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# Exploring Accessibility to Employment Opportunities in African Cities

## A First Benchmark

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## Abstract

This paper presents an analysis of transit accessibility to employment for 11 African cities. The use of identical methodologies and similar data sets allows for the creation of the first benchmark to compare accessibility across urban areas in Africa through different metrics and visuals. The study shows how the spatial pattern of land use and transport systems perform in connecting people to employment opportunities in these various settings. This first comparable benchmark is achieved by overcoming two significant data hurdles that are common in many developing country cities and in Africa in particular: (i) the scarcity of information on the distribution of employment and (ii) the lack of information on transit routes and travel times. These data gaps are filled through a novel methodology to estimate the distribution of employment in urban areas (Employment Opportunity Areas) as well as a comprehensive mapping of informal transit networks. The analysis developed here can be replicated in different cities in the future. The computation of these baseline accessibility studies also opens up the possibility to assess the impacts of future transport investments and/or land use changes, through the use of counterfactual scenarios, which could assist decision makers in these cities. Finally, this analysis can serve as a demonstration that the computation of accessibility metrics is achievable, including in data scarce environments, and should be considered as a progress indicator for Sustainable Development Goal 11.2, which focuses on safe and affordable transport for all, including public transport.


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A First Benchmark [1]

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# 1 INTRODUCTION

Cities can schematically be viewed as labor markets (Bertaud 2014), which excel in matching job seekers and employers because they are able to connect the two efficiently. Access to economic opportunities in cities, and jobs in particular, is central to achieving large and efficient labor markets which can promote agglomeration economies, economic development and social inclusion (Rosenthal and Strange 2004). Conversely, low accessibilities can have adverse consequences whereby (i) households are forced to compromise on living conditions to remain within reasonable travel times of jobs (Gulyani, Talukdar, and Jack 2010), and (ii) fragmented urban labor markets impede the development of large scale, high productivity economic activities (Duranton and Puga 2004; Combes and Gobillon 2015). Beyond these, employment spatial mismatch in developing country cities can reinforce patterns of social segregation with high social exclusion and economic costs in terms of vulnerability, crime, violence and inequality.

The analyses supporting most urban transport projects have been aimed traditionally at enhancing citizens' 'mobility' – i.e. their ability to move freely and swiftly about the city – instead of enhancing a citizen's access to opportunities through the adoption of a more comprehensive land use and transport lens. This approach has led most cities to develop far reaching and intricate highway networks that have mostly bred more congestion and the perils that come with it (e.g. auto-dependency; longer travel times for the poor vis-à-vis higher income residents; pollution; climate change) (Levine, Grengs, and Shen 2009; Litman 2017). Dysfunctional transport and land markets mean that cities have failed to capture the productivity and agglomeration benefits of integrated labor markets.

Accessibility offers a powerful lens to assess how a mobility system is serving an urban area. We can reframe the efficiency of transport systems in terms of their ability to connect people with opportunities rather than mobility. A city's accessibility levels is a product of two variables: (i) the land use patterns of a city, and (ii) the efficiency of the transport system. Accessibility emphasizes the interconnected nature of mobility and land-use, and provides a framework to evaluate the city in terms of its ability to connect its citizens to opportunities. It provides a starting point to identify land use planning options and transport investments that can foster more integrated urban labor markets through the use of counterfactual scenarios. While the natural candidate to increase accessibility to employment opportunities has traditionally been investments in the transportation networks, some works have shone a light on the importance of urban planning and coordinating land uses with transport infrastructure (Peralta Quirós and Mehndiratta 2015; Avner and Lall 2016). In particular Avner and Lall (2016), show in Nairobi, Kenya, that alternative land use settings could double average accessibility to employment opportunities, without any investments in the transportation system.

Utilizing new tools to study accessibility offers a lens by which we can better understand and plan transport and land use policies. But whereas the use of accessibility metrics is becoming more common in many countries (most OECD countries, Argentina, Brazil, and Colombia, for example), it hinges on the availability of data such as the distribution of people, jobs and the characteristics of the transport network that can connect them. These data are typically difficult to come by in developing countries and for African cities in particular. As a result, accessibility metrics have seldom been computed or used in these settings and when they have, analysis has generally focused on one or two cities (Avner and Lall 2016; Chen et al. 2017; Campbell et al. 2019).

This paper is a first attempt to fill this gap. It brings together a number of data sets on the distribution of economic opportunities,[2] people and the characteristics of the public transport in 11 African cities to compute baseline public transport accessibility metrics in a consistent manner. In doing so it creates a benchmark for accessibility that allows for comparisons between cities and produces visuals and descriptive statistics for each city. In producing this baseline, the paper also sets the basis for further analysis that could investigate the impacts of transport or land use modifications.[3]

## 2 WHY FOCUS ON ACCESSIBILITY? A SHORT LITERATURE REVIEW

Starting with Kain's spatial mismatch hypothesis (Kain 1968), there has been a vast literature investigating how accessibility to employment opportunities[4] could affect employment, wages, productivity and well-being in urban areas. Initially focused on African-Americans' employment outcomes in US urban areas, the research has broadened to investigate the role of space and accessibility first for all minorities and then for all individuals' outcomes in general. While the literature is still massively geared toward developed country cities, some studies focusing on urban areas in developing countries are emerging.

From a theoretical standpoint, there are several reasons why increased accessibility could reduce unemployment or increase the quality of individuals' employment (for a detailed review of theoretical explanations for the spatial mismatch, see Gobillon et al. (2007)). In this paper the rationale for focusing on accessibility is underpinned by the following theoretical framework: higher accessibility implies lower job search costs which i) incentivizes a more intensive job search and improves the probability of finding a job and/or ii) for a given job search intensity will improve the probability of finding a job that matches a worker's skills and aspirations – the quality of the matching.

On the productivity side, empirical evidence indicates that accessibility, measured as the number of opportunities an individual can access within a given amount of time, matters. Prud'homme and Lee (1999) demonstrate that the elasticity of productivity to the share of jobs accessible within 30 minutes for the average worker in 23 French cities is 0.15. From an employer's point of view, Cervero (2001) shows that in the San Francisco Bay area there is weaker yet positive evidence that labor-marketshed[5] positively influences worker productivity levels. Melo et al. (2013) show for a sample of US cities that increasing accessibility to jobs results in increased productivity as measured by real wages. The authors report that a doubling of the number of jobs accessible per worker within a 20-minute thresholds results in an average increase in real wages of 6.5%. Venables (2017) identifies that commuting costs and thus

[2] In this paper we use 'employment opportunities' understood as a proxy for jobs. Because we are using a proxy for job distribution, we prefer not to call them jobs. Employment opportunities should also not be understood as vacant jobs to be filled.

[3] Although this paper does not go as far as computing counterfactuals, such work can easily piggy-back on this effort.

[4] Accessibility is defined differently depending on the studies considered (bee-line distance to jobs, network distance, costs of commuting,…). All these metrics share that accessibility goes up decreasing costs to reach jobs (time and/or money).

