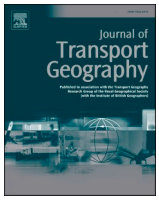
Journal of Transport Geography 105 (2022) 103464

Contents lists available at ScienceDirect

Journal of Transport Geography

journal homepage: www.elsevier.com/locate/jtrangeo



Accessibility and sustainable mobility transitions in Africa: Insights from Freetown

Daniel Oviedo [a,*], Clemence Cavoli [a], Caren Levy [a], Braima Koroma [b], Joseph Macarthy [b], Orlando Sabogal [a], Fatima Arroyo [c], Peter Jones [a]

[a] University College London, London, UK
[b] Sierra Leone Urban Research Centre, Freetown, Sierra Leone
[c] The World Bank, Washington D.C., USA

ARTICLE INFO

Keywords:
Accessibility
Mobility
Transitions
Sustainability
Mixed methods
Africa

ABSTRACT

In the context of still-low-but-rising levels of motorization and economic growth, increasing social and spatial inequalities, and growing concerns about air pollution and climate change, the formulation and implementation of policies, practices and partnerships that can support an accelerated implementation of sustainable mobility policies is an urgent concern for rapidly developing cities. This paper seeks to contribute to reframing some of the knowledge and methodologies produced in and about cities of Sub-Saharan Africa, through a comprehensive assessment of mobility patterns and accessibility needs within a larger debate about mobility transitions and sustainable development. By deploying a mixed-methods approach that builds upon case-study focus groups and city-wide accessibility and mobility analysis in the city of Freetown, Sierra Leone's capital, the paper maps travel patterns and their links with structural factors such as urban form, poverty, informality and social identities at the macro, *meso* and micro levels. The paper also presents evidence from a variety of methods that illustrate the significance of accessibility-centred information and analysis for establishing policy priorities for improving urban mobility and accessibility in the local, African and global contexts.

1. Introduction

This paper seeks to contribute to reframing some of the documented knowledge produced in and about cities of Sub-Saharan Africa, drawing on a comprehensive assessment of accessibility patterns, as well as business and citizen needs in the city of Freetown, Sierra Leone. The paper is situated within the debates related to mobility transitions and sustainable development, exploring the base conditions under which trajectories towards more sustainable mobility can be identified and what role accessibility plays in such trajectories. It sets out to produce evidence that will add to academic knowledge and inform policymaking in Freetown and similar cities in Sub-Saharan Africa, aimed at accelerating sustainable and socially inclusive transport developments at different scales.[1]

Although some research is now underway, there is limited evidence about the configuration and development patterns of urban transport in sub-Saharan African cities. There are considerable gaps in the documentation and understanding of urban mobility and accessibility, their links with realised and non-realised travel, and the role of walking and the built environment in supporting inclusive and sustainable urban development (Bryceson et al., 2003; Venter et al., 2018; Weiss et al., 2018). By deploying a mixed-methods approach that builds upon case-study focus groups and city-wide accessibility and mobility analysis, the paper maps reported travel patterns and explores their links with structural factors such as urban form, poverty, and social identities. The paper also presents evidence of local livelihood strategies used to

* Corresponding author.
E-mail addresses: daniel.oviedo@ucl.ac.uk (D. Oviedo), clemence.cavoli@ucl.ac.uk (C. Cavoli), c.levy@ucl.ac.uk (C. Levy), orlando.sabogal.20@ucl.ac.uk (O. Sabogal), farroyoarroyo@worldbank.org (F. Arroyo), peter.jones@ucl.ac.uk (P. Jones).

[1] This paper is based on research done in the Transitions to Sustainable Urban Mobility (T-SUM) project, an interdisciplinary and cross-sectoral collaborative project that aims to identify the conditions under which pathways to sustainable and inclusive transport and land use development can be developed and accelerated in growing cities in the Global South. The T-SUM project focuses on Maputo, Mozambique, and Freetown, Sierra Leone, with the aim to challenge the traditionally assumed inevitable links between economic growth and car-based urban transport, to document the socioeconomic and spatial inequalities stemming from current urban transport systems and to collectively explore with local policy makers the potential benefits of adopting urban sustainable mobility and land use policies.

https://doi.org/10.1016/j.jtrangeo.2022.103464
Received 26 October 2020; Received in revised form 3 October 2022; Accepted 5 October 2022
Available online 18 October 2022

negotiate access to essential services across the urban setting, taking advantage of available formal and informal opportunities and modes of transport. Acknowledging that most approaches and methodologies related to transport have been developed in the context of industrialised societies, the paper identifies the need for rich and in-depth data in cities of the global south about current understandings of accessibility by citizens in different social, spatial and transport-related positions, and how their needs are articulated in their interrelation with more traditional accessibility methods used to inform decision-making in transport and land-use planning and policy.

This paper sits within a larger research question about the extent to which rapidly growing Sub-Saharan African cities can initiate and implement sustainable urban mobility transitions. Here the concept of a sustainable urban mobility transition refers to the capacity cities have to develop mobility systems that are efficient, ecologically sustainable, and socially equitable. It is particularly focused on influencing the current correlation across a variety of cities between GDP per capita and percentage of private motorised modal share (as illustrated in Fig. 1).

Fig. 1 shows city-level relationships, at one point in time (1995), between GDP per capita and the share of trips made by residents in private motorised modes (i.e., car and motorcycle drivers and passengers) in a range of large cities across different continents. From this we can see that there are two distinct patterns associated with cities of increasing wealth. Although this is based on cross-sectional data, Teoh et al. (2020) show that this is broadly replicated over time in individual city trajectories. African cities such as Freetown are currently to the far left of this graph within the circle, with relatively low GDP and private motorised trips, but beginning to experience a rapid growth in car ownership levels. This means that these African cities are facing long-term choices that need to be addressed now (either implicitly or explicitly) about which of the paths in Fig. 1 they wish to follow – or, indeed, whether they seek to develop a unique pathway, learning from the mistakes and successes of cities further along the two trajectories have experienced.

Our research is built on the recognition that transport systems and land use patterns co-evolve over time and are mutually interdependent (e.g., high levels of car use go together with urban sprawl). It postulates that policy and planning can intervene at critical points to contribute to more sustainable trajectories in this evolution. The analysis and debates put forward in this paper are based around the concept of accessibility, acknowledging that transport, and land-use policies affect many of the components that make up accessibility to a decent life (e.g., ease of access to jobs, education, health care, etc). Moreover, the Sustainable Development Goals (SDGs) agreed by the (UNDP, 2015) argue that access is a key part of the targets of human development for the next decade. In particular, Goal 11 (Sustainable cities and communities) includes in one of its targets an aim to "by 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, …with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons" (UNDP, 2015 p.21). Moreover, global support for sustainable urban development embodied in the UN's New Urban Agenda, promotes equitable access to sustainable transport, with an emphasis on the conditions faced by low-income and peripheral urban populations, which facilitates participation in both social and economic activities (UNDP, 2015).

We argue for a conceptual refocussing, from an emphasis on mobility to one on accessibility, in line with research debating the interpretation and value of the two concepts and highlighting the advantages of adopting an accessibility framing (Black, 2018; Dimitriou and Gakenheimer, 2011; Ferreira and Papa, 2020; Levine, 2020). Traditional transport planning has mainly focused on mobility and on providing the fastest physical movement between two points. But transport is largely a derived demand, so we argue that it is more meaningful to focus on accessibility, which measures the ability of people to reach destinations and take part in activities that are important to them living a decent life. Mobility metrics are not very informative in this regard and unlike accessibility, they do not assist in the direct identification of inequality (Foth et al., 2013; Pereira et al., 2017; Zagatti et al., 2018). For example, longer trips could equally signify a disbenefit (e.g., being located far from the nearest hospital) or a benefit (e.g., freedom to explore other parts of the country). Whereas measures of accessibility are much less ambiguous, as they directly measure levels of participation in activities.

The analysis reported in this paper combines traditional spatial measures of accessibility, the mapping of informal transport provision in collaboration with local communities, and qualitative research methods; in order to develop an accessibility-centred analysis that can enrich policy and practice in Sub-Saharan African cities, using Freetown as case study.

Participatory methods have been widely applied in the social sciences and the humanities to engage vulnerable communities including

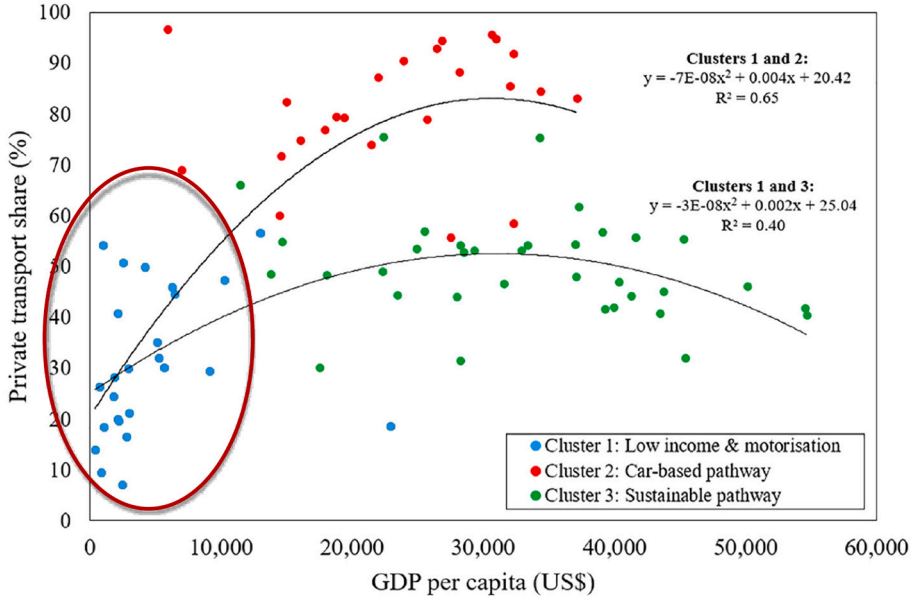


Fig. 1. City-level relationships between GDP per capita and private motorised mode share.
Source: (Teoh et al., 2020)

knowledge co-production, with more recent applications in health-related research (Katapally, 2019). Community-based approaches have contributed valuable research insights into urban and social development, and changing ways of approaching urban research, particularly in underserved communities (Castán Broto et al., 2022; Dick, 2017). We seek to expand on the scope and applicability of techniques for participatory research into daily life, by actively engaging with volunteer researchers from diverse backgrounds in under-served urban communities. In this way, we seek not only to co-create approaches to transport research, but also to empower engagement with concepts and measures of urban mobility, and to contribute to awareness raising about citizen's spatial literacy with a focus on urban spatial accessibility. The paper acknowledges the limitations of accessibility analysis at the city-scale, by delving into understanding the diversity of transport needs, preferences and behaviours at the neighbourhood level, and how these relate to the social, economic, and physical conditions in which mobility and access are realised.

2. Concepts of accessibility, inequality, and sustainable mobility

Accessibility can be understood as "the ease of reaching desired destinations given a number of available opportunities and intrinsic impedance to the resources used to travel from the origin to the destination" (Bocarejo and Oviedo, 2012:143). However, these opportunities and impedances are in a reciprocal relationship with the social position of transport users, and the spatial structure of and distribution of activities in cities (Levy, 2019). In this regard, "access is unequally distributed, but the structuring of this inequality depends inter alia on the economics of production and consumption of the objects relevant to mobility, the nature of civil society (…), the geographical distribution of people and activities, and the particular mobility-systems in play and their forms of interdependence". (Urry, 2007, pp.: 17).

One of the main characteristics of transport approaches to sustainability developed in the wake of environmental awareness movements in the early 2000s is that the goal changed from moving vehicles to moving as many people as efficiently as possible. This is a positive goal as it places people and their mobility at the centre of transport planning. However, it still assumes that "an increase in travel mileage or speed benefits society" (Litman, 1999 p. 29), and although different modes are considered, placing public transport and high-occupancy vehicles (HOV) as feasible solutions, it still prioritises private motorised vehicles (Ibid).

Accessibility offers a basis for pursuing equity, strongly related to the rights to enjoy essential goods and services. The accessibility paradigm places access as the goal, not just as an adjunct of the transport system; hence, mobility shifts from being an end, to be a means to access desirable opportunities. Therefore, access as a priority became a primary social good that predetermines the benefits of living in an urban area (Martens, 2012; van Wee and Geurs, 2011; Vargas et al., 2017; Vecchio et al., 2020), while mobility became an intermediate good. The analysis of accessibility enables multi-modal assessments that consider, motorised, non-motorised modes and substitutes between different modes of transportation, considering the most suitable according to user needs and capabilities. Additionally, land use is taken as fully integral and with the same importance as transportation systems (Litman, 2003) and sustainability. The individual characteristics or social positions of transport users, such as their intersecting social identities related to class, age, gender, physical abilities and ethnicity also emerges as critical to an understanding of accessibility (Jaramillo et al., 2012; Levy, 2013; Niehaus et al., 2016; Vasconcellos, 2014).

Within such a paradigm, Handy and Niemeier (1997, p. 1175) characterised accessibility as "the potential for interaction, both social and economic, the possibility of getting from home to a multitude of destinations offering a spectrum of opportunities for work and play", a conceptualisation supported by several authors even in the most recent available research (Dong et al., 2006; Farrington, 2007; Kwan and Weber, 2008; Oviedo, 2021; Oviedo and Guzman, 2020; Vargas et al., 2017). Accessibility is determined by the spatial distribution of potential destinations, the magnitude, quality, and character of the activities found there and the ease of reaching them, all of which is determined by the transportation system, individual characteristics and resources. Travel costs and travel 'choices' -in terms of availability of destinations and modes- are therefore essential for determining accessibility. Hence, several authors focus on understanding how population groups with different socio-economic characteristics, experience accessibility differently (Currie, 2004; Gao et al., 2010; Guzman et al., 2017; Halden, 2002; Kwan, 1999; Lovett et al., 2002; Páez et al., 2012; Schönfelder and Axhausen, 2003; Ureta, 2008).

In a policy context, the UK Social Exclusion Unit (Social Exclusion Unit, 2012) used accessibility for evaluating and designing social policy, acknowledging the strategic relationship between transport-related social exclusion and accessibility. Furthermore, building upon the transport and equity relationship, an emergent strain of research relates to transport and social justice (Banister, 2019; Farrington and Farrington, 2005; Justice et al., 2008; Levy and Dávila, 2017; Martens, 2012). Here the relation between transport disadvantage and poverty is examined, focusing on the transport governance, political ideals and power relations that define transport trajectories (Lee et al., 2014; Lucas, 2019).

