sustainable LRT depends more on the LRT receiving city authorities' political will, related to political systems in the literature [5]; the level of technology transferred, i.e., the technological environment[4], from the Chinese to the two countries on operations and maintenance of LRTs; and thirdly on the combination of a context-specific decision-making process of the RRA and expert light-rail knowledge from the RPC [10]. Nigeria, Ethiopia, and China have demonstrated adequate context-specific decision-making processes during the implementation of light-rail systems, which serves as a benefit to both the RPC and RRA. This is because more cities in transitioning to light-rail will be encouraged to partner with RPC, leading to more symbiotic relationships between RRA and RPC, since collaboration fosters adequate context-specific decision-making processes, which aids better knowledge transfer and implementation processes.

This research departs from the theories of contextual factors [4,5], poly-contextualization [23], and context-specific decision-making processes [10]. This research correlates with the statement that all factors that emerged in time and space have defined the reasons why a context is specifically the way it is presently [5]. In addition, it correlates with the concept of poly-contextualization, describing the procedure of integrating various scopes within a context aimed at a complete and objective comprehension of any phenomena in it [23]. Findings from this research supports the theories that contextual factors depend on the particular challenge at hand [3]. The context-specific decision-making process is evident in the adequate cooperation of the RPC's rail experts with the local and crucial knowledge from the RRA, which forms a symbiotic relationship, as the expert knowledge relies on the local context knowledge to develop the light-rail infrastructure.

Therefore, this research was able to expand the current academic literature by filling in some literature gaps. This is especially the case in the area of infrastructural innovation adaptation in urban transport sciences, with specific contextual factors that have emerged overtime and in space that have shaped the implementation processes of a Light-Rail Transport in three African cities, and results show the reasons why a context is the way it is in the two countries. Furthermore, it provides meaningful data about particular contexts in different types of cities with similar and diverse socio-economic conditions for appropriate decision making on cost and energy efficient LRT, good quality, and user friendliness for light-rail passengers. This contextual process is necessary because it also shows how capable the RPC from China are in terms of contextualizing the LRT to any city's contexts. These contextual processes are sometimes complex and require both the technical and local context capacities from both parties to implement light-rail. Thus, the RPC will run the risk of poor warranty to RRA or other potential clients in other countries interested in investing on the LRT from MNCs in China in the future, if they do not have the capability to innovatively contextualize cities LRT to their contexts. However, results in this research shows that the RPC has demonstrated an adequate level of capability to contextualize these contextual factors with the RRA. Consequently, if the LRT receiving cities through their engineers, scientists, and managers do not provide the necessary local

context ideas that will aid the MNC and city LRT to implement a contextualized LRT system, they will run the risk of system dysfunction and a low cash return rate. The RRA within the three cities also demonstrated an adequate use of their local context knowledge during the implementation processes.

The key recommendations for the transferability of this research findings to other local contexts are derived from lessons learnt from each city case study. Therefore, it is recommended that cities with an inadequate power supply should use other sources of energy apart from electric energy, or use hybrid energy (such as electric and diesel) LRT systems, such that the system can use diesel or similar forms of energy and easily switch to electricity when it is adequate or more stable. To augment inadequate electric energy, this should include the use of renewable energy, such as solar energy by other infrastructure, such as escalators, elevators, ticket machines, and the whole light-rail station building in general. Back-up batteries should also accompany the use of electricity in the operation of the light-rail, so that the light-rail can be parked safely during electric power failure.

Cities with limited space for barrier turnstiles at light-rail platforms should provide more light-rail vehicles to augment the existing ones, thus reducing congestion in the LRT due to high travel demand, especially during peak hours, which consequently allows for the use of electronic tickets via swiping cards on ticket machines inside the LRT and reduces the level of fare evasion. TOD and the land value along the LRT route should be adequately designed and captured respectively, to maximize its internally generated income, which augments the income from fare charges and government committed funds, to cover the operations and maintenance costs. To encourage better public transport use, the LRT connectivity to other transport modes should be improved by constructing or redirecting other transport routes to the LRT route, such as BRT stops or airport terminals within 2–5 minutes walking distance of the LRT stops or stations. Apart from including air-conditioning systems in the light-rail for the comfort of the passengers during warm temperatures, it is recommended to have windows that can be slightly opened to allow fresh air into the light-rail without opening the windows completely. This is to avoid discomfort when the electricity fails or when the temperature becomes too warm to bear for the passengers, which improves the air quality inside the light-rail. To save a significant amount of money and time, i.e., to be frugal, it is recommended that cities should tidy-up their third-party issues before implementing the LRT. This entails policies to prevent unwanted buildings being built along the LRT routes, and settling any existing third-party issues through compensation, relocation, or demolition as the legitimate situation demands. This will prevent delays and unnecessary expenditure during the implementation of the LRT

Further research questions are present and grounded on the results of this research. These are: Why are certain contextual factors more common in certain cities than in others during the implementation of LRT? To what extent does a Build Operate and Transfer (BOT) or Design and Build (DB) business model provide a more sustainable LRT? How can city governments create an enabling environment for LRT implementation, where investors can gainfully invest, while city governments only regulate? How can multi-national corporations from China and other advanced rail transport countries collaborate more effectively to deliver LRT, with affordable costs, reduced third-party issues and sustainable rail technological transfers?

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