[5] Number of workers that can access work within a defined peak period ranging from 30 to 60 minutes.

average accessibility matters in urban settings. In order to attract skilled workers, firms must compensate for their travel costs by offering higher wages. While this will benefit households, it can prevent firms from reaping productivity gains and entering international markets because the average wage needed to compensate workers is higher than competitive international standards.

In terms of individuals' employment outcomes, evidence of the link with accessibility is more ambiguous, in part because of the methodological difficulty of disentangling the role of accessibility relative to individual characteristics and preferences. In particular, residential location is endogenous – households are not randomly assigned to specific locations, so that a link between low accessibility and bad employment outcome may in fact reflect self-sorting of low productivity households into areas with less good accessibility. There are nonetheless a number of studies that have shown positive impacts of increased accessibility on labor market outcomes. Employment accessibility has been found to have positive impacts on the employment prospects of the youth in Ethiopia (Franklin 2015), through reductions in transport costs, and in Accra (Chen et al. 2017), both in terms of the probability of being employed and in more formal and better paying positions. In France, an experiment of subsidizing driving lessons for young disadvantaged adults, thereby lowering their lifecycle commuting costs, proved to increase their access to temporary (but not permanent) jobs (Le Gallo, L'Horty, and Petit 2017). On the other hand, the introduction of a commuter train in Sweden, on a pre-existing rail-track was shown to have no impact on the earnings and unemployment rates of affected individuals (Åslund, Blind, and Dahlberg 2017). Jin and Paulsen (2017) find that job accessibility plays a strong role in explaining employment rates and household income in Chicago. Increased accessibility to jobs improved both, especially for low-income households. Norman et al. (2017) find similar results in Sweden with a negative relationship between employment accessibility and unemployment rates which is stronger for low-educated workers. Aslund et al. (2010) using a natural experiment in Sweden again – a refugee dispersal policy – that allowed them to overcome the endogeneity challenge inherent to this type of study, also find that the proximity to jobs positively impacts employment prospects even in the long term.

From the perspective of households, accessibility constraints in developing country cities may be manageable in the short-run, as long as local employment within low-wage, non-tradeable (and often informal) service sector occupations dominates; but as the nature of employment shifts from non-tradable services to manufacturing and tradable services, and from informal to formal, requiring higher firm density, the demands for metropolitan-wide accessibility can be expected to increase. Indeed, there are already indications that in order to remain within reasonable commuting times of their jobs, households are ready to compromise on living conditions. In Nairobi, most residents of informal settlements have jobs and comparatively high levels of education relative to those living in formal housing, yet their living conditions remain basic (Gulyani, Talukdar, and Jack 2010). This situation probably reflects a premium already placed on accessibility.

The empirical literature is still growing and there remains some disagreement between scholars on the impact of accessibility to employment opportunities. In particular studies investigating the link between employment accessibility and employment rates have come to contradictory conclusions, ranging from no impact to a strong and positive effect. We nevertheless consider that the volume of positive evidence linking employment accessibility to urban productivity and employment outcomes is convincing (with some early day indications that it matters for livability too). And that based on these premises, pursuing increased urban accessibility is a valid and important policy objective.

# 3 METHODOLOGY

## 3.1 Analysis of Accessibility

In urban transportation, and loosely following Koenig (Koenig 1980), 'accessibility' refers to the ease with which an individual can reach opportunities (e.g. employment, health or education services), given the spatial distribution of land uses in the city, the transportation infrastructure and services available (transportation supply), the temporal constraints of individuals and activities, and the individual characteristics of people.

To calculate accessibility in urban areas we need information on: (i) the travel times for a set of Origin-Destination pairs, (ii) the spatial distribution of opportunities within the urban area and (iii) the spatial distribution of the population.

For the purpose of this research we focus on access to employment opportunities using non-private transport modes – specifically public transportation and non-motorized transport. One would expect auto accessibility to be higher, primarily because motorization in the region is low. If the entire population were to travel by car however, then congestions would hurt all users, hindering the access to opportunities.

In order to calculate access, first, we utilize the transport and transit network, to calculate the travel times for every origin-destination pair in the city. Second, we then utilize the estimated travel times for each origin-destination to calculate the number, or the share, of opportunities that are within a given travel time threshold. Thus, we are able to calculate for every point in the city the number of opportunities (e.g., employment opportunities) that are within a given travel time (e.g., 60-min) using a specific transport mode. And finally, accounting for the spatial distribution of people, we can compute the average accessibility in the urban area.

Building on traditional accessibility measures (Pooler 1995; Cervero, Rood, and Appleyard 1999; Geurs and van Wee 2004; Busby 2004), the Isochrone model (Hansen 1959) takes into account the total number of opportunities that can be reached within a given time, distance or cost threshold. This model requires the least data calculation since it uses a standard binary (0 or 1) threshold to determine the accessible opportunities:

$$A_i = \frac{\sum_j O_j * W_j}{\sum_j O_j}$$

Where $A_i$ is the accessibility indicator for location $i$, within a given urban area, $O_j$ represents the number of opportunities in location $j$, again of a given urban area, and $W_j$ is a parameter which takes the value of 1 if $C_{ij} \leq C^*$ and the value of 0 if $C_{ij} > C^*$. $C_{ij}$ is the travel time or cost between locations $i$ and $j$ and $C^*$ is a travel time (or cost) threshold in a given city. When $W_j = 1$, opportunities in location j can be reached and are added to the total of reachable opportunities. In the other case they are assigned the value of 0.

The use of a binary threshold considers any opportunity within that threshold equally accessible, although there might be a larger impedance to travel a longer distance. This model is the easiest to compute and interpret, among the accessibility family, compared to alternatives that assume exponentially decreasing attraction of opportunities with costs $C_{ij}$ between locations $i$ and $j$. But it does not include the temporal and user components of accessibility (e.g. mode preference or subset of opportunity preferences).

We utilize an urban accessibility tool, which utilizes the road network (in this case OpenStreetMap), and transit attributes (specifically, the cities' General Transit Feed Specification (GTFS) files and/or a transit network GIS layer), to calculate the travel times between origin and destination pair in the city. The tool then combines the estimated travel times and location data for employment opportunities (or other opportunity inputs) to calculate the accessibility value for every point in the city.

This flexible open source tool provides, with ease and detailed granularity, the basis for the accessibility analysis of the city. It is developed by Conveyal,[6] and uses a simple web-based interface to generate detailed raster accessibility maps. Raster maps offer a representation of the area divided into a regular, standardized grid of cells and are useful for storing high resolution data that vary continuously. This output can be processed and analyzed in greater depth and collated with other sources of data with other GIS software.

When averaged over the whole urban area, localized accessibilities are weighted by population $n_i$, to account for population distribution within the city. This produces an average accessibility for the urban area, $\bar{A}$.

$$\bar{A} = \frac{\sum_i n_i * \left(\sum_j O_j * W_j\right)}{\sum_i n_i * \sum_j O_j}$$

While the time threshold can be set to any value, this analysis takes 60 minutes as the threshold, which has been recognized as meaningful to capture labor market access in urban areas (Bertaud 2014).