The scales at which accessibility is approached has also evolved across the literature, changing from a focus on the "how", looking at inter-area movement patterns, to a thorough consideration of the "who" or "what" (Handy, 2020). As Halden et al. (2005) acknowledged, "People and opportunities have been considered within the planning of improved transport only to the extent that the characteristics of the people or the places affect mobility and the demand for travel." (Halden et al., 2005, p.3). Within the accessibility paradigm, two other scales of accessibility emerged below the macro or strategic level, that of *meso* and micro-accessibility (Jones and Lucas, 2012). Meso focuses on the movement at a neighbourhood level, regarding local street network connectivity and permeability by different transport modes, and access by various disability groups. The micro-scale focuses on the physical ability to move along or cross the footway and carriageway, the ability to enter/leave vehicles, or to manoeuvre within them, and to individual capabilities and possibilities (Jones and Lucas, 2012). The authors argue that achieving high levels of accessibility require good performance at all three scales. Building on such definitions, we argue that although 'Accessibility' has various meanings, these can be loosely grouped into three levels as shown in Fig. 2.

Access can be achieved in a variety of ways, such as by travelling from home to a destination, having the good or service delivered to/provided at the home, or in proximity, accomplishing the activity via the web (e.g., watching a film), or using pipes (e.g., water), wires (e.g., electricity) or air waves (e.g., radio) to link people and products. In this regard, we can differentiate between Accessibility and Access, the first being the potential to reach opportunities and the second the realisation of such potential. While people may not necessarily study at all "reachable" schools or work in "reachable" jobs identified by potential accessibility metrics, Accessibility focus is on the potential availability of opportunities for interaction, providing a bird's eye view on how land-use and transport systems interact and provide a differentiated set of opportunities that individuals can reach. Their availability in practice depends on individual and collective social, economic, and cultural drivers that enable individuals to have different levels of access. Accessibility is determined by the costs associated with the distance or time involved, and the availability and capacity of opportunities of a given category. In contrast, Access to those potential opportunities is affected by individual identities and social norms linked with relations of gender, age, class, and religion, among others. These structure individual capacities, skills and abilities, economic and social barriers to participating in a given activity or consuming a given good, and the provision and availability of services, activities, and the supply of goods at different times. In other words, accessible opportunities are not

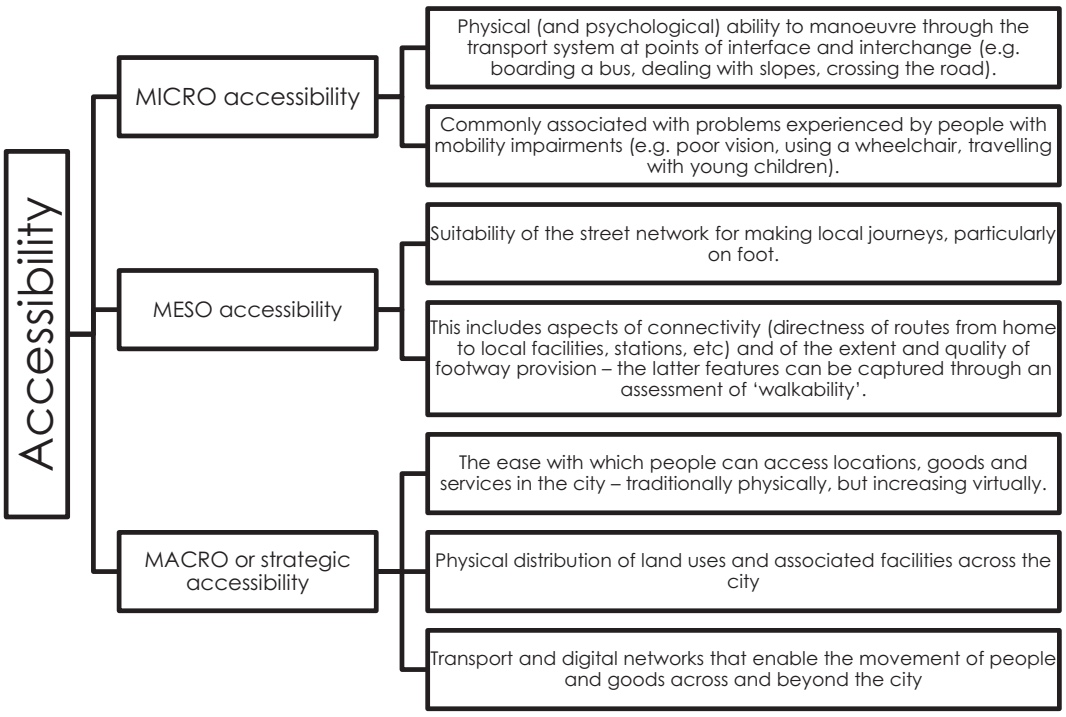


Fig. 2. Scales of accessibility.
Source: Own elaboration based on (Jones and Lucas, 2012)

accessed equally by all groups in society.

Geurs and Van Wee (2004) identify four main components in the concept of accessibility: (i) land-use, which refers to the quantity, quality and distribution in space of opportunities such as jobs, shops, healthcare and, social and recreational facilities at destination locations, and the demand for opportunities at origin locations; (ii) transport, which accounts for the features of the transport system expressed in terms of the (dis)utility for an individual to travel between origins and destinations using a given mode of transport; (iii) time, which reflects time constraints related to both availability of opportunities during the day, and the availability of time for individuals to make use of such opportunities; and, (iv) individual, which reflects the needs, abilities and opportunities of individuals who can influence levels of access to transport and their ability to participate in opportunities. According to these standard relations and components of accessibility, the interactions between the components outlined above produce differentiated levels of accessibility by mode, location, social groups, and activity (Geurs and Van Wee, 2004).

These components form the cornerstones of the conceptual framework for this paper, as set out in Fig. 3, which, based on the previous discussion, makes selected additions to the Geurs and Van Wee (2004) components. Empirical and conceptual research in rapidly changing urban contexts suggest the need for an expanded definition that accounts for the diversity of experiences of urban mobility for individuals and social groups with different intersecting social identities that might be excluded by virtue of their social position e.g. class, gender, age, ethnicity etc., as well as the potential negative effects of accessibility relations for communities affected by the operation of an imperfect transport system (Geurs and Van Wee, 2004). Some of these elements have been picked by recent research on accessibility, although a consolidated framework has not been proposed accounting for the complexities of accessibility in global south contexts (Benevenuto and Caulfield, 2019; Lucas, 2019; Venter et al., 2019). In this regard, to understand the role of accessibility in the development of specific trajectories for sustainable mobility, it is necessary also to account explicitly for the room for manoeuvre that informality, technology and dynamic relations of power may introduce into each of the components and relations suggested by (Geurs and Van Wee, 2004), and the role that governance and institutions play in many of the decisions underlying the distribution of each component of accessibility presented in Fig. 3.

It is important to note that many variations of the framework presented in Fig. 3 have been proposed based on the initial ideas of Geurs and Van Wee (2004).; In practice, no mathematical accessibility measure based on this framework e manages to encompass the whole complexity in Fig. 3.

3. Freetown context

Freetown is the capital of Sierra Leone. The central area is built at an elevation of 49 m above sea level. Freetown is located on a mountainous peninsular, which is approximately 38 km long and 16 km wide, with topographic relief rising to over 700 m. The city occupies an area of 74 km^2 which is less than 1 % of the total land area of Sierra Leone. The whole peninsula has a total land area of 357 km^2 with a coastline of about 40 km.

3.1. Socio-demographics and development trends

With a population of about 1.1 million (approximately 21.1% of Sierra Leone's population), Freetown is densely settled with a population density of 12,878 persons per km^2 (Statistics Sierra Leone, 2017). This is expected to rise to 25,000 persons per km^2 by 2028 (MCLPE & FCC, 2014). With an annual growth rate of 4.2%, the population of Freetown is projected to reach 2 million residents by 2028 (Government of Sierra Leone, 2015), accounting for 65% of the total population living in the urban areas of Sierra Leone (Statistics Sierra Leone, 2017). Internal displacement during the civil war (1991–2002) and migration in search of employment opportunities has further contributed to the growth of the city's population (Macarthy et al., 2019).

Freetown has been unable to provide adequate housing, social infrastructure, and service provision to keep pace with population growth. With Freetown having the largest share of households (18.2%)

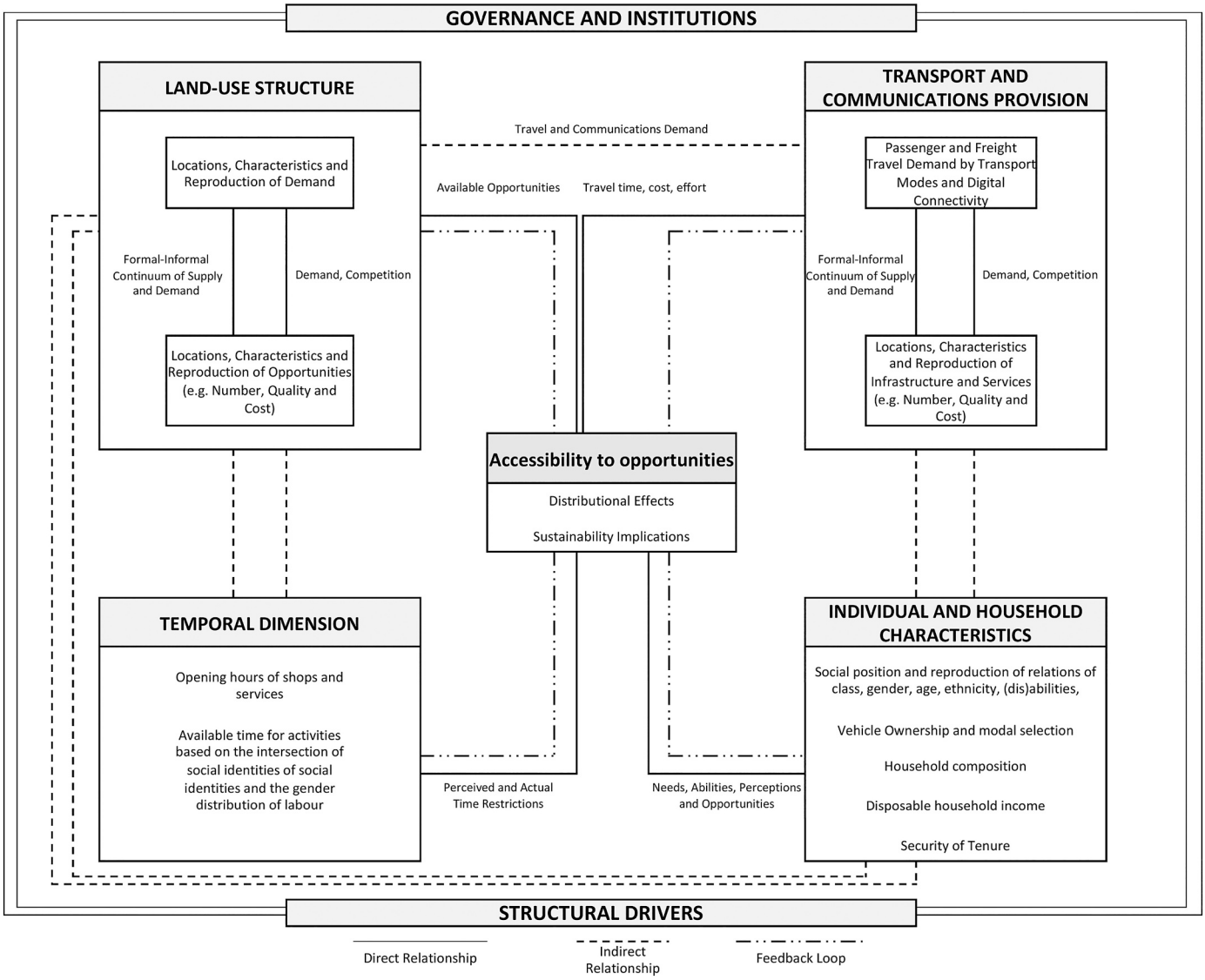


Fig. 3. Components and relations of accessibility.
(Source: Own elaboration)

in Sierra Leone, growth in the urban population already wields a heavy burden on service delivery in the city. The 2015 census lists 12% of dwellings as impoverished homes/kiosks or unnamed etc. representing the spatial expansion of low-income groups into marginal and vulnerable settlement areas (Statistics Sierra Leone, 2016). Overall, Freetown has a Gini Coefficient of 0.32 based on 2002 data[2]. Similarly, urban poverty in Freetown between was 31% in 2011 but has declined to 28.5% in 2019 (SSL, OPHI, and UNEP, 2019:2).

3.2. Economy

Already, a large share (about 75%[3]) of Freetown's population live in informal settlements with the informal economy estimated to provide jobs for as much as 70% percent of the city's population (Government of Sierra Leone, 2019). The service sector accounted for about 33% of the country's labour force in 2014 (mostly in Freetown), though its contribution to GDP declined from 30% in 2001 to 20% in 2015. More than half of the individuals aged between 15 and 35 participate in the labour force, and 91% percent of these are self-employed (Statistics Sierra Leone, 2016). Recent studies show that Freetown contributes 30% of the country's GDP, indicating the economic potential of the capital city (World Bank Group, 2018) and has an average annual growth rate (2010−2020) of 4.22%[4]. Table 4 summarises the main demographic and economic features of the city.

In Freetown, 87% of the jobs are in the tertiary sector. The transport sector is the second highest generator of jobs, although more than 85% of them are informal, which puts this group in a vulnerable position (World Bank, 2018). The Freetown Structure Plan (MCLPE & FCC, 2014) suggest that although the construction sector provides employment for a significant proportion of Freetown's working population, most of these jobs are either informal (72%) or unpaid (8%). The Central Business District is the main commercial centre in Freetown including offices of consulting firms, financial offices, banks, and insurance operations

[2] Gui, 2009. Global Urban Indicators – Selected Statistics Monitoring the Habitat Agenda and the Millennium Development Goals, Global Urban Observatory. November 2009.

[3] Also, about 25% of the Freetown population live in slums

[4] World Urbanization Prospects: The 2011 Revision, UNDESA, New York 2012

Table 4
Demographic and Economic Indicators, Freetown.

Indicator	Value	Source
Population	1,055,964	Statistics Sierra Leone 2015
Population density (persons per sq.km)	12,878	Statistics Sierra Leone 2015
Population annual growth rate	4%	Statistics Sierra Leone 2015
Contribution to the national GDP (%)	30%	World Bank 2018
Annual GDP growth rate (2010–2020)	4.22%	MTNDP 2019
Gini Coefficient	0.32	ADB 2009[a]
Percentage of the population under the national poverty line	28.5%	SSL, OPHDI and UNDP 2019

Source: ADB, 2009; SSL, OPHDI, &UNDP, 2019; MTNDP, 2019; World Bank, 2018; SSL, 2015.

[a] African Development Bank, 2009. African Statistical Yearbook 2009. Addis Ababa. Economic Commission for Africa

(Macarthy et al., 2019).

3.3. Transport features

Rapid population growth in Freetown has caused increasing pressure on the existing transport systems, which are themselves inadequate and do not meet current transport needs. As a result of limited, poorly maintained roads, and the uncontrolled expansion of private and informal public transport, street trading, and inefficient traffic management, the city is experiencing high levels of congestion and poor conditions for basic access. Uncontrolled parking is a compounding issue, with formal passenger collection points either not observed (due to poor enforcement) or not clearly defined, leading to circulation problems at the main interchanges and terminals in the city. In addition, there are poor conditions for pedestrians as a result of blocked walkways and damaged or non-existing pavements.