A second set of metrics and visuals complement the average accessibility indicator. They provide information on the distribution of accessibility – spatially through maps and in aggregate through Lorenz curves and the calculation of Gini coefficients. The distribution of accessibility is an important component of the overall picture, in tandem with the average accessibility, which brings to light the equity distribution of access within a city.

Similar to the way income inequality is often captured, we compute Lorenz curves and Gini coefficients to represent how equally accessibility is distributed for each urban area in our sample. When looking at income inequality, it is common to sum the total incomes of a country and explore what proportion of that total "income pot" goes to a given share of the country's population. The higher the inequality the lower the share of the total incomes that goes to the poorest.

In the framework of this paper, and following the methodology proposed in Avner and Lall (2016), we replace the "income pot" by the "accessibility pot", which is the total of accessibility to opportunity levels when summed over the entire population of a given urban area. And the Lorenz curves will capture what share of the population has access to what share of the "accessibility pot", sorting the population within a city on the x-axis by increasing accessibility levels.

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[6] https://www.conveyal.com/

The Gini coefficient is a metric that captures the extent to which the situation in a given urban area departs from the perfect equality situation (where every individual has an accessibility level equal to the average of the urban area). Mathematically it is equal to the area between the 45 degree line and the Lorenz curve for accessibility (see section 5 for a graphical illustration). The higher the Gini coefficient the more unequally distributed the level of accessibility within the urban area.

The Gini coefficients for accessibility $G$are calculated with the following formula:

$$G = 1 - 2\sum_{i=1}^{I}\left(\frac{\sum_k \sum_{i=1}^{k} A_i * n_i}{\sum_{i=1}^{I} A_i * n_i} * \frac{n_i}{\sum_{i=1}^{I} n_i}\right)$$

Where the localized accessibility indicators are sorted in increasing order so that $A_i \leq A_{i+1}$. The first part of the numerator displays the cumulative sum of total accessibilities opportunities, where $k \in \{1, \dots, I\}$ and $I$ represents the index of the pixel with the highest localized accessibility.

### 3.2 Geographic Frame of Analysis

In order to have a comparable frame of analysis between metropolitan areas, regardless of different definitions of administrative boundaries, we established a uniform boundary for the metropolitan area. The boundaries of the analysis for each region were defined as all areas with an accessibility of above zero – that is, locations that fall inside a 1-hour travel time access to at least a single employment opportunity or proxy thereof. This defined the study area of our analysis.

As opposed to relying on administrative areas, and extending beyond the geographic distribution of opportunities/jobs within the analysis, peri-urban areas are included in the analysis based only on access to employment opportunities identified within the urban area, and not in outlying areas themselves. Thus, areas at the outer edges of the analysis may not account for access to nearby employment opportunities that fall outside the core area analyzed.

## 4 DATA

Based on the methodology previously described, this work required three main sources of data inputs: (i) the public transportation network in order to calculate travel times between OD pairs, (ii) the spatial distribution of employment opportunities and (iii) the spatial distribution of population. Below is a description of the data sources used.

### 4.1 Public Transportation Networks

Transport data were based on available GTFS feeds and shapefiles. In order to calculate accessibility, first a digital representation of the public transport network is created - either the General Transit Feed Specifications (GTFS) which is the standard data used for planning routes or a Geographic Information System (GIS) shapefile with the information on public transportation travel speeds and frequencies. General Transit Feed Specification (GTFS) is a free and open template for entering data related to basic transit system services, such as routes, stops, fares, and schedules. The information on routes may also be digitally recorded as a GIS shapefile. This shapefile must include each route that is served in the city. Additional to the routes the file must contain information about the frequency and speed, at different times of day, particularly the am peak.

All the analyses for cities in the report were run with the following identical variables:

- 4km/h walking speed for pedestrians accessing transit
- 7AM to 9AM on a weekday – peak travel time
- Within 60 minutes travel time between departure and arrival
  Where GTFS feeds with specific stops were unavailable, 400 meters was assumed as the distance between stops.

Data produced by WhereIsMyTransport[7] were used for five cities – Lusaka, Kampala, Harare, Douala and Cape Town. WhereIsMyTtransport is a South African company which collects and digitizes data from formal and informal public transport networks to produce GTFS feeds. Data collected include information on fares, stops, routes, frequencies and travel times and speeds. This mapping is carried out with local partners and identification of all available modes of transport within the city and local teams of data collectors. Routes and data are validated in the field by the local team during daily feedback sessions with data collectors.

The transport data for Nairobi are based on the Digital Matatus Project. This was carried out in 2012-2014 by the DigitalMatatus consortium comprising the Universities of Nairobi, Columbia, MIT and Groupshot, to produce a map of the Matatu minibus network in Nairobi. University of Nairobi students collected information on bus routes, schedules and stops with GPS technology based on their phones. Students and the Civic Data Design lab at MIT analyzed the data, and created a public transit map and a GTFS feed (Williams et al. 2015; Klopp et al. 2015).

The transport data for Dar es Salaam were a combination of sources, collected and aggregated by the World Bank office. The transport system includes the DalaDala routes, mapped as an initiative of the Ramani Huria team, the Tanzania Open Data Initiative (TODI) team from the World Bank, and Ally.[8] The transit information for the operating BRT routes where provided the by DART transit agency.

For Conakry, the route map is based on maps produced for the ongoing Plan de Déplacement Urbain (PDU) de Conakry, produced by the European Union and a 2006 study produced by SYSTRA. For Bamako, the maps of the Sotrama minibus taxi network were produced and provided by the "Cellule de Préfiguration de l'Agence Urbaine de Bamako" (CPAUB) housed in the mayor of Bamako's office. The data for Kigali were collected by IGC for a study on accessibility performed in 2016.

### 4.2 Employment Opportunities

Data on the location of jobs were available for this study only for Kigali, Bamako and Dar es Salaam.[9] These data sets showed the location and number of firms at the district level, and in the case of Kigali, also the number of employees. For the other cities, an extrapolation of job locations was created by analyzing available information and creating a relative index of job-

[7] https://www.whereismytransport.com/about/
[8] *http://ramanihuria.org/putting-dar-es-salaam-dala-dalas-map/*
[9] Although it exists also for Nairobi, Dakar and Kampala through travel surveys. Because we could not cover the whole sample of 11 cities with official data sources, we looked for proxies for employment data for the whole sample.

likeliness throughout each metropolitan area by identifying 'Employment Opportunity Areas' (EOAs) of different intensity.

These were determined by scoring different indicators on 500-meter cells in a grid covering each city. The scores include the count of employment-related amenities extracted from Google Maps and Open Streets Map, within each cell and its adjacent cells. This count included the number of retail financial establishments, the proximity to major intersections, and the proximity to taxi ranks or bus stops. A full description of this methodology, as well as its validation, is available in a companion paper (Avner et al. forthcoming). The validation performed on Dakar, Kampala and Nairobi shows that, despite widely varying contexts, correlation coefficients linking urban form attributes to the relative distribution of jobs within cities are consistent.

Thus, EOA scores are comparable both within and between cities, and offer an approximation of the distribution of jobs (but not a conversion into a number of jobs, which may differ between cities). This, in combination with the transport networks, generates an analysis of access to the proportion of 'EOA points' in the city from any given point, as a proxy for employment opportunities.

For Kigali, the employment data came from the establishment census, finalized in 2017, which gives a number of employees for each city sector. For Bamako, employment data are based on a business registry carried out in 2015, which locates jobs to city neighborhoods.

### 4.3 Population

The population data for all the cities in the report were taken from WorldPop,[10] an open repository of population density data based at the University of Southampton, using 100x100 meter population density mapping (Linard et al. 2012). The WorldPop population estimates are based on a combination of available census data, land-cover satellite imagery and mathematical modeling. This allows higher resolution estimates than are available from other sources, and on a nation-wide basis, without regard for administrative units, which can be inconsistent, difficult to compare and do not necessarily match the analysis in the paper. Furthermore, the WorldPop data are freely usable and do not require requesting census and administrative data.

As mentioned in section 3.2, in order to provide a comparable geographic unit among cities, we relied on a uniform study area of the metropolitan region based on access patterns, rather than administrative units - which are not comparable between cities. TABLE 1 summarizes the geographic and population scope of each study area – as defined by the uniform metropolitan boundary described previously. This is in comparison with the UN 2015 World Urbanization Prospects (UN DESA 2015) estimated metro population in the next column – which utilize administrative boundaries to define the urban area. Cities whose study area populations fall far below the UN Population estimates may have underperforming transport systems in terms of reach, while those that are above it have more of their peripheral population with access to the city.

| | Area in km sq | Population Within Study Area | UN Pop Estimate 2015 |
|---|---|---|---|
| **Nairobi** | 822 | 5,685,117 | 3,914,000 |

[10] www.worldpop.org. Note that supplementary work could investigate how sensitive our results are to using other global data sources such as Landscan or GHS-Pop.

| | | | |
|---|---|---|---|
| **Conakry** | 196 | 1,608,238 | 1,714,000 |
| **Lusaka** | 837 | 1,489,053 | 2,187,000 |
| **Bamako** | 478 | 2,967,235 | 2,219,000 |
| **Kigali** | 454 | 929,723 | 951,000 |
| **Kampala** | 834 | 3,101,666 | 2,577,000 |
| **Cape Town** | 2467 | 2,699,422 | 4,100,000 |
| **Dar es Salaam** | 1000 | 3,673,173 | 6,048,000 |
| **Dakar** | 2325 | 3,065,622 | 2,978,000 |
| **Douala** | 288 | 2,802,368 | 3,259,000 |
| **Harare** | 1454 | 2,273,485 | 1,500,000 |

TABLE 1: FRAMES OF ANALYSIS

The data sources used are summarized in the table below.

| City | Population Data | Opportunity Data | Transport Data |
|---|---|---|---|
| Nairobi | WorldPop | EOA Analysis | Digital Matatus |
| Lusaka | WorldPop | EOA Analysis | WheresMyTransport |
| Kampala | WorldPop | EOA Analysis | WheresMyTransport |
| Cape Town | WorldPop | EOA Analysis | WheresMyTransport |
| Kigali | WorldPop | Rwanda Census | IGC |
| Bamako | WorldPop | Bamako Business Registry | Bamako Mayor's Office |
| Conakry | WorldPop | EOA Analysis | Plan de Déplacement Urbain (EU, Min. Transports) |
| Dakar | WorldPop | EOA Analysis | SAFEGE |
| Dar es Salaam | WorldPop | Dar Es Salaam Firm Census | Collected by World Bank |
| Harare | WorldPop | EOA Analysis | WheresMyTransport |
| Doula | WorldPop | EOA Analysis | WheresMyTransport |

TABLE 2: DATA SOURCES

## 5 RESULTS

The table below summarizes the results for each city. Average accessibility is the percentage of estimated employment opportunities throughout the city accessible by the average individual within 60 minutes. The best access level is the highest percentage of jobs accessible from the single best-positioned location.

| | Average Accessibility | Best access level | Distribution of Accessibility 'Gini' |
|---|---|---|---|
| **Nairobi** | 28.5% | 67.4% | 0.36 |
| **Conakry** | 29.4% | 65.1% | 0.41 |
| **Lusaka** | 34.1% | 86.0% | 0.42 |
| **Bamako** | 34.3% | 97.5% | 0.37 |
| **Kigali** | 15.2% | 23.0% | 0.26 |

| | | | |
|---|---|---|---|
| **Kampala** | 31.7% | 71.0% | 0.36 |
| **Cape Town** | 6.5% | 42.2% | 0.63 |
| **Dar es Salaam** | 12.2% | 69.7% | 0.60 |
| **Dakar** | 46.7% | 70.7% | 0.18 |
| **Douala** | 39.0% | 69.3% | 0.30 |
| **Harare** | 20.8% | 83.0% | 0.42 |

TABLE 3: ACCESSIBILITY METRICS

The distribution of access shows the percentage of jobs accessible by each percentage of the population. These results are summarized below in Table 4 below which shows cumulative accessibility - the percentage of jobs accessible by each percentage of the population, at 5% intervals. The left column describes the level of accessibility and each column describes the percentage of residents that has that level of accessibility. For example, we can see that in Nairobi, 51% of the population has access to at least 30% of the job opportunities. As can be seen there, no city has 100% access to all job opportunities for 100% of all residents – in fact, no city has 100% access to all job opportunities for any residents: this is represented by the bottom line of the table. But as the different colors of the columns show, some cities come closer to this goal than others – for example, Bamako is best at delivering good accessibility, but only to a relatively small percentage of the population. Dakar, on the other hand, is best at delivering relatively equitable accessibility – over 50% of job opportunities (left columns) are accessible to over 50% of the population (green).