The city is grappling with not only limited available land space for residential development, but also is occupying an increasing share of urban land for road infrastructure. Recent estimates suggest that only 5% of the total land area in Freetown is allocated to roads, of which only 24% are paved compared with regional benchmarks of 10% and 50%, respectively (DFID, 2018). Road density per capita is about 165 m of paved road per 1000 citizens in the Greater Freetown Area, which is around half of the average in low-income African countries (318 m/1000 people) (AfDB, 2017; World Bank, 2018).

The poor quality of the road network and narrow roads with a heavy use of private cars, and a poor public transport service, considerably hinders accessibility within the city. Mobility is also impacted by lack of sidewalks, which if they exist are usually occupied by parked vehicles or traders.

The private sector is the major supplier of transport services in Freetown, accounting for almost 85% of the market share (World Bank, 2018). Limited institutional capacity for planning and delivery of public transport services has created gaps in the market that unregulated private transport services have filled. They are primarily provided by the informal sector, largely through a mix of a few full-sized buses, poda-podas (minibuses), shared taxis operating on fixed routes, kekeh (three-wheelers) and okadas (motorcycles). Though these services provide an essential means of mobility across the city, their low capacity and irregular stops mean that they contribute significantly to congestion. Furthermore, citizens with physical and cognitive disabilities have limited basic mobility, both on and off-street, with inaccessible transport infrastructure and a large share of buildings with no design consideration for such population groups (Walker and Ossul-Vermehren, 2021).

4. Methods and data

Based on the multi-factor understanding of accessibility, as shown in Fig. 3, this paper critically examines urban mobility, urban structure, and land-use developments and related socio-economic, cultural, and environmental issues at the city level and in selected localities. The paper uses spatial and historical quantitative and qualitative analysis to assess the role that past and contemporary transport and urban policy, planning and governance have played in influencing conditions for access across Freetown, and their implications for sustainable mobility transitions. We build on various secondary data sources to conduct an analysis of mobility, accessibility, urban structure, and land-use; and carry out original qualitative and spatial analyses of primary data, including semi-structured interviews with selected stakeholders, participatory mapping, and focus groups with residents in selected contrasting neighbourhoods to inform an analysis of distributional impacts.

One innovation in our methodology was the combination *Small* and *Big Data*. The first was defined as qualitative as well as local quantitative and spatial information that, despite not having a large sample size, can shed light on issues not previously explored. The second encompassed large datasets such as phone records to pinpoint the main travel attractors in the city. Small Data, as used in this project, provides 'seed' information that could be later scaled up organisations with more resources.

4.1. Accessibility

We used a variety of information, of different forms and spatial scales, from the city of Freetown to translate the main features of the framework shown in Fig. 3 into the empirical reality of the city.

This analysis uses the cumulative accessibility model, which divides the city into small zones and identifies the number of reachable opportunities from the centroid of each zone within a specific travel time threshold. Standard outputs from a cumulative accessibility model state, for example, that 20 health facilities are reachable from a particular zone within 15 min.

Mathematically, the total accessibility for zone "i" at an established travel time threshold "t" is defined as A_i and expressed as:

$$A_i = \sum_{j=1}^{n} D_j * f(c_{ij}); f(c_{ij}) = 1 \; if \; c_{ij} \leq t \; and \; f(c_{ij}) = 0 \; otherwise \quad (1)$$

where D_j is the number of opportunities within zone "j," $f(c_{ij})$ the impedance function, and c_{ij} the travel time between the centroid of zone "i" and the centroid of zone "j."

If population information is available for all zones (as is the case in this research), then it is possible to measure the number and percentage of a population reaching a certain number of opportunities within a travel time limit "t".

To compute the cumulative accessibility model, three main inputs are needed: (i) zones with population information, (ii) the geolocation of opportunities analysed, and (iii) the travel times for all pairs of zones (often expressed in form of a matrix) and that are calculated from transport networks. Below is a summary of sources of information used for this part of the analysis.

- Population: We used the most recent data from WorldPop (WorldPop, 2019). This source divides Sierra Leone into small grids of 1 km2 and estimates the population within each grid.
- Opportunities (main travel attractors, health, and education facilities): we used information collected by the World Bank from a local phone operator to identify the main trip attractors across Freetown. The dataset includes over 50,000 data points collected in one month in 2018: Although not enough to capture the full range of travel patterns in Freetown, it enabled a clear identification of the main hotspots of attraction. For health and education facilities the team used open datasets from OSM. This data was depurated and

complemented using field-collected data from the World Bank and the Freetown City Council (World Bank, 2018).

- Travel time (networks): We used a combination of the road network downloaded from Open Street Maps (OSM) supplemented by information from Freetown City Council (FCC) and the World Bank. Freetown's General Transit Feed Specification (GTFS) has detailed operation of the transport system in the city. The GTFS defines a common format for public transportation schedules and associated geographic information. GTFS structures the way public transit agencies publish their transit data and developers write applications, so that the data can be used in an interoperable way. GTFS has the location of places where people are allowed to board buses and the travel time between stations. We used OSM to calculate walking travel time from home zone centroids to the closest boarding location, and from alighting locations to facilities. Travel times are calculated using shortest path algorithms.

We use the formula in Eq. (1) to estimate location-based accessibility in 15-min time bands between 0 and 120 min (Brussel et al., 2019). This cumulative accessibility measure incorporates the land-use structure and transport components from Fig. 3, neglecting the temporal and the individual and household characteristics of accessibility.

As mentioned, previously, a limitation of the cumulative accessibility model is that it measures theoretically reachable opportunities without necessarily reflecting real access to opportunities. For example, people might live close to a school but study in a more distant school because of affordability or quality issues.

4.2. Focus groups

During May 2019, a series of focus groups involving residents were organised in the four different neighbourhoods shown in Fig. 4. Data collection was preceded by a two-day training programme for research coordinators in the field. After the training programme, the research team approached local leaders who acted as 'gatekeepers' and facilitated access to communities. A local meeting served to introduce the research to neighbourhood residents and obtained informed and voluntary consent for participation in the study from participants. Table 5 summarises the main characteristics of the neighbourhoods analysed.

The sample of selected neighbourhoods is diverse and captures differences in macro, *meso* and micro accessibility factors (see Fig. 2) related to the different availability of opportunities and road infrastructure, environmental risks, difficulties for mobility and access, and other information presented below and summarised in Table 5.

Each focus group contained 12–16 participants large enough to capture a diversity of opinions but small enough to provide the opportunity for all participants to share their views (Silverman, 2014). In total 57 individuals participated in these discussions. This small group of participants also allowed the team to address some of the challenges that characterize focus group discussions, such as keeping focus, coordinating logistics and ensuring that everyone attends. Participants of the study were provided with a project information sheet and signed an informed consent form before participating in the discussions. The consent form described what data participants would provide for the study, its intended use, data protection guarantees and the right to the withdrawal of their information.

On average women and men were equally represented.[5] The age of participants in Brookfields, Cline town and South Ridge varied between 17 and 63 years whereas participants in Moyiba were considerably younger, ranging between 21 and 33 years old. Most participants had lived in their neighbourhood for over 5 years. Each focus group lasted two hours and was conducted in a combination of English and the local Krio language, according to participants' language preferences. The focus groups aimed to obtain evidence in three areas, namely people's (i) behaviours and practices, (ii) rationales and motivations, and (iii) expectations and suggestions related to policy and practice.

4.3. Collaborative mapping of informal transport

Building on this approach, we collected information from semi-structured interviews with local government and representatives from the *Okada* and *Kekeh* Associations in Freetown. Three participants representing each Association were interviewed and provided an initial approximation for the mapping. Findings from the qualitative interviews and information shared by the Associations were utilised to co-produce the maps of semi-formal transport modes presented in Section 5. The team used the geo-location feature in WhatsApp to create a protocol that enabled the mapping of the main hubs of operation of motorcycle taxis and rickshaws across Freetown. The accuracy of WhatsApp geolocation depends on the characteristics of the phones used; nevertheless, in worst case scenarios, accuracy should have an error ranging from 3 to 10 m, which was deemed as acceptable for our research given the stark lack of geocoded information about informal transport in the city.

Despite their many positive contributions and potential for community empowerment and capacity building, co-production methods related with citizen science involve complex ethical considerations, particularly in the context of vulnerable and disadvantaged communities (Resnik et al., 2015). Recent research has pointed to the need to incorporate principles of inclusivity, adaptation, sensitivity, safety and reciprocity, which involve additional complexities (Chesser et al., 2019). In this research, the team engaged directly with these ethical considerations through continuous monitoring of the development and implementation of training of volunteer young researchers and the collection of data by fostering dialogue at the local, and city scales with peer citizen scientists. This led to relevant reflections on the importance of informal transport in community life and showcased participation and community-led approaches in addressing transport-related gaps. Researchers and volunteers from the communities of the neighbourhoods that were selected as case studies visited all hubs of semi-formal transport services to geolocate the information. The main features of the process of data collection, analysis and appropriation are as summarised in the following Table 6.

5. Findings

5.1. Network coverage and access to public transport

Data on the public transport modes operating in Freetown is limited and provides an incomplete overview of the coverage and availability of urban transport alternatives in the city. The public transport modes in the city are illustrated in Fig. 5. Although there have been significant efforts from local and national governments to produce updated and reliable information about demand for, and supply of, public and private transport, such efforts have not yet been fully successful, leaving substantial gaps in information in the city Table 7.

The private sector is the major supplier of passenger transport services in Freetown, accounting for almost 85% of the market share (World Bank, 2018). Limited institutional capacity for planning and delivery of public transport services has created gaps in the market that private operators – many unregulated- have filled. They are primarily provided by the semi-formal sector, through a mix of a small number of full-sized buses, poda-podas (minibuses), shared taxis operating on fixed routes, kekeh (three-wheelers) and okadas (motorcycles). Though these services provide an essential means of mobility across the city, their low capacity and informal on-demand stops mean that they contribute significantly to congestion. Growth of low-capacity vehicles providing public transport is fuelled by high youth unemployment, low barriers of entry (low upfront cost) and time savings for passengers - as the smaller

[5] In the Moyiba focus group discussion 2/3 of participants were women.

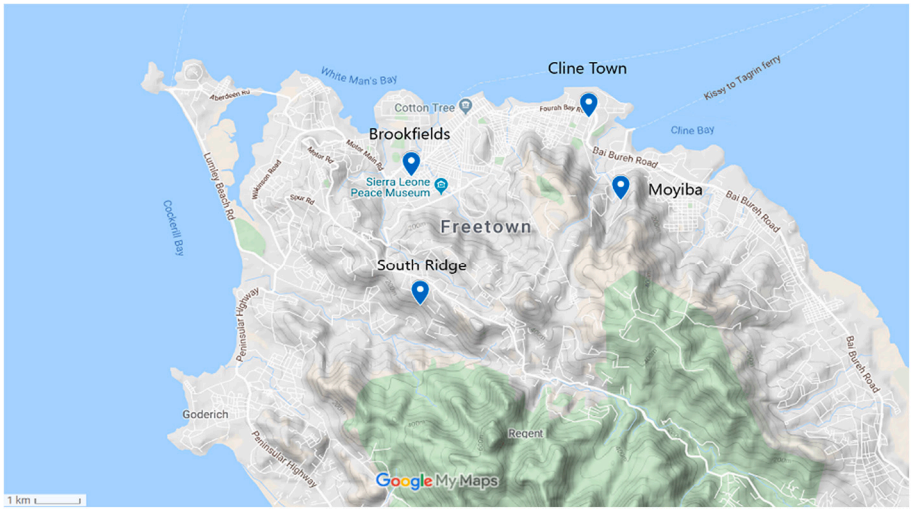


Fig. 4. Location of case-study neighbourhoods for the focus groups.
(Source: Own elaboration)

Table 5
Case-study neighbourhoods selected for focus groups.

Criteria for participation	Cline Town	Moyiba	Brookfields	Southridge
Socioeconomic characteristics	Middle-low-income neighbourhood, closer to the city centre	Hilltop neighbourhood of low-income informal settlements	Middle, middle-high income close to the city centre	Mixed neighbourhood with different income levels
MACRO (strategic) Accessibility	High accessibility	Low accessibility	High accessibility	Low accessibility
Availability of Private Motorised transport	Low private motorised vehicle uses and ownership	Low private motorised vehicle uses and ownership	Larger than average motorisation, private motorisation in the neighbourhood's	Relatively high private motorised vehicle used in the high-income segment population
Nearby opportunities	Major ports, secondary industries, and residential and commercial services (banks), health care facilities, police station, place of worship, historical buildings (former Fourah Bay College) and the railway museum, metal workshops and repair garages, large concentration of warehouses, and recreation areas	Offices (Sierra Leone Standard Bureau, SLRA, SLRTC), Peace Market for trading activities, Close to the University of Sierra Leone (Fourah Bay College), schools, artisanal stone quarrying	Public administration (Youyi building housing mostly government ministries, department, and agencies offices), National Football Stadium, Educational institutions such as the Freetown Secondary School for Girls, Convent, and many other secondary and tertiary training institutions; health care, markets	American Embassy, Health care centre (Choithram – private hospital), communication office, Leicester peak (highest point in Freetown)
Distance to city centre (km)	3.31 km	5.09 km	2.27 km	9.36 km

Source: Own elaboration.

vehicles are better able to navigate through the traffic in congested areas. Furthermore, in the context of cities with a limited paved road network, okadas and kekehs offer the only motorised option for many citizens to access their home in unpaved hilly areas. These highly inaccessible areas can be identified in Fig. 6, where a 500-m radius is plotted around public transport stops (SLRTC, poda-poda and shared taxis routes). Middle- and low-income household members who do not have access to private vehicles in areas such as Goderich, Gbendembu, Tangbeth Town and area parallel to Bai Bureh Road, depend on okadas and kekehs as the only motorised option to access jobs and social services.

Although two and three-wheelers are the only motorised public transport services available for several areas in Freetown, low- income household members cannot afford them in many cases and opt instead for walking long distances or staying in limited areas within their neighbourhoods. It is estimated that the percentage of average cost per *okada* trip to income for a household on the minimum wage for commuting is 18%, compared to modes with fixed routes (SLRTC, *poda-poda* and shared taxis) where the percentage is 12%.

5.2. *Accessibility by collective transport*

We analysed patterns of trip attractions using mobile phone data, as well as existing datasets for land use, to estimate a cumulative accessibility index to opportunities for different thresholds of time, using fixed-route public transport as reflected by the city's GTFS.

The first analysis, shown in Fig. 7 plots the distribution of access from residential areas to the main travel attractors in the city, which are a proxy for the main types of economic activity, using thresholds of 15 and 60 min. As mentioned before, there could be a mismatch between potential accessibility and real access. Nevertheless, the use of accessibility metrics facilitates understanding of urban problems and helps the design of specific policy targets. Despite the limitations of accessibility measures to express real access, it is one of the main tools used in transport planning. As can be observed (see upper figure in Fig. 7), a minority of the population of Freetown can secure access to the main areas of activity in 15 min or less.