| | Percentage of the population (cells) with access to x% of jobs (rows) in each urban area | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Nairobi | Lusaka | Bamako | Kigali | Kampala | Cape Town | Dar es Salaam | Dakar | Harare | Douala | Conakry |
| >0% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| >5% | 85% | 85% | 89% | 84% | 86% | 39% | 62% | 97% | 85% | 88% | 82% |
| >10% | 78% | 76% | 81% | 77% | 80% | 25% | 42% | 95% | 71% | 86% | 78% |
| >15% | 71% | 69% | 75% | 63% | 74% | 16% | 30% | 93% | 56% | 82% | 73% |
| >20% | 64% | 62% | 69% | 39% | 68% | 9% | 20% | 90% | 43% | 76% | 65% |
| >25% | 58% | 56% | 62% | 0% | 61% | 4% | 14% | 86% | 32% | 72% | 57% |
| >30% | 51% | 51% | 58% | 0% | 55% | 2% | 10% | 82% | 24% | 67% | 49% |
| >35% | 43% | 46% | 49% | 0% | 48% | 0% | 7% | 79% | 18% | 63% | 44% |
| >40% | 35% | 41% | 39% | 0% | 40% | 0% | 5% | 77% | 14% | 57% | 37% |
| >45% | 22% | 37% | 29% | 0% | 31% | 0% | 3% | 70% | 10% | 52% | 29% |
| >50% | 11% | 32% | 27% | 0% | 23% | 0% | 2% | 56% | 6% | 43% | 20% |
| >55% | 4% | 26% | 21% | 0% | 12% | 0% | 1% | 39% | 4% | 31% | 8% |
| >60% | 1% | 21% | 13% | 0% | 6% | 0% | 0% | 17% | 2% | 15% | 1% |
| >65% | 0% | 15% | 7% | 0% | 2% | 0% | 0% | 4% | 1% | 4% | 0% |
| >70% | 0% | 10% | 6% | 0% | 0% | 0% | 0% | 0% | 1% | 0% | 0% |
| >75% | 0% | 5% | 4% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| >80% | 0% | 2% | 3% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| >85% | 0% | 0% | 2% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| >90% | 0% | 0% | 2% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| >95% | 0% | 0% | 1% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 100% | 0% | 0% | 0% | 0% | 0 | 0% | 0% | 0% | 0% | 0% | 0% |

TABLE 4: PERCENTAGE OF THE POPULATION (COLOR/CELL) WITH ACCESS TO X% OF OPPORTUNITIES (LEFT COLUMN/ROWS)

Table 3 and Table 4 provide some information on how equally distributed are the access levels to employment opportunities. Cape Town's best accessibility from a single point, for example, is 42%. This is higher than Kigali, where it is 23% (Table 3). However, in Cape Town the higher levels of access are available to only a small proportion of the population and the average is 7%, while in Kigali the average is 15% as a relatively larger proportion of the population is located within higher-access areas.

Another, maybe more common or intuitive, way of understanding how (un)equally distributed levels of accessibility are, is through the use of Lorenz curves and Gini coefficients of accessibility. Section 3.1 provided some details as to how Lorenz curves for accessibility relate to the more common metric for income inequality. Lorenz curves and Gini coefficients have the advantage of focusing solely on how equally distributed accessibility levels are, irrespective of the absolute accessibility levels in the city.

Similar to the way income inequality is often captured, we compute Lorenz curves and Gini coefficients to represent how equally accessibility is distributed for each urban area in our sample. When looking at income inequality, it is common to sum the total incomes of a country and explore what proportion of that total "income pot" goes to a given share of the country's population. Graphically, the x-axis represents the increasing population share, ordered from poorest to richest, and the y-axis the increasing share of the total "income pot". When there is perfect equality in a given economy, the Lorenz curve drawn from joining the pairs of population and "income pot" shares, is the 45% degree line. It means that x% of the population has access to exactly x% of the total wealth in the economy, with x being exactly the average.

If there is some inequality, the Lorenz curve departs from the 45 degree line and the larger the gap, the higher the inequality.

In the framework of this paper, we replace the "income pot" by the "accessibility pot", which is the total of accessibility to opportunity levels when summed over the entire population of a given urban area. And the Lorenz curves will capture what share of the population has access to what share of the "accessibility pot", sorting the population on the x-axis by increasing accessibility levels.

Graphically, the Gini coefficient is an approximation of the area between the 45 degree line (perfect equality) and the Lorenz curve. The higher the Gini coefficient the more unequally distributed the level of accessibility within the urban area.

The Lorenz curve for each of the cities in the analysis, as well as the Gini coefficients are shown below:

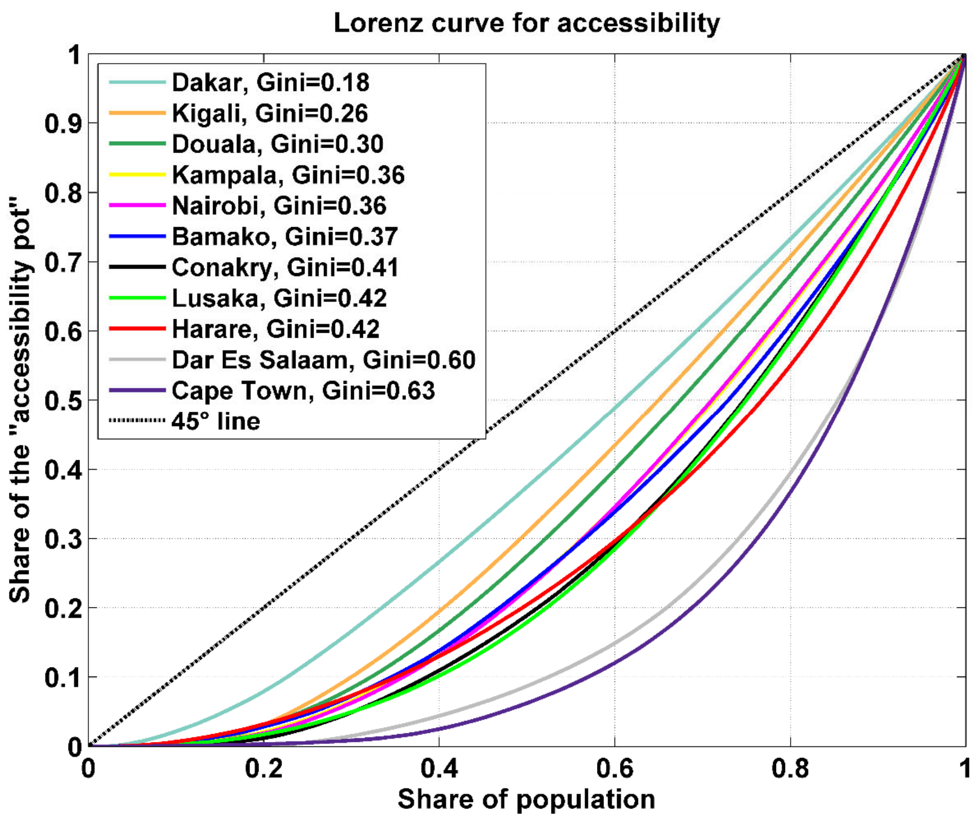



FIGURE 1: GINI COEFFICIENT OF ACCESSIBILITY

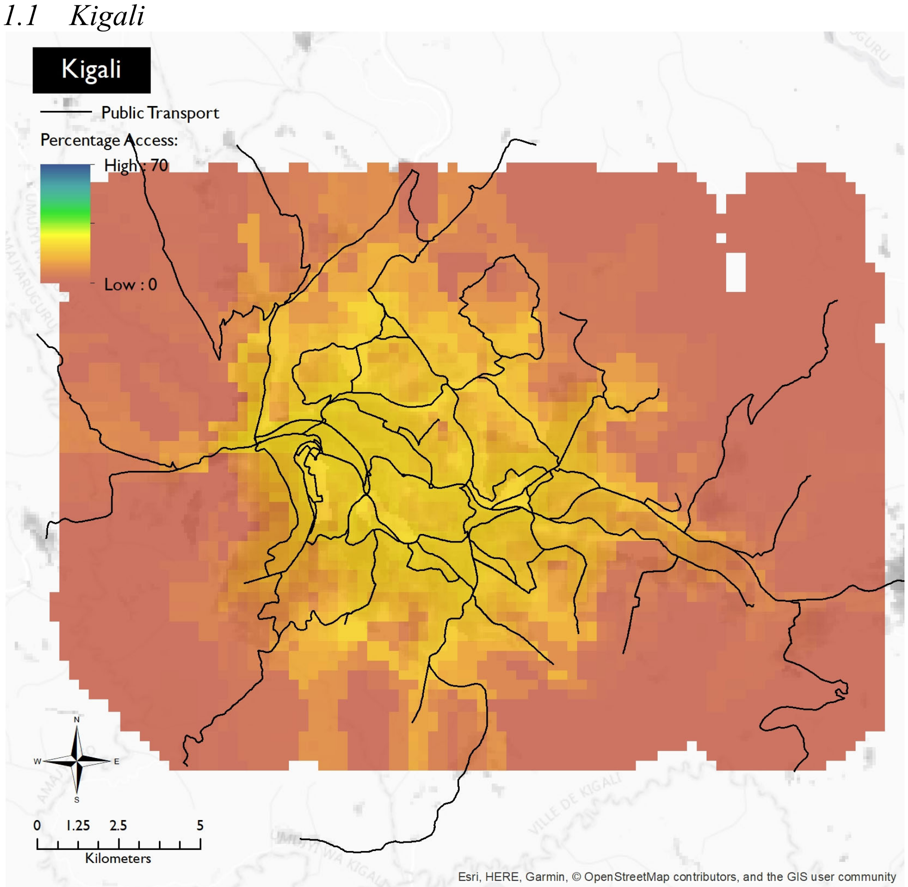
Three distinct groups of cities appear.

1. **The Equitable Cities**: Dakar, Douala, Kigali display above average equality in terms of employment opportunities accessible for residents with Gini coefficients of 0.18, 0.30 and 0.26, and similarly relatively high average accessibility. Their levels of maximal accessibility, however, are middling. This pattern can be seen in Figure 1, marked by a slightly convex curve, which are closest to the 45° line.

2. **The Inequitable Cities:** Dar Es Salaam, Cape Town and Harare are significant outliers with highly unequal distributions of employment accessibility levels. The Gini coefficients are 0.60 and 0.63 respectively for Dar and Cape Town and 0.42 for Harare (but with a clear distinction in access between the better connected 40% and the other 60%) and large gaps between the best level accessibility (i.e., that available to a small minority) and the average level of accessibility. (These are marked by a highly convex pattern in figure 1.)
3. **The In-between Cities:** Finally, a group of five cities, Kampala, Nairobi, Bamako, Conakry and Lusaka, are bunched up together on 1, with similar Lorenz curves and Gini coefficients ranging from 0.36 to 0.42. They are marked by relative linearity in terms of access distribution amongst the population, and show substantial differentiation only at the higher levels of access, affecting relatively small proportions of the population.

## 5.1 Equitable Cities

### *5.1.1 Kigali*

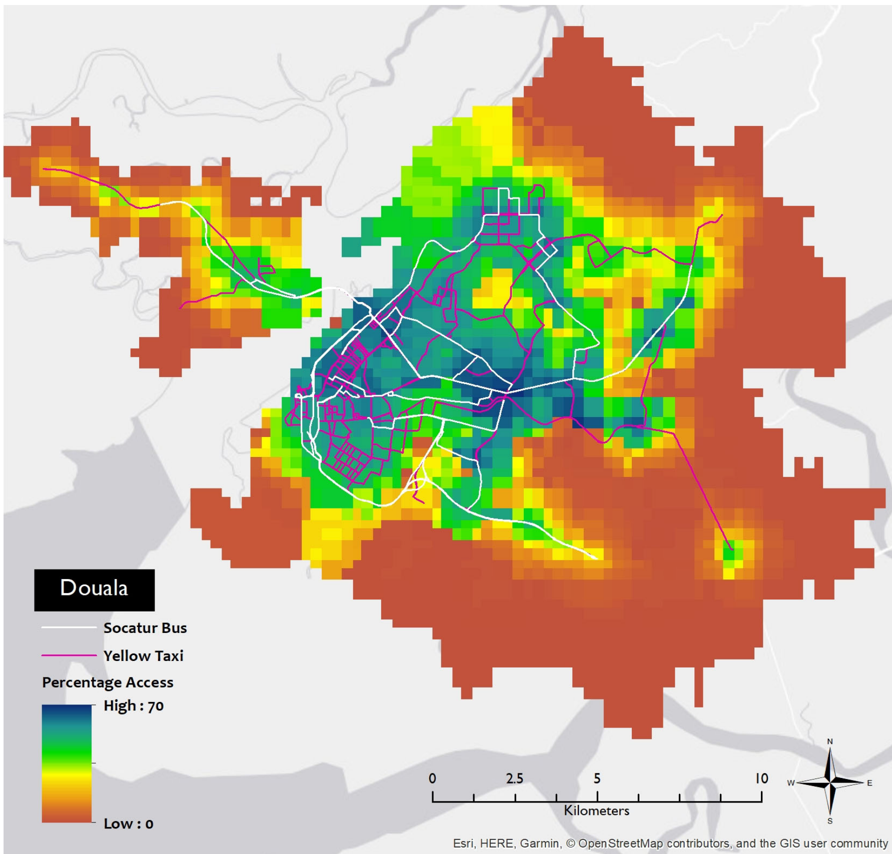



MAP 1: KIGALI, ACCESSIBILITY TO EMPLOYMENT OPPORTUNITIES

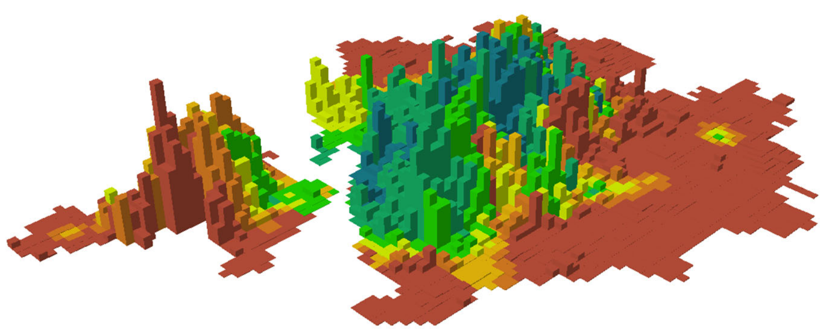
The public bus system of Kigali is operated by three private service providers, KSB, RFTC and Royal. The three operators serve seventy routes that connect the city center with the outer areas of the city. The data were collected by IGC for a study on accessibility performed in 2016. The public transportation speeds however were capped at 20km/hr, and headways increased to better represent the reality on the ground.