Even within a threshold of 60 min (lower figure in Fig. 7), the limited supply of fixed-route public transport services, combined with a

Table 6
Participatory mapping process.

	Inputs	Participants	Outputs
Qualitative scoping of hubs and their locations	Semi-structured interviews with Association leaders	Three interviewees from Kekeh and Okada Associations	Approximate number and locations of paratransit stations
Recruiting and training of volunteer community researchers	Project briefing, mobile data access, training, and sensitisation to spatial data collection	Three project training facilitators Four women and four men volunteer researchers, aged between 20 and 26, from the focus group neighbourhoods	3-day capacity building workshops on community mapping, transport spatial information, and day-to-day digital tools for research. Co-produced data collection protocol. Digital data collection checklist for location, trip, and audio-visual material
Mapping of paratransit hubs	Approximate locations from semi-structured interviews Mobile data access, logistics (e.g., local transport to fieldwork sites), and WhatsApp groups for data collection Definition of selection criteria for mapping points	Three project fieldwork facilitators Eight volunteer researchers	Geolocation of hubs of Kekehs and Okadas Collection of text, location, and photographs of each point Algorithm to automate the location of WhatsApp trips in R Shapefiles with hub geolocations
Participatory workshop with operators	Shapefiles with hub geolocations Documentation from Associations Oral inputs from workshop participants	Three workshop facilitators Eight volunteer researchers Five Kekeh and Okada operators Three representatives from Association	Testing and confirmation of initial map with operators and Associations Joint definition with users and operators of pilot locations for trip analysis
Pilot trip mapping between Okada and Kekeh hubs	Pilot locations for trip origins and destinations Digital data collection checklist for location, trip, and audio-visual material WhatsApp groups for data collection	Three project fieldwork facilitators Eight volunteer researchers Two data analysts	Data from 120 WhatsApp-registered trips in as many vehicles between 6 test locations (58 Kekehs and 62 Okadas). Geographic and content analysis of data Construction of affordability indices and cost curves maps
Participatory workshops with communities	Finalised maps of locations and affordability indices Audio-visual material from fieldwork	Four workshop facilitators Eight volunteer researchers Circa 50 community participants	Presentations and reflections by volunteer researchers Feedback from communities about use and relevance of mapping Transfer of material to communities and commitment of accompanying advocacy activities using mapping and methods

Source: Own elaboration.

unidirectional pattern of travel towards a concentrated city centre of opportunities, means that a large share of the urban population on the peripheries and in hilly parts of Freetown are isolated from the main travel attractors. Measures of accessibility at 2.5 h of travel time still leave nearly 8% of the population with no access to at least a fraction of trip attractors in the city, signalling high levels of isolation in areas where fixed-route public transport cannot operate.

Fig. 8 shows the accessibility to opportunities for primary and secondary education. The recent education policy in Sierra Leone has led to an increase in investment in the development and rehabilitation of school facilities across the city, which is reflected by the availability of opportunities in most parts of the city. As shown in the upper half of Fig. 8, around 50% of the population in Freetown have access to at least one school within 15 min by fixed-route public transport, and over 90% of the population can access at least one school within an hour (lower figure). Although this speaks well about the coverage of educational opportunities, the map of the 60-min threshold still reflects inequalities in the distribution of access as well, as areas of the city that remain isolated. Moreover, considering that the average income in Freetown is very low and most of the economy is informal, disposable income to pay for motorised public transport is likely to be restricted to those in employment; which may lead to many children not being able to access education, despite a comparatively good public transport coverage. In addition, the capacity of schools is limited, which will lead to competition and increasing travel distances to access education for many pupils who can't – or choose not to – obtain a place in their nearest school; this is not taken into account in this accessibility metric.

Fig. 9 shows accessibility to health facilities in the city. This coverage is sufficiently comprehensive for 90% of the population to access at least one opportunity within the 15-min threshold, and for 100% of the population to access at least one facility within one hour, using fixed-route public transport.

These findings highlight various *islands of inaccessibility* that can emerge in relation to specific opportunities. As shown in Figs. 7 to 9, peripheral settlements in Freetown, which also tend to be low income and informal, are the most disadvantaged in relation to access to centres of economic activity, education, and health - essential opportunities to overcome poverty and social disadvantage.

However, in some cases, particularly in the eastern part of the city, isolated areas correspond to newly developed land occupied by higher-income groups, who take advantage of the available road infrastructure to gain access to opportunities by car. Thus, higher-income groups with access to private vehicles can overcome the poor levels of accessibility afforded by the limited coverage of fixed-route public transport services. These not only pose a larger social cost, in terms of pollution and congestion, but also represent a higher risk for pedestrians and cyclists, who tend to utilise modes used mostly by lower-income populations.

5.3. Transport disadvantage and the semi-formal private sector response

In the face of the isolation and inaccessibility resulting from the limited supply of fixed-route public transport services, we developed the method described in Section 4.2 to determine the coverage of non-fixed route public transport provided by *okadas* and *kekehs*. The team mapped all hubs of operation of these modes using WhatsApp; they identified

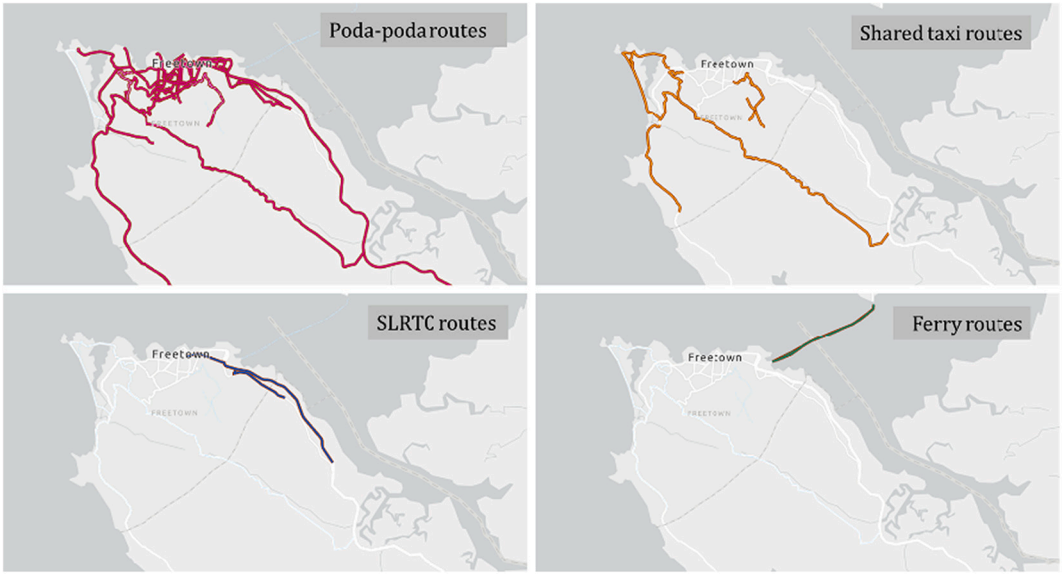


Fig. 5. GTFS routes by modes.
(Source: Own elaboration)

Table 7
Modal split of motorised transport in Freetown.

Rate of motorization (per 1000 population)	Modal split
25 (total vehicles - national figure) 7 (private vehicles – national figure)	18% private car/motorcycle 23% poda-poda (minibuses) 22% shared taxis 13% okadas (moto-taxi) 12% kekehs (rickshaws) 12% buses**

Source: Statistics Sierra Leone, 2015; 2017

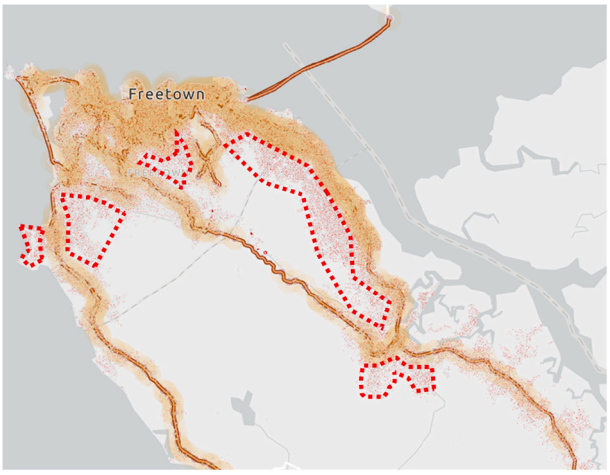


Fig. 6. Highly inaccessible areas using fixed-route modes – SLRTC, poda-poda and shared taxis.
(Source: Own elaboration)

124 points across Freetown where these operators congregate to pick up and drop off passengers. Fig. 10 shows the location of the hubs and the spatial coverage of the services (% of population within 500 to 3000 m of a collection/distribution point) in Freetown.

Adding public transport services supplied by two and three-wheelers increase considerably the access to motorised transport for the majority of the population in Freetown. 77% of the population can access an *okada* or *kekeh* hub within 1000 m of their home, which is still an acceptable walking distance; while nearly 50% of the population can do so within 500 m. Even in areas characterised by isolation and low degrees of accessibility by fixed-route public transport, the evidence shows a good degree of availability of non-fixed route services. This suggests a much higher degree of flexibility and adaptability of these services to the challenges of the topography and infrastructure, as well as a more rapid response to new land developments, which require some degree of public transport supply - even in areas of higher income and high private motorisation. This is a very important finding for Freetown, as no spatial inventory of these services has been carried out to-date.

5.3.1. What are the effects of Okada and Kekehs on affordability and social disadvantage?

The mapping of the hubs of *okadas* and *kekehs* was expanded to include a small sample of trips conducted by researchers and volunteers between six hubs, in order to carry out affordability assessments of paratransit modes with no fixed route. The team co-produced the evidence with participants from previous data collection exercises, obtaining information about origins and destinations, posted fares, and negotiated fares, at different times of the day and for users of different gender, age, etc.

Fig. 11 shows the posted and paid fares for three-wheeler services to and from selected points, between the six hubs. The result are isocost curves for various parts of the city, where paid prices range from 2000 Le (USD$0.21) up to 4000 Le (USD$0.41). For reference, the average cost of fixed-route public transport is Le 1500, which is considerably lower than the cheapest trip registered by three wheelers. However, as shown in the figure, the ability of users to negotiate down prices on these less-regulated services can increase the affordability of certain trips and the equalisation of travel costs across fixed and flexible route public transport services for specific destinations.

Fig. 12 shows the findings of the same analysis for *okada* services. It finds a similar trend to the one observed in Fig. 11. There are visible differences between posted and paid prices, which suggests an ability to negotiate in some instances. Results in Figs. 11 and 12 complement the findings in sections 5.1 and 5.2, as they demonstrate cheaper fares to the city centre, where a higher density of both supply and demand is concentrated; conversely, areas with lower coverage of both flexible and fixed-route services tend to be more expensive, particularly in the south-east of the city. This analysis considers all the drivers of accessibility

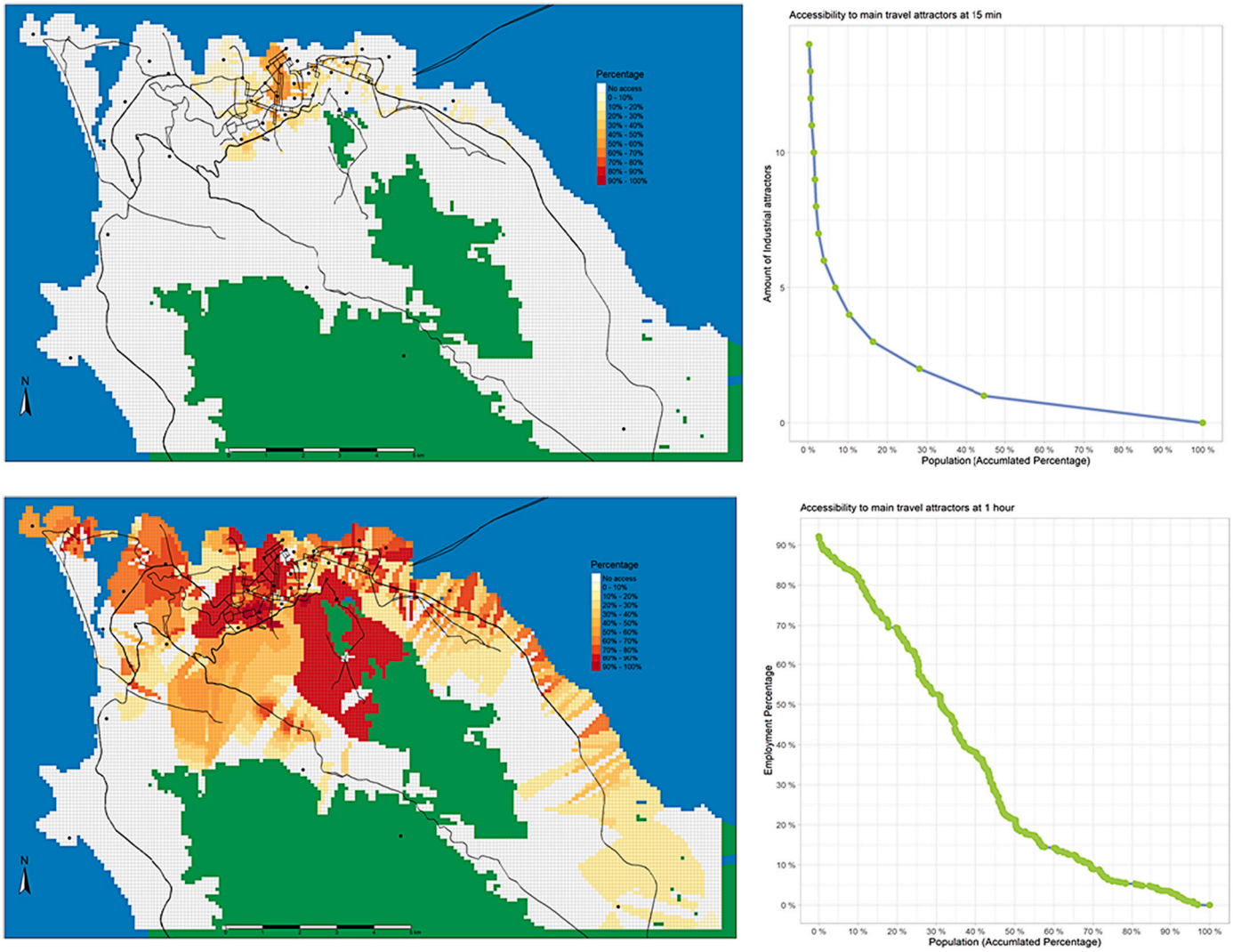


Fig. 7. Accessibility to main trip attractors in Freetown within 15 min (upper figure) and 60 min (lower figure) network travel times. (Source: Own elaboration)

shown in Fig. 3, as it also considered the temporality variability of pricing, driven by special conditions such as peak times and dry/rainy seasons. There are also strong differences in price between morning and afternoon peaks, with the former being more expensive.

Findings have identified strong gender differences between the amounts posted and paid and the willingness of operators to negotiate, who tend to agree to lower prices for men than women, particularly young women. Posted and negotiated prices respond not only to the availability of other forms of public transport at the origin and destination, but also to the state of infrastructure, as drivers tend to charge more in areas where the road is not paved or the topography is more challenging, adding an additional dimension to the affordability of non-fixed route paratransit.

This is compounded by the lower availability of supply at certain destinations, as drivers tend to reject trips to areas where they perceive it will be more difficult to find a passenger for the return trip.

5.4. How do people experience and deal with accessibility challenges in their daily lives? The value of citizen perspectives

As shown in Fig. 13, findings at the macro and *meso* accessibility scales presented in previous sections illustrate individual's and communities' abilities to navigate constraints and opportunities for accessing transport and the opportunities it makes possible. Focus Groups discussions across the selected neighbourhoods add richness and depth to the high-level and mode-specific views of accessibility presented earlier.

As shown in Fig. 13, there is an awareness of the interrelated individual, neighbourhood and more strategic-level challenges faced when moving around the city; and how these vary according to spatial location and socio-demographic characteristics. However, despite these variations, most participants would not want to live elsewhere, illustrating the relevance of housing in the land-use dimension of accessibility.

In Moyiba and in Brookefields, most participants stated that being able to own and build their homes was a key reason for them or their families to move into the neighbourhood and now to stay there. Residents of better-served neighbourhoods have an added incentive to remain there. Participants from Brookefields highlighted the importance of having local access to services such as churches and mosques, schools, markets, and hospitals, among others.

In neighbourhoods farther from the centre, such as Cline Town, participants complained about the centralisation of services in the city centre; while in South Ridge, a participant reflected on how the lack of local amenities is compounded by limited financial resources by noting: "Majority of us are not working and so lack of financial resources often restrict us from going out to visit friends, families, watch football games

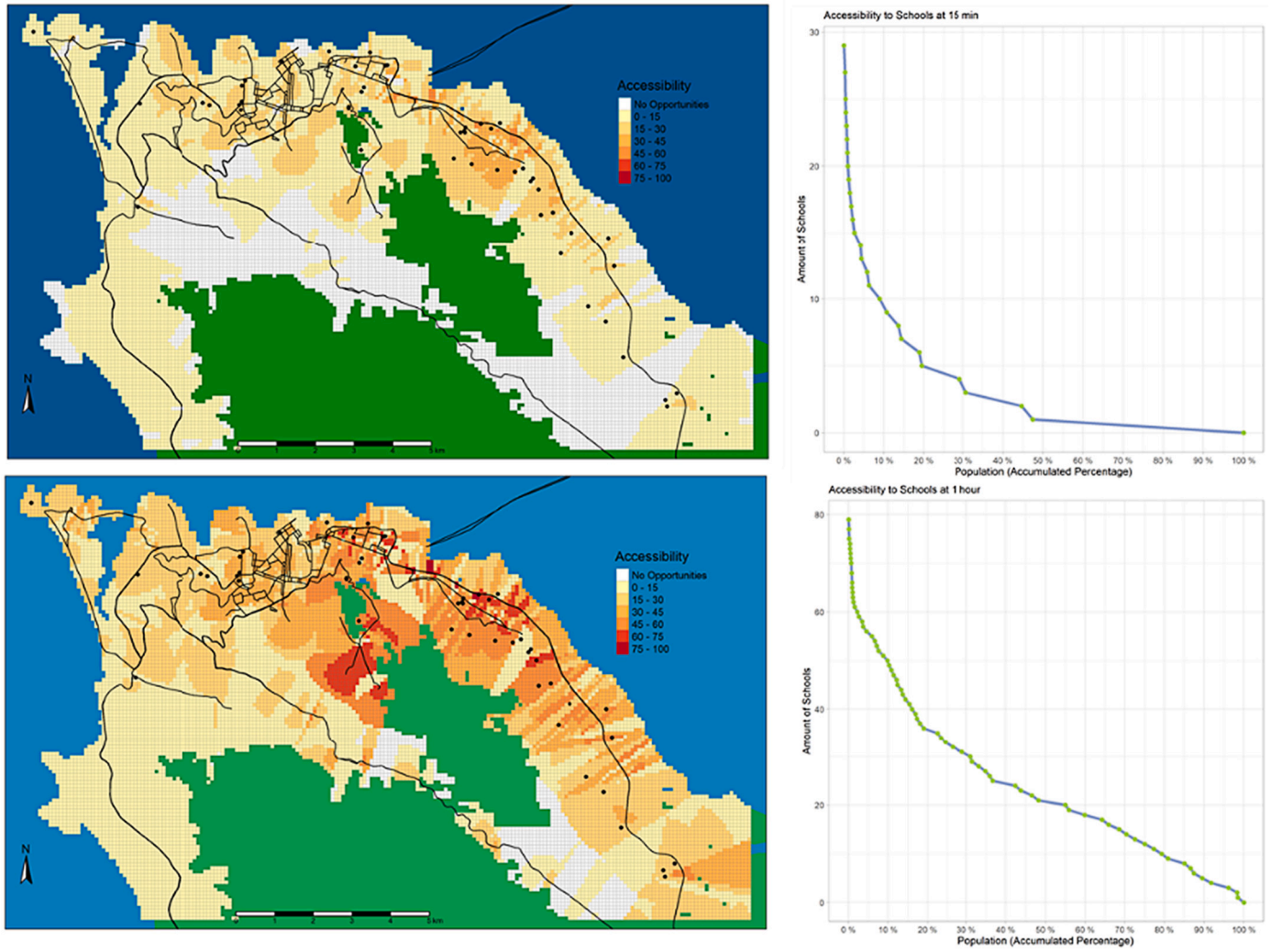


Fig. 8. Accessibility to School opportunities in Freetown within 15 min (upper) and 60 min (lower) network travel times. (Source: Own elaboration)

and other social amenities. So, we prefer saving the little we have just for feeding because things are hard these days" (F, South Ridge).

Despite differences in access to opportunities and amenities, a participant in Moyiba captures a sentiment often expressed across all neighbourhoods: "Most of us are here in this community because it is only here that we can have access to land and build our own houses" (M, Moyiba).

Overall, lower-income residents experience poorer levels of accessibility, both across and within neighbourhoods. However, participants identified specific vulnerable groups who are especially constrained, often leading to total immobility. These included: breastfeeding women, ill and elderly residents, obese people, people with physical and cognitive disabilities, and children - who all tend to remain in their neighbourhoods, given lack of appropriate public transport supply and a limited disposable income restricting travel. In Moyiba, a young female participant reported that: "as for me, my mum is old and cannot go out" (F, Moyiba), while in Brookefields participants suggested that some transport providers refuse rides to specific residents: " those sick and the elderly, who are not strong enough to take a motorbike, and students and pupils who cannot afford transport, so riders are unwilling to take them".

More vulnerable groups and lower-income residents tend to walk more and to make trade-offs between walking and the use of okadas and kekehs at different times of the day. In Cline Town, a young participant explained that: "for us, the students, we are most tired before getting to school due to walking long distances, we also spend more time on the road and sometimes get late to school." This was seconded by a young woman in the same neighbourhood who added: "at times while walking, you may be pushed by other people or may be hit by vehicles, bikes or kekehs and will not even stop. Also, because the roads are too narrow, you are likely to be pickpocketed when you get to a busy area" (F, Cline Town).

In addition to captive walking trips, there are other 'sacrifices,' in the form of setting off in the very early hours and long commutes – indicating the importance of the temporal dimension of accessibility in Freetown. In South Ridge, a participant illustrated this issue: "My wife leaves here at 2am every morning to go to town to buy business, you see; the women are going through a lot due to transportation problems that are because of bad roads here" (M, South Ridge). A similar experience is echoed in other neighbourhoods; in Moyiba, a participant noted that: "Whereas for us who are not well to do, will wake up every morning at 4am for transportation to go to different parts of the city for jobbing, schooling, and education. To wake up very early in the morning is the best solution to catch up with transportation constraints in this community to prevent being late for job, school or business place" (M, Moyiba). A South Ridge participant illustrated the consequence of being walking dependent by explaining that: "most time people spend two to three hours walking to go to town, especially business people" (M, South

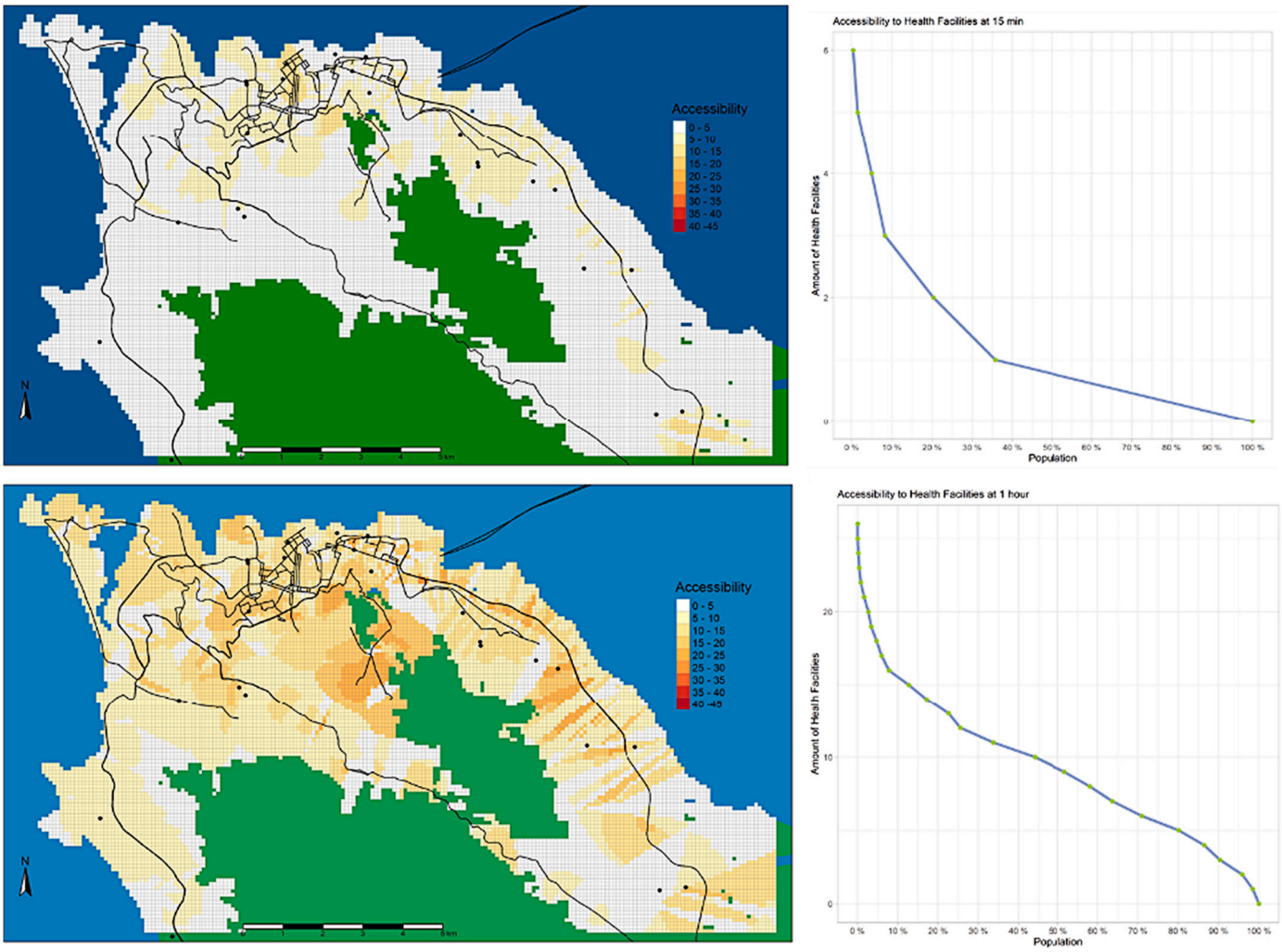
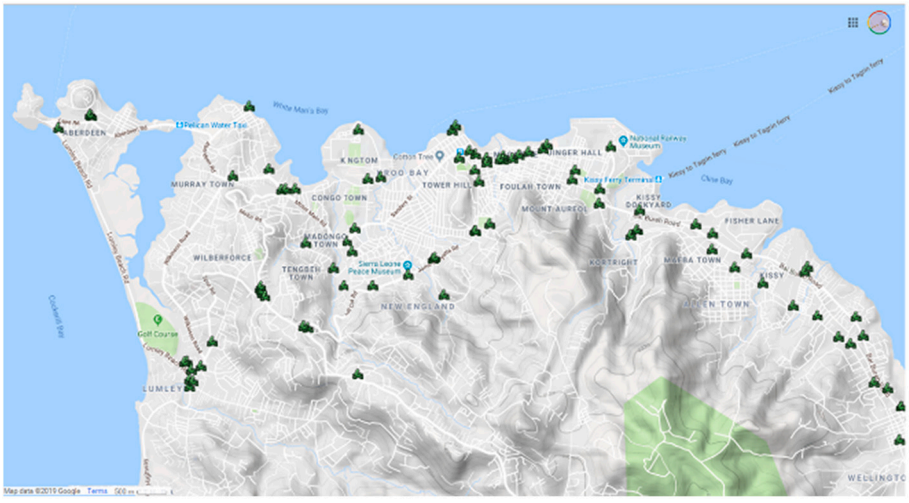


Fig. 9. Accessibility to Health facilities in Freetown at 15 min (upper) and 60 min (lower) network travel times.
(Source: Own elaboration)



Distance	Population	% Population
500	541,113	48%
1000	873,607	77%
1500	1,010,928	89%
2000	1,068,462	94%
2500	1,101,723	97%
3000	1,132,043	100%

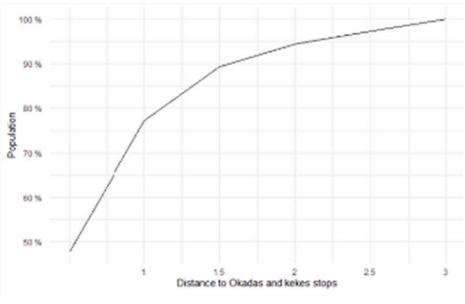


Fig. 10. Coverage of Okadas and Kekeh: Distribution of hubs (left) and population coverage (right).
(Source: Own elaboration)