Employment data came from the establishment census finalized in 2017 which gives the establishment location at the sector level (ID3) plus the number of employees. Kigali consists of only 35 sectors, which is a significant limitation to the data and may explain the low level of access shown – as job locations which may be clustered around roads, business centers and towards the city center are processed as being randomly distributed at the district level.

### *5.1.2 Douala*



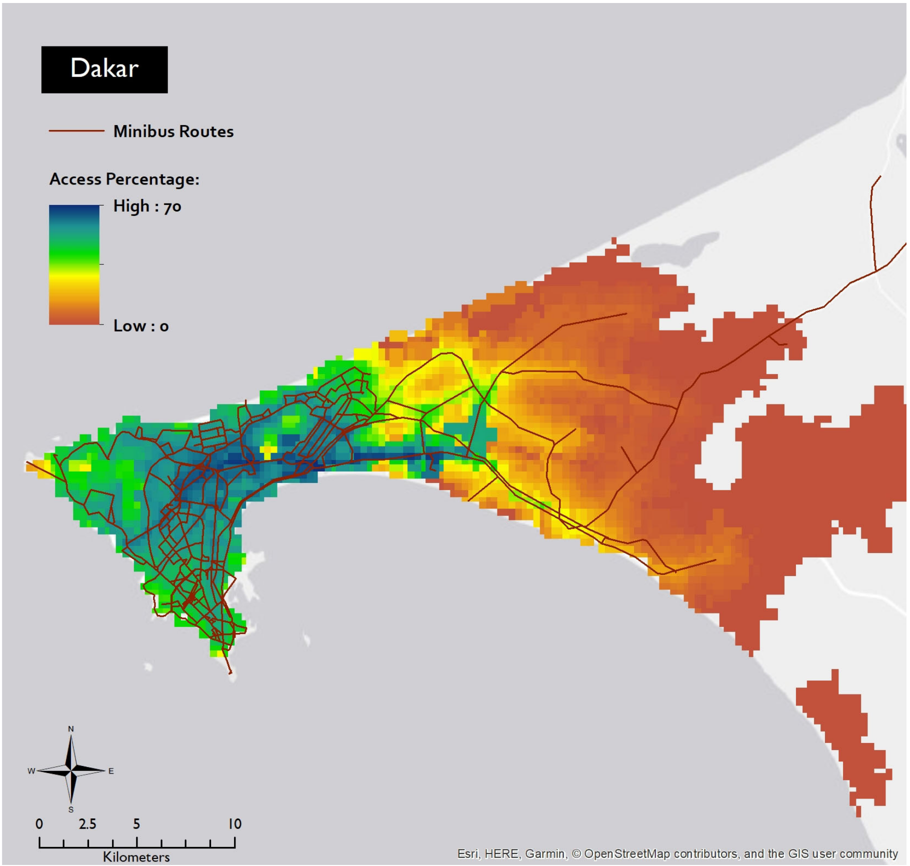

MAP 2: DOUALA, ACCESSIBILITY TO EMPLOYMENT OPPORTUNITIES



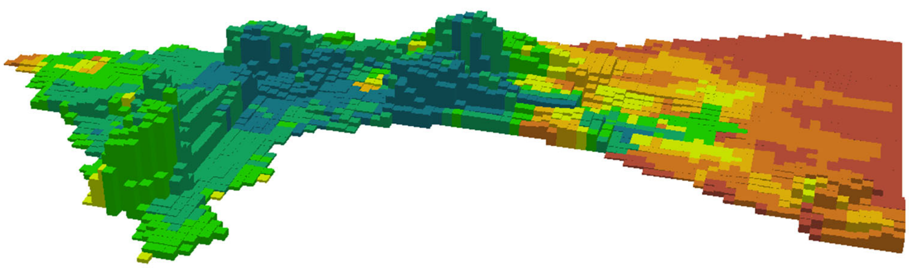
Map 3: Douala, Population (height) and Accessibility (color)

Douala has a relatively high average accessibility, at 39%, and the population is largely concentrated within areas of high and average accessibility, as can be seen on Map 3.

### *5.1.3 Dakar*




Map 4: Dakar, Accessibility to Employment Opportunities



Map 5: Dakar, Population (height) and Accessibility (color)

Dakar has some of the best, and in particular most equitable, levels of job-opportunity accessibility of the cities in the study. The average accessibility rate is 46.7%, despite a middling best accessibility level of 70.7%. The Gini coefficient is just 0.18. As the 3-D Map 5 shows, Dakar's population is concentrated in areas of high accessibility.