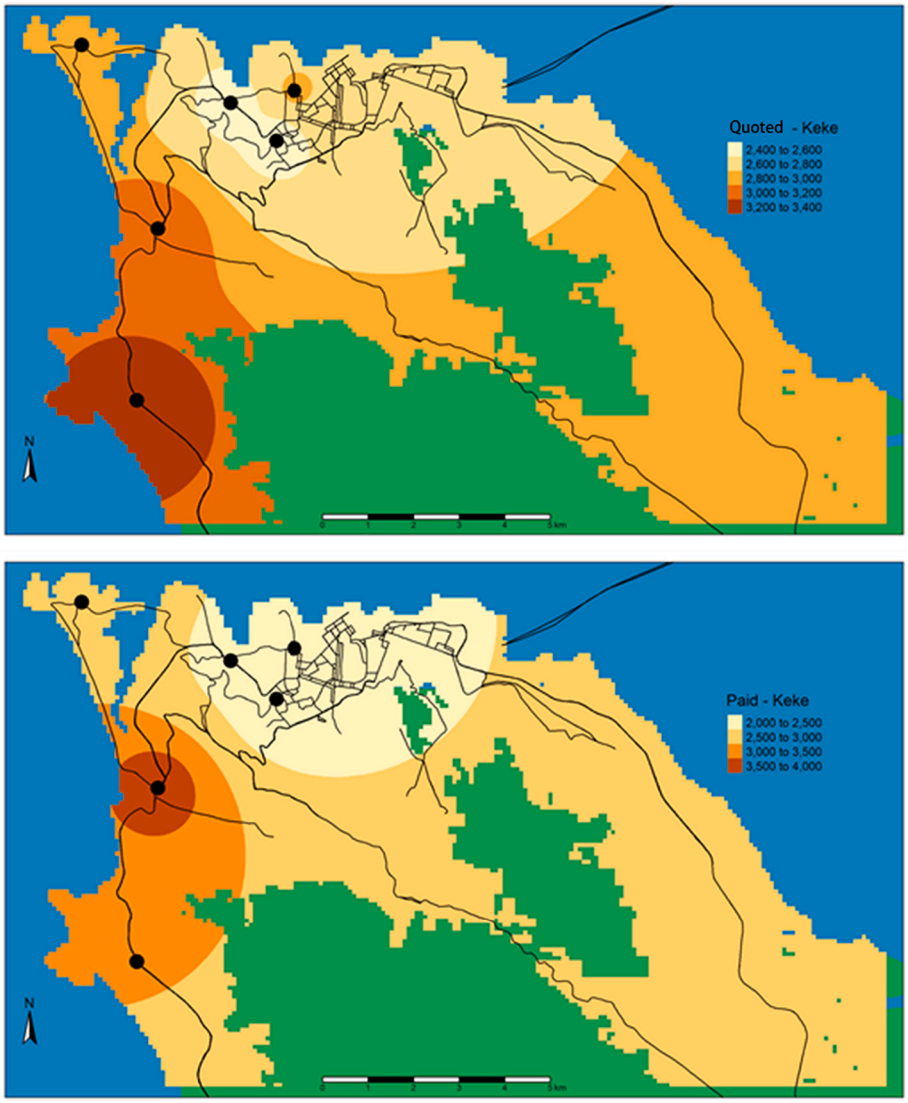


Fig. 11. Affordability curves for Kekeh: Price quoted by the operator (upper) and the paid price, after negotiation (lower). (Source: Own elaboration)

Ridge). Seasonal effects were noted by all participants, in terms of differences in their ability to travel during the rainy and the dry season. During the rainy season a large share of the population had very restricted mobility (as summarised in Fig. 13).

Participants revealed that obtaining access to opportunities comes at a steep price for many residents - and this goes beyond economic costs. Higher exposure and risk related to air pollution, crime and road accidents in the vicinity of their neighbourhood are frequently cited concerns. In Moyiba, a participant explained that it is "very difficult for us to return home when we are out, especially at night, because of the bad roads and transportation constraints which makes motor bike riders ride roughly and very scary way." People are aware of the risk and exposure they accept when using services like okadas. However, in the words of a South Ridge participant: "I believe that everything you do in life is a risk. Even to drive a vehicle is a risk. Drinking water is a risk. But the motor bike is faster (…) there are some areas that are not motorable, but you can use a bike to go to those places and do your business" (M, South Ridge). Okadas and Kekehs are instrumental for urban mobility despite their risks and limitations.

Residents highlighted the role of the informal transport sector in providing access to relevant goods and services. Their contribution is not only in terms of the increase in transport options to leave the neighbourhood, but there is also an active informal economy that brings goods and services to the neighbourhood (e.g. clothes, agricultural produce, plumbing, electrician), via itinerant vendors and service providers using these informal transport modes. In Moyiba, a community leader explained that: "Usually we buy foodstuffs like fish, paper, groundnut, and the rest at 'Bottom Mango,' but these traders now come and sell to us in the community, making things easier for us. People also come with water in drums to sell to us so that we will not have to go down the community every day to fetch water for household uses" (M, Moyiba). Respondents who were questioned about people bringing goods and services into Cline Town reported that: "yes, people come to sell fruits like mango, banana, oranges and so on (..) it helps us not to go out to buy certain stuffs most of the time" (M, Cline Town), while another respondent added that: "they help us not to spend money and time, travelling to the markets" (F, Cline Town).

When questioned about their current forms of access, residents were aware of their high dependency on motorised and low-occupancy transport. In Moyiba, a participant shared a common perception by stating that: "we don't use bicycles because the roads are bad, narrow and congested". Responses across the four neighbourhoods indicate that the car-oriented configuration of the street space, and the use of such space by those having a car, negatively affects all residents in their

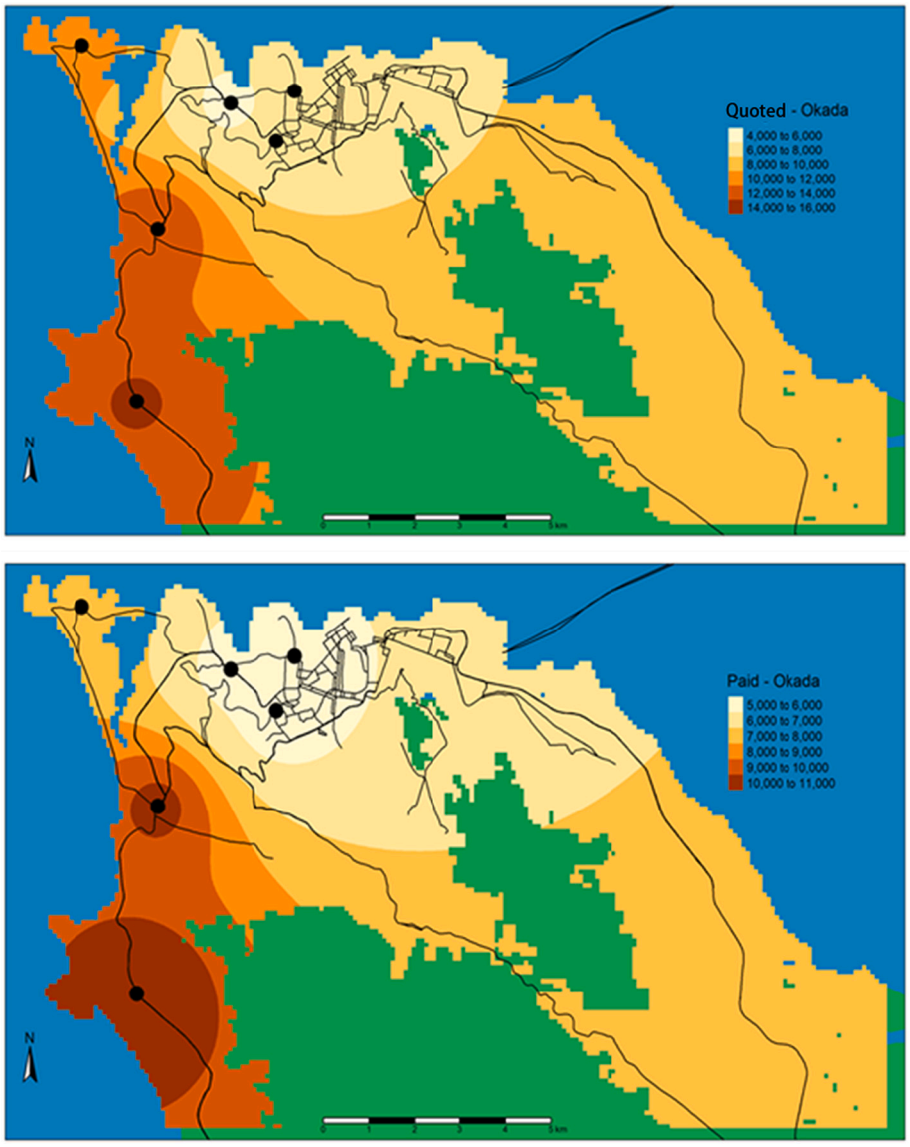


Fig. 12. Affordability curves for Okada: Posted price (upper) and Paid price (lower).
(Source: Own elaboration)

respective neighbourhoods. There was a perception by non-car-users that higher income groups have contributed to the detrimental quality of available infrastructure, without contributing sufficiently to an improvement in connectivity in their neighbourhoods or the city.

In Cline Town, a respondent observed that "people will just park their cars on the streets, taking part of the streets and causing the roads to be narrower" (M, Cline Town). In Brookefileds, residents see traffic as problematic, with a participant reporting that "in Freetown, there are certain areas that are constantly having traffic, due to the increasing population and vehicles. Most of these areas have roundabout, we have Congo-Cross, Lumley, Eastern-Police and Kissy Road for example, which are almost always having traffic" (M, Brookefields). At the neighbourhood scale, a participant from South Ridge added that since "the majority of our houses are built very close to the street, whenever people come with their vehicles, they have no options but to park in the street, very close to the house" (F, South Ridge). A resident in Moyiba captures the severity of these detriments in the street, by adding that: "I must fight to make my way through to a vehicle everyday coming home" (F, Moyiba).

6. Discussion

In Sub-Saharan African cities, issues at the macro scale have almost invariably been addressed from a top down perspective, both in the accessibility literature and in practice (Bautista-Hernández, 2020; Levine, 2020), and from a quantitative perspective (Cheng and Bertolini, 2013; Klopp and Cavoli, 2017; Malekzadeh and Chung, 2020; Páez et al., 2012; van Wee, 2016). This leads to decision-making processes disconnected from the experiences of citizens most affected by the way the city develops (Oviedo and Nieto-Combariza, 2021; Uteng and Lucas, 2017; Venter et al., 2019).

While findings from different quantitative data analyses contribute to an understanding of the wider dimensions of accessibility and its distribution at the macro scale, and some of the challenges associated with issues of coverage and affordability of both fixed-route and flexible-route public transport, in-depth insights from citizens becomes an essential input to capture the nuances of the dimensions of accessibility presented in Fig. 3. Our focus group discussions complement mainstream approaches, showing that most participants understand how long-term and city-level urbanization and land-use planning and development processes influence their ability to use diverse forms of

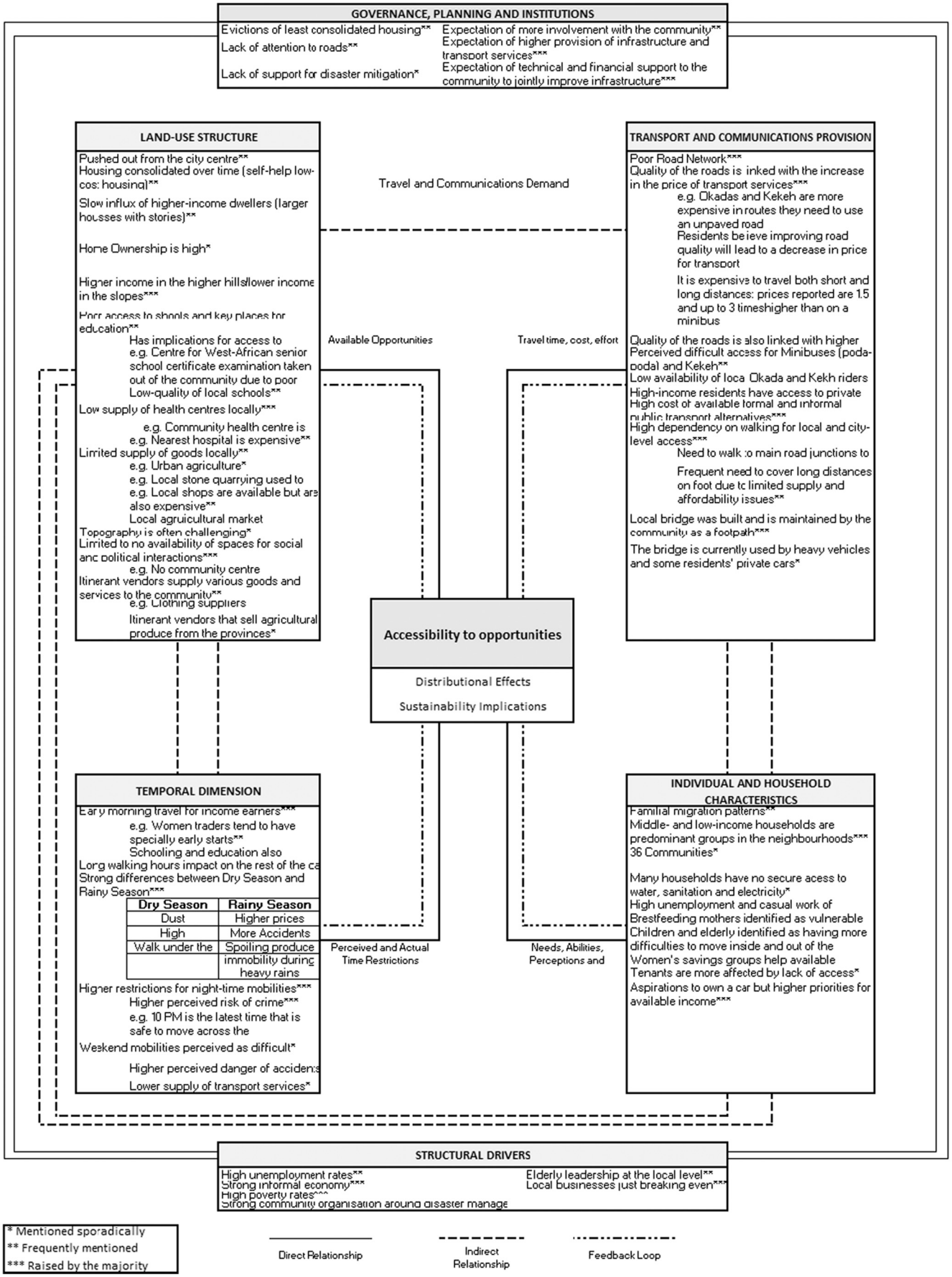

GOVERNANCE, PLANNING AND INSTITUTIONS
Evictions of least consolidated housing**
Lack of attention to roads**
Lack of support for disaster mitigation*
Expectation of more involvement with the community**
Expectation of higher provision of infrastructure and transport services***
Expectation of technical and financial support to the community to jointly improve infrastructure***
LAND-USE STRUCTURE
Pushed out from the city centre**
Housing consolidated over time (self-help low-cos: housing)**
Slow influx of higher-income dwellers (larger houses with stories)**
Home Ownership is high*
Higher income in the higher hills/lower income in the slopes***
Poor access to shools and key places for education**
Has implications for access to
e.g. Centre for West-African senior school certificate examination taken out of the community due to poor
Low-quality of local schools**
Low supply of health centres locally***
e.g. Community health centre is
e.g. Nearest hospital is expensive**
Limited supply of goods locally**
e.g. Urban agriculture*
e.g. Local stone quarrying used to
e.g. Local shops are available but are also expensive**
Local agruicultural market
Topography is often challenging*
Limited to no availability of spaces for social and political interactions***
e.g. No community centre
Itinerant vendors supply various goods and services to the community**
e.g. Clothing suppliers
Itinerant vendors that sell agricultural produce from the provinces*
Travel and Communications Demand
Available Opportunities
Travel time, cost, effort
TRANSPORT AND COMMUNICATIONS PROVISION
Poor Road Network***
Quality of the roads is linked with the increase in the price of transport services***
e.g. Okadas and Kekeh are more expensive in routes they need to use an unpaved road
Residents believe improving road quality will lead to a decrease in price for transport
It is expensive to travel both short and long distances: prices reported are 1.5 and up to 3 timeshigher than on a minibus
Quality of the roads is also linked with higher
Perceived difficult access for Minibuses (poda-podal and Kekeh**
Low availability of loca Okada and Kekh riders
High-income residents have access to private
High cost of available formal and informal public transport alternatives***
High dependency on walking for local and city-level access***
Need to walk :o main road junctions to
Frequent need to cover long distances on foot due tc limited supply and affordability issues**
Local bridge was built and is maintained by the community as a footpath***
The bridge is currently used by heavy vehicles and some residents' private cars*
Accessibility to opportunities
Distributional Effects
Sustainability Implications
TEMPORAL DIMENSION
Early morning travel for income earners***
e.g. Women traders tend to have specially early starts**
Schooling and education also
Long walking hours impact on the rest of the ca
Strong differences between Dry Season and Rainy Season***
Dry Season | Rainy Season
Dust | Higher prices
High | More Accidents
Walk under the | Spoiling produce
immobility during heavy rains
Higher restrictions for night-time mobilities***
Higher perceived risk of crime***
e.g. 10 PM is the latest time that is safe to move across the
Weekend mobilities perceived as difficult*
Higher perceived danger of accidents
Lower supply of transport services*
Perceived and Actual Time Restrictions
Needs, Abilities, Perceptions and
INDIVIDUAL AND HOUSEHOLD CHARACTERISTICS
Familial migration patterns**
Middle- and low-income households are predominant groups in the neighbourhoods***
36 Communities*
Many households have no secure acess to water, sanitation and electricity*
High unemployment and casual work of
Brestfeeding mothers identified as vulnerable
Children and elderly identified as having more difficulties to move inside and out of the
Women's savings groups help available
Tenants are more affected by lack of access*
Aspirations to own a car but higher priorities for available income***
STRUCTURAL DRIVERS
High unemployment rates**
Strong informal economy***
High poverty rates***
Strong community organisation around disaster manage
Elderly leadership at the local level**
Local businesses just breaking even***
* Mentioned sporadically
** Frequently mentioned
*** Raised by the majority
Direct Relationship
Indirect Relationship
Feedback Loop

Fig. 13. Insights from Focus Groups about the different dimensions of accessibility that impact on individuals and communities. (Source: Own elaboration)

transport and gain accessibility.

Such reflections resonate with research unpacking the city's development from different perspectives (Koroma et al., 2020; Oviedo et al., 2021; World Bank Group, 2018). Despite significant differences in each neighbourhood's socioeconomic, spatial, and motorization characteristics, results suggest that formal and informal practices related to land-use, housing, and transport are significant influences on accessibility. The lived experiences of accessibility can be illustrated in each of the dimensions of the proposed framework, as summarised in Fig. 13.

However, our understanding of the interactions between different dimensions of accessibility would not be as clear without the quantitative city-level accessibility analyses presented in Section 5.2; and the complexities of transport provision and its links with individual circumstances and temporal dimensions, can best be explored through the analysis of coverage and affordability as presented in Sections 5.1 and 5.3. The latter represents a relevant contribution to the African literature, as there are few published analyses of affordability in the region (Venter and Behrens, 2005; Venter, 2011). Collective experiences at the neighbourhood level, and the individual experiences of residents from the four neighbourhoods, contribute to define urban land use conditions underpinning access and dependency of both motorised and non-motorized transport depending on how each neighbourhood fits in the larger accessibility landscape of Freetown.

The findings presented in this paper supports the need to consider different timescales and time periods when analysing accessibility in its different dimensions and scales. Residents' experiences of accessibility are not only spatially differentiated, but also continually changing as a consequence of varying risks found in the environment, seasonality of weather, and the ever-changing configuration of the network of formal and informal public transport provided in the city.

As supported by previous literature, the high dependency on walking in Freetown is explained by factors such as: affordability, poor road infrastructure that cannot support the operation of motorised transport - particularly in neighbourhoods challenged by topography and peripherality - (Bryceson et al., 2003; Cervero, 2013; Kamalipour and Dovey, 2019; Oviedo et al., 2021), and the need for securing livelihoods, even at the expense of long walking times and personal risks of injury and exposure to crime (Esson et al., 2016; Pojani and Stead, 2017; Venter et al., 2014). Results also suggest that, in neighbourhoods where residents have been both partially excluded from transport supply and priced out of using the public transport services, gaps in mobility, accessibility, and expenditure in transport (in terms of time, money, and effort) are more marked, leading to higher levels of immobility in some population groups (see Fig. 12).

7. Conclusions

This paper summarises the results of a multidisciplinary research study into urban accessibility in a context that has not been frequently explored in the transport literature, namely in Sub-Saharan Africa. The paper presents novel evidence providing a multi-scalar and multidimensional understanding of accessibility, in the context of mobility transitions in Freetown, and taking full account of inequality issues.

The paper also demonstrates the value of using new sources of information to examine the effect of informal transport provision on access to a range of opportunities. Such information needs to encompass different scales and degrees of depth and complexity, which suggests the need for both qualitative as well as quantitative data to identify current and future accessibility practices. Despite relatively small sample sizes and the limited accuracy of some of the tools deployed, as compared to more sophisticated technologies and more resource-demanding quantitative methods, the findings add substantially to the literature, both qualitatively and quantitatively. Furthermore, the availability and quality of georeferencing information can be improved, at least at an exploratory level, using tools such as WhatsApp. The pilot exercise presented in this paper suggests that the use of relatively common technologies, in a participatory fashion, expands the availability of quantitative and spatial data, and facilitates the use of results by community groups, outside the expert-led circles of policy and practice. Greater levels of community engagement provide new opportunities for implementing new collaborative data collection strategies, such as the ones outlined in this paper, combined with other engagement techniques such as workshops, tours and photovoice. These combinations can contribute to a better understanding of people's everyday experiences, as well as to greater levels of participation of citizens in urban planning decisions.

The findings from the various analyses of accessibility presented here suggest that inaccessibility can lead to double marginalisation. On the one hand, inaccessible areas and population groups suffer from exclusion from opportunities supporting the development and accumulation of economic, social, and human capital. On the other hand, as reflected by residents in South Ridge, the lack of sufficient access, combined with inequalities in the use of road space and infrastructure, can lead to vulnerability and exposure to environmental risks and externalities, particularly for more vulnerable social groups.

In the face of limited local technical and financial capacity, there is a need to develop practical incremental planning and transitional actions, informed by comprehensive, evidence-based understandings of accessibility in its different guises and scales. Accessibility analysis needs to inform the detailed assessment of distributional issues, the targeting of policies and the optimisation of resources. This becomes even more urgent with the recognition of how inequalities play out in relation to the COVI-19 pandemic. Freetown is not new to such challenges, given the Ebola pandemic (2014).

Such types of analysis, which can be communicated and interpreted in a myriad of formats, is also helpful to foster collaborative debate among policy makers, planners, and citizen representatives. In the specific context of Freetown and Sierra Leone, the types of accessibility analysis presented here can inform policy and public investment decisions (i) at national level, by the Ministry of Transport and the Ministry of Land and Housing, (ii) the Freetown City Council and the Sierra Leone Road Transport Company at the local level, and (iii) organisational practices by organisations in the private and civil society sectors, paratransit associations, land developers, and community-based organisations, such as the Federation for the Urban Poor. Furthermore, this information can be adopted by academic institutions tasked with training new generations of transport and planning practitioners locally, expanding the scope of mainstream approaches to transport planning practice. Such analyses, and their adoption across all sectors, are essential for the co-production of a city vision and future policy directions that are rooted in improving accessibility, while decreasing car dependency and promoting more sustainable modes and uses and distribution of land. The provision of collective deliberative spaces is essential for translating academic action research into policy and practice.

In this regard, it is important to recognise that a number of African cities are at a similar point in the motorisation process as Freetown. This is, therefore, a critical opportunity for a wider consideration of the relevance and use of the findings and methodological learnings set out in this paper, for other Sub-Saharan African cities.

CRediT authorship contribution statement

Daniel Oviedo: Conceptualization, Formal analysis, Investigation,

Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing. **Clemence Cavoli:** Formal analysis, Project administration, Resources, Validation, Writing – original draft, Writing – review & editing. **Caren Levy:** Conceptualization, Formal analysis, Validation, Writing – original draft, Writing – review & editing. **Braima Koroma:** Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. **Joseph Macarthy:** Formal analysis, Validation, Writing – original draft, Writing – review & editing. **Orlando Sabogal:** Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. **Fatima Arroyo:** Data curation, Formal analysis, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. **Peter Jones:** Conceptualization, Funding acquisition, Supervision, Validation, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

None.

Data availability

Data will be made available on request.

Acknowledgements

This research was funded by the Social and Economic Research Council of the United Kingdom through grant ES/S00050X/1 as part of the Global Challenges Research Fund programme. The authors want to thank all the participants in this research for their valuable inputs, their time, and commitment to participate in this research. We also thank the World Bank Group for enabling access to data and resources necessary for the accessibility analysis.

References

AfDB/OECD/UNDP, 2017. African Economic Outlook 2017: Entrepreneurship and Industrialisation. Available at. https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/AEO_2017_Report_Full_English.pdf. /doi:10.1787/aeo-2017-en (Last accessed 17/05/2019).

Banister, D., 2019, May 4. Transport for all. Transp. Rev. 39 (3), 289–292. https://doi.org/10.1080/01441647.2019.1582905.

Bautista-Hernández, D.A., 2020. Commuting inequality, role of urban structure, and identification of disadvantaged groups in the mexico City metropolitan area. J. Transp. Land Use 13 (1), 159–183. https://doi.org/10.5198/jtlu.2020.1611.

Benevenuto, R., Caulfield, B., 2019. Poverty and transport in the global south: an overview. Transp. Policy 79, 115–124. https://doi.org/10.1016/j.tranpol.2019.04.018.

Black, J., 2018. Urban transport planning. In: In Urban Transport Planning. Routledge. https://doi.org/10.4324/9781351068604.

Bocarejo, S.J.P., Oviedo, H.D.R., 2012. Transport accessibility and social inequities: a tool for identification of mobility needs and evaluation of transport investments. J. Transp. Geogr. 24, 142–154. https://doi.org/10.1016/j.jtrangeo.2011.12.004.

Brussel, M.J., Zuidgeest, M., Pfeiffer, K., Van Maarseveen, M.F.A., 2019. Access or Accessibility? A critique of the urban transport SDG indicator. Int. J. Geo-Information 8 (2), 67–90.

Bryceson, D.F., Mbara, T.C., Maunder, D., 2003. Livelihoods, daily mobility and poverty in sub-saharan Africa. Transp. Rev. 23 (2), 177–196. https://doi.org/10.1080/01441640309891.

Castán Broto, V., Ortiz, C., Lipietz, B., Osuteye, E., Johnson, C., Kombe, W., Mtwangi-Limbumba, T., Cazanave Macías, J., Desmaison, B., Hadny, A., Kisembo, T., Koroma, B., Macarthy, J., Mbabazi, J., Lwasa, S., Pérez-Castro, B., Peña Díaz, J., Rodríguez Rivero, L., Levy, C., 2022. Co-production outcomes for urban equality: learning from different trajectories of citizens' involvement in urban change. Curr. Res. Environ. Sustain. 4, 100179 https://doi.org/10.1016/J.CRSUST.2022.100179.

Cervero, R.R., 2013. Linking urban transport and land use in developing countries. J. Transp. Land Use 6 (1), 7–24. https://doi.org/10.5198/jtlu.v6i1.425.

Cheng, J., Bertolini, L., 2013. Measuring urban job accessibility with distance decay, competition and diversity. J. Transp. Geogr. 30, 100–109. https://doi.org/10.1016/j.jtrangeo.2013.03.005.

Chesser, S., Porter, M.M., Tuckett, A.G., 2019. Cultivating citizen science for all: ethical considerations for research projects involving diverse and marginalized populations, 23 (5), 497–508. https://doi.org/10.1080/13645579.2019.1704355.

Currie, G., 2004. Gap analysis of public transport needs: measuring spatial distribution of public transport needs and identifying gaps in the quality of public transport provision. Transp. Res. Rec. 1895, 137–146. https://doi.org/10.3141/1895-18.

Dick, D.M., 2017. Rethinking the way we do research: the benefits of community-engaged, citizen science approaches and nontraditional collaborators. Alcohol. Clin. Exp. Res. 41 (11), 1849–1856. https://doi.org/10.1111/ACER.13492.

Dimitriou, H.T., Gakenheimer, R., 2011. Urban transport in the developing world: A handbook of policy and practice. In: In Urban Transport in the Developing World: A Handbook of Policy and Practice. https://doi.org/10.4337/9781849808392.

Dong, X., Ben-Akiva, M.E., Bowman, J.L., Walker, J.L., 2006. Moving from trip-based to activity-based measures of accessibility. Transp. Res. A Policy Pract. 40 (2), 163–180. https://doi.org/10.1016/j.tra.2005.05.002.

Esson, J., Gough, K.V., Simon, D., Amankwaa, E.F., Ninot, O., Yankson, P.W.K., 2016. Livelihoods in motion: linking transport, mobility and income-generating activities. J. Transp. Geogr. 55, 182–188. https://doi.org/10.1016/j.jtrangeo.2016.06.020.

Farrington, J.H., 2007. The new narrative of accessibility: its potential contribution to discourses in (transport) geography. J. Transp. Geogr. 15 (5), 319–330. https://doi.org/10.1016/j.jtrangeo.2006.11.007.

Farrington, J., Farrington, C., 2005. Rural accessibility, social inclusion and social justice: towards conceptualisation. J. Transp. Geogr. 13 (1 SPEC. ISS), 1–12. https://doi.org/10.1016/j.jtrangeo.2004.10.002.

Ferreira, A., Papa, E., 2020. Re-enacting the mobility versus accessibility debate: moving towards collaborative synergies among experts. Case Stud. Transp. Policy 8 (3), 1002–1009. https://doi.org/10.1016/j.cstp.2020.04.006.

Foth, N., Manaugh, K., El-Geneidy, A.M., 2013. Towards equitable transit: examining transit accessibility and social need in Toronto, Canada, 1996-2006. J. Transp. Geogr. 29, 1–10. https://doi.org/10.1016/j.jtrangeo.2012.12.008.

Gao, L., Wu, J., Liu, R., 2010. Time contours: using IC toll information to describe public transport networks accessibility. Proc. Conf. Traffic Transp. Stud. ICTTS 383, 1089–1097. https://doi.org/10.1061/41123(383)102.

Geurs, Karst, Van Wee, Bert, 2004. Accessibility evaluation of land-use and transport strategies: review and research directions. J. Transp. Geograph. 12 (2), 127–140. https://doi.org/10.1016/j.jtrangeo.2003.10.005.

Government of Sierra Leone, 2015. Habitat III National Report. GoSL, Freetown, Sierra Leone.

Government of Sierra Leone, 2019. Sierra Leone's Medium-Term National Development Plan 2019-2023: A New Direction for Improving People's Lives through Education, Inclusive Growth, and Building a Resilient Economy. GoSL, Freetown, Sierra Leone.

Guzman, L.A., Oviedo, D., Rivera, C., 2017. Assessing equity in transport accessibility to work and study: the Bogotá region. J. Transp. Geogr. 58, 236–246. https://doi.org/10.1016/j.jtrangeo.2016.12.016.

Halden, D., 2002. Using accessibility measures to integrate land use and transport policy in Edinburgh and the Lothians. Transp. Policy 9 (4), 313–324. https://doi.org/10.1016/S0967-070X(02)00017-3.

Halden, D., Jones, P., Wixey, S., 2005. Measuring Accessibility as Experienced by Different Socially Disadvantaged Groups. Accessibility Analysis Literature Review, Group, June.

Handy, S., 2020. Is accessibility an idea whose time has finally come? Transp. Res. Part D: Transp. Environ. 83, 102319 https://doi.org/10.1016/j.trd.2020.102319.

Handy, S.L., Niemeier, D.A., 1997. Measuring accessibility: an exploration of issues and alternatives. Environ. Plan. A 29 (7), 1175–1194. https://doi.org/10.1068/a291175.

Jaramillo, C., Lizárraga, C., Grindlay, A.L., 2012. Spatial disparity in transport social needs and public transport provision in Santiago de Cali (Colombia). J. Transp. Geogr. 24, 340–357. https://doi.org/10.1016/j.jtrangeo.2012.04.014.

Jones, P., Lucas, K., 2012. The social consequences of transport decision-making: clarifying concepts, synthesising knowledge and assessing implications. J. Transp. Geogr. 21, 4–16. https://doi.org/10.1016/j.jtrangeo.2012.01.012.

Justice, S., Taylor, I., Sloman, L., 2008. Towards Transport Justice. April.

Kamalipour, H., Dovey, K., 2019. Mapping the visibility of informal settlements. Habitat Int. 85, 63–75. https://doi.org/10.1016/j.habitatint.2019.01.002.

Katapally, T.R., 2019. The SMART framework: integration of citizen science, community-based participatory research, and systems science for population health science in the digital age. JMIR Mhealth Uhealth *7* (*8*), *E14056*.

Klopp, J.M., Cavoli, C.M., 2017. The paratransit puzzle: mapping and master planning for transportation in Maputo and Nairobi. Urban Mobil. Global South 95–110. https://doi.org/10.4324/9781315265094.

Koroma, B., Oviedo, D., Yusuf, Y., Macarthy, J., Cavoli, C., Jones, P., Levy, C., Sellu, S., 2020. CITY PROFILE: Freetown Base conditions of mobility, Accessibility, and Land Use. T-SUM Working Papers 1, 1–54. https://www.t-sum.org/.

Kwan, M.P., 1999. Gender and individual access to urban opportunities: A study using space–time measures. Prof. Geogr. 51 (2), 210–227. https://doi.org/10.1111/0033-0124.00158.

Kwan, M.P., Weber, J., 2008. Scale and accessibility: implications for the analysis of land use-travel interaction. Appl. Geogr. 28 (2), 110–123. https://doi.org/10.1016/j.apgeog.2007.07.002.

Lee, N., Sissons, P., Hughes, C., Green, A., Atfield, G., Adam, D., Rodríguez-pose, A., 2014. Cities, growth and poverty: A review of the evidence. In: In Joseph Rowntree Foundation (Issue February 2014).

Levine, J., 2020. A century of evolution of the accessibility concept. Transp. Res. Part D: Transp. Environ. 83, 102309 https://doi.org/10.1016/j.trd.2020.102309.

Levy, C., 2013. Travel choice reframed: "deep distribution" and gender in urban transport. Environ. Urban. 25 (1), 47–63. https://doi.org/10.1177/0956247813477810.

Levy, C., 2019. Travel choice reframed: "Deep distribution" and gender in urban transport. In: Integrating Gender into Transport Planning: From One to Many Tracks.

Springer International Publishing, pp. 43–65. https://doi.org/10.1007/978-3-030-05042-9_3.
Levy, C., Dávila, J.D., 2017. Planning for mobility and socio-environmental justice: The Case of Medellín, Colombia. In: In Environmental Justice and Urban Resilience in the Global South. Palgrave Macmillan, pp. 37–56. https://doi.org/10.1057/978-1-137-47354-7_3.
Litman, T., 1999. Exploring the paradigm shifts needed to reconcile transportation and sustainability objectives. Transp. Res. Rec. 1670, 8–12. https://doi.org/10.3141/1670-02.
Lovett, A., Haynes, R., Sünnenberg, G., Gale, S., 2002. Car travel time and accessibility by bus to general practitioner services: A study using patient registers and GIS. Soc. Sci. Med. 55 (1), 97–111. https://doi.org/10.1016/S0277-9536(01)00212-X.
Lucas, K., 2019. A new evolution for transport-related social exclusion research? J. Transp. Geogr. 81, 102529 https://doi.org/10.1016/j.jtrangeo.2019.102529.
Macarthy, Joseph, Frediani, Alex, Kamara, S.F., 2019. Report on the role of Community Action Area Planning in expanding the participatory capabilities of the urban poor. SLURC, Freetown, Sierra Leone.
Malekzadeh, A., Chung, E., 2020. A review of transit accessibility models: challenges in developing transit accessibility models. Int. J. Sustain. Transp. 14 (10), 733–748. https://doi.org/10.1080/15568318.2019.1625087.
Martens, K., 2012. Justice in transport as justice in accessibility: applying Walzer's "spheres of Justice" to the transport sector. Transportation 39 (6), 1035–1053. https://doi.org/10.1007/s11116-012-9388-7.
MCLPE & FCC, 2014. Preparatory Components and Studies for the Freetown Development Plan "The Urban Planning Project". Freetown City Council, Freetown, Sierra Leone.
Niehaus, M., Galilea, P., Hurtubia, R., 2016. Accessibility and equity: an approach for wider transport project assessment in Chile. Res. Transp. Econ. 59, 412–422. https://doi.org/10.1016/j.retrec.2016.05.003.
Oviedo, Daniel, 2021. Making the links between accessibility, social and spatial inequality, and social exclusion: A framework for cities in Latin America. *Advances in Transport Policy and Planning*, 8. Elsevier, pp. 135–172, 5.
Oviedo, D., Guzman, L.A., 2020. Revisiting accessibility in a context of sustainable transport: capabilities and inequalities in Bogota. Sustainability (Switzerland) 12 (11), 4464. https://doi.org/10.3390/su12114464.
Oviedo, D., Nieto-Combariza, M., 2021. Transport planning in the global south. Int. Encyclopedia Transp. 118–124 https://doi.org/10.1016/B978-0-08-102671-7.10624-4.
Oviedo, D., Okyere, S.A., Nieto, M., Kita, M., Kusi, L.F., Yusuf, Y., Koroma, B., 2021. Walking off the beaten path: everyday walking environment and practices in informal settlements in Freetown. Res. Transp. Bus. Manag. 100630 https://doi.org/10.1016/j.rtbm.2021.100630.
Páez, A., Scott, D.M., Morency, C., 2012. Measuring accessibility: positive and normative implementations of various accessibility indicators. J. Transp. Geogr. 25, 141–153. https://doi.org/10.1016/j.jtrangeo.2012.03.016.
Pereira, R.H.M., Schwanen, T., Banister, D., 2017. Distributive justice and equity in transportation. Transp. Rev. 37 (2), 170–191. https://doi.org/10.1080/01441647.2016.1257660.
Pojani, D., Stead, D., 2017. The urban transport crisis in emerging economies: An introduction. In: Pojani, D., Stead, D. (Eds.), Urban Book Series. Springer, pp. 1–10. https://doi.org/10.1007/978-3-319-43851-1_1.
Resnik, D.B., Elliott, K.C., Miller, A.K., 2015. A framework for addressing ethical issues in citizen science. Environ. Sci. Pol. 54, 475–481. https://doi.org/10.1016/J.ENVSCI.2015.05.008.
Schönfelder, S., Axhausen, K.W., 2003. Activity spaces: measures of social exclusion? Transp. Policy 10 (4), 273–286. https://doi.org/10.1016/j.tranpol.2003.07.002.
Silverman, R.M., 2014. Analysing qualitative data. In: Silva, E.A., Healey, P., Harris, N., Van den Broeck, P. (Eds.), Routledge Handbook of Planning Research Methods: Analysing Qualitative Data (Issue March). https://doi.org/10.4324/9781315851884.ch3.2.
SSL, OPHI, and UNEP, 2019. Sierra Leone Multidimensional Poverty Index. United Nations Economic Programme.
Statistics Sierra Leone, 2016. Population and Housing Census: Summary of Final Results. SSL, Freetown, Sierra Leone.
Statistics Sierra Leone, 2017. Population and Housing Census: National Analytical Report. SSL, Freetown, Sierra Leone.
Teoh, R., Anciaes, P., Jones, P., 2020. Urban mobility transitions through GDP growth: policy choices facing cities in developing countries. J. Transp. Geogr. 88, 102832 https://doi.org/10.1016/j.jtrangeo.2020.102832.
UK Department for International Development, 2018. DFID Sierra Leone country profile. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/913344/Sierra-Leone-Profile.pdf. (Accessed 11 August 2021).
Unit, S.E., 2012. Making connections. In: Health devices, Vol. 41. Issue 4. http://www.ncbi.nlm.nih.gov/pubmed/23930429.
United Nations Development Program, 2015. Sustainable Development Goals. https://www.undp.org/content/undp/en/home/sustainable-development-goals.html. (Accessed 17 January 2020).
Ureta, S., 2008. Mobilising poverty?: Mobile phone use and everyday spatial mobility among low-income families in Santiago, Chile. Inf. Soc. 24 (2), 83–92. https://doi.org/10.1080/01972240701883930.
Urry, J., 2007. Mobilities. Polity. https://books.google.co.uk/books?hl=en&lr=&id=uVwNYJlBxvgC&oi=fnd&pg=PR5&dq=urry+2007+mobilities&ots=EyfkXvYled&sig=rzaE6bTezX6t8_DnJqPVJTAwuGA.
Uteng, T.P., Lucas, K., 2017. Urban mobilities in the global south. In: Uteng, T.P., Lucas, K. (Eds.), Urban Mobilities in the Global South. Routledge. https://doi.org/10.4324/9781315265094.
van Wee, B., 2016. Accessible accessibility research challenges. J. Transp. Geogr. 51, 9–16. https://doi.org/10.1016/j.jtrangeo.2015.10.018.
van Wee, B., Geurs, K., 2011. Discussing equity and social exclusion in accessibility evaluations. Eur. J. Transp. Infrastruct. Res. 11 (4), 350–367. https://doi.org/10.18757/ejtir.2011.11.4.2940.
Vargas, J., Brassiolo, P., Sanguinetti, P., Daude, C., Goytia, C., Álvarez, F., Estrada, R., Fajardo, G., 2017. Urban growth and access to opportunities: a challenge for Latin America. In: Report on Economic Development. CAF. https://econpapers.repec.org/RePEc:dbl:dblrep:1091.
Vasconcellos, E.A., 2014. Urban transport environment and equity: the case for developing countries. In: Urban Transport Environment and Equity: The Case for Developing Countries. Routledge. https://doi.org/10.4324/9781315071756.
Vecchio, G., Tiznado-Aitken, I., Hurtubia, R., 2020. Transport and equity in Latin America: a critical review of socially oriented accessibility assessments*. Transp. Rev. 40 (3), 354–381. https://doi.org/10.1080/01441647.2020.1711828.
Venter, C., 2011. Transport expenditure and affordability: the cost of being mobile. Dev. South. Afr. 28 (1), 121–140. https://doi.org/10.1080/0376835X.2011.545174.
Venter, C., Behrens, R., 2005. Transport expenditure: is the 10% policy benchmark appropriate?. In: Proceedings of the 24th Southern African Transport Conference, SATC 2005 (Issue January, pp. 668–679).
Venter, C.J., Molomo, M., Mashiri, M., 2014. Supply and pricing strategies of informal rural transport providers. J. Transp. Geogr. 41, 239–248. https://doi.org/10.1016/j.jtrangeo.2014.10.001.
Venter, C., Jennings, G., Hidalgo, D., Valderrama Pineda, A.F., 2018. The equity impacts of bus rapid transit: A review of the evidence and implications for sustainable transport. Int. J. Sustain. Transp. Vol. 12 (Issue 2), 140–152. Taylor and Francis Ltd. https://doi.org/10.1080/15568318.2017.1340528.
Venter, C., Mahendra, A., Hidalgo, D., 2019. From mobility to access for all: Expanding urban transportation choices in the global south. In: World Resource Report. www.citiesforall.org.
Walker, J., Ossul-Vermehren, I., 2021. (Re-)constructing disability through research: methodological challenges of intersectional research in informal urban settlements. Inclusive Urban Development in the Global South 167–181. https://doi.org/10.4324/9781003041566-12.
Weiss, D.J., Nelson, A., Gibson, H.S., Temperley, W., Peedell, S., Lieber, A., Hancher, M., Poyart, E., Belchior, S., Fullman, N., Mappin, B., Dalrymple, U., Rozier, J., Lucas, T. C.D., Howes, R.E., Tusting, L.S., Kang, S.Y., Cameron, E., Bisanzio, D., Gething, P.W., 2018. A global map of travel time to cities to assess inequalities in accessibility in 2015. Nature 553 (7688), 333–336. https://doi.org/10.1038/nature25181.
World Bank Group, 2018. Reviving Urban Development: The Importance of Freetown for the National Economy (Issue 1).
WorldPop, 2019. Population Data for Sierra Leone. https://www.worldpop.org. (Accessed 1 February 2020).
Zagatti, G.A., Gonzalez, M., Avner, P., Lozano-Gracia, N., Brooks, C.J., Albert, M., Gray, J., Antos, S.E., Burci, P., Zu Erbach-Schoenberg, E., Tatem, A.J., Wetter, E., Bengtsson, L., 2018. A trip to work: estimation of origin and destination of commuting patterns in the main metropolitan regions of Haiti using CDR. Develop. Eng. 3, 133–165. https://doi.org/10.1016/j.deveng.2018.03.002.