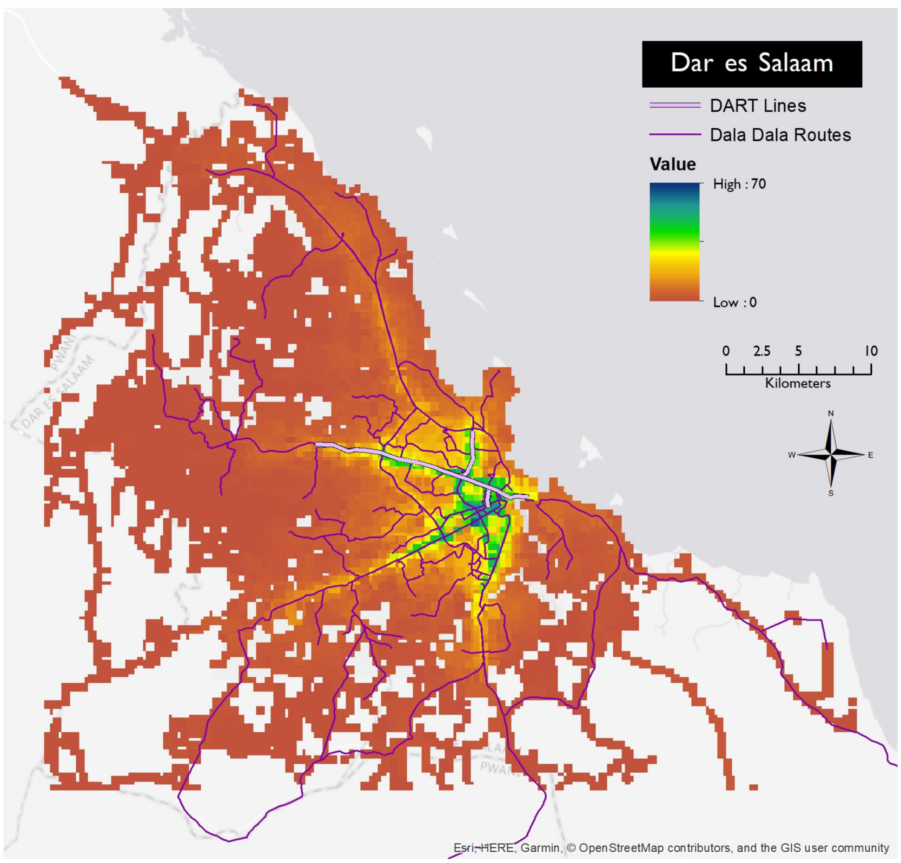
## 5.2 Inequitable Cities

### *5.2.1 Dar es Salaam*

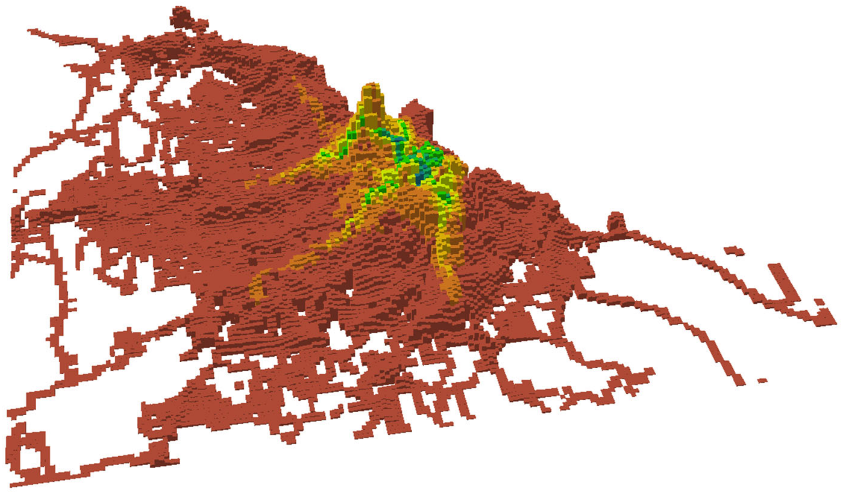
The Dar es Salaam transport data are divided between the Dala Dala Minibus services and the in-progress implementation of the DART BRT corridor. This analysis includes the first stage of the DART, but not subsequent planned phases which are set to expand the BRT.

Employment data are based on a survey of formal firms operating at the district level and extrapolated to account for informal employment for an estimate of total employment.

Dar es Salaam has some of the worst levels of accessibility to employment opportunities, as well as highly unequal distribution of access. The Gini coefficient is 0.60, and the average percentages of opportunities accessible within 1 hour is just 12.2%.




MAP 6: DAR ES SALAAM, ACCESSIBILITY TO EMPLOYMENT OPPORTUNITIES



MAP 7: DAR ES SALAAM, POPULATION (HEIGHT) AND ACCESSIBILITY (COLOR)

### *5.2.2 Cape Town*

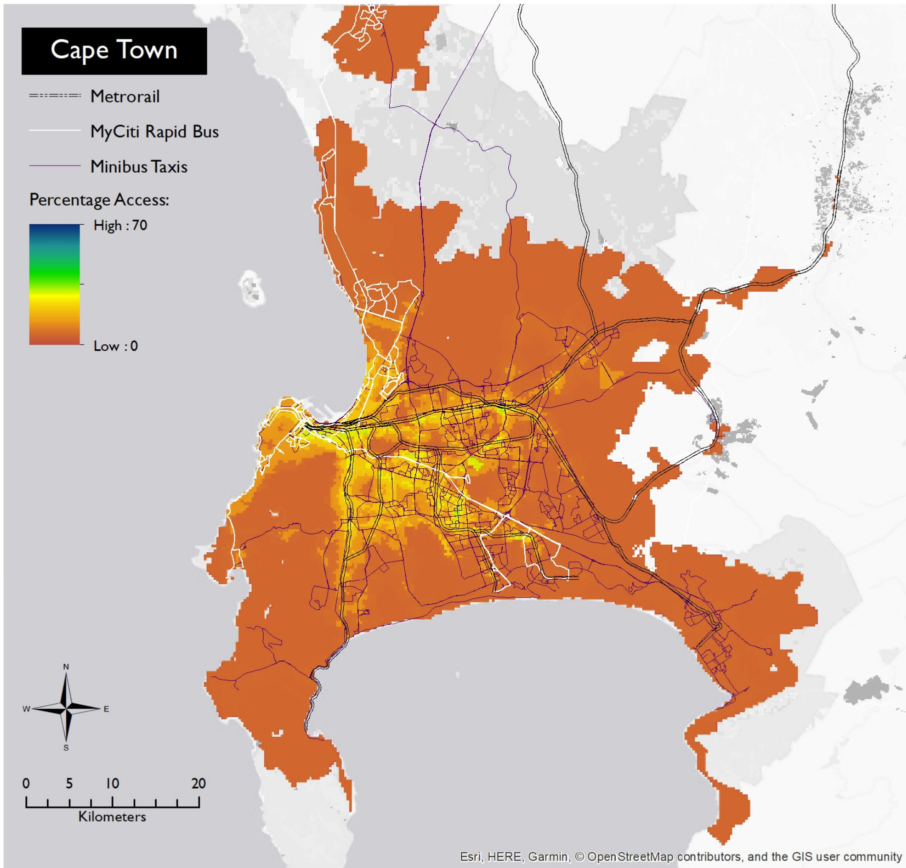
Transport data for Cape Town were gathered by WheresMyTransport into a GTFS file in 2016 and includes three separate transport systems:

| System | Number of Routes | Number of Stops |
|---|---|---|
| Minibus Taxis | 630 | 1438 |
| MyCiti Rapid Bus Transit | 106 | 819 |
| MetroRail | 196 | 125 |

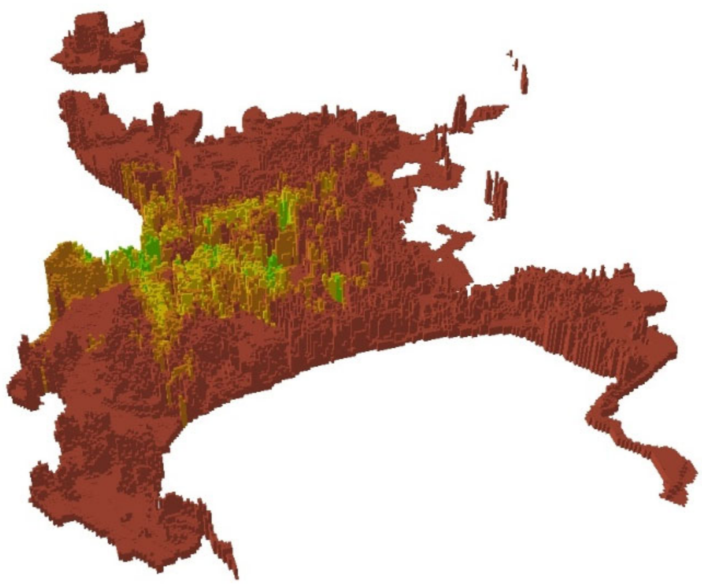
TABLE 5: COLLECTIVE TRANSPORT CHARACTERISTICS IN CAPE TOWN

Opportunity data are based on the EOA grids produced for this project.

Cape Town shows the lowest accessibility level in the analysis, and is a significant outlier. This may be due to a combination of factors. Size – Cape Town is the largest city in the sample in terms of territory and shows substantially more employment opportunities than any other city, including per capita, making it correspondingly more difficult to arrive at wide access. Secondly, spatial structure – Cape Town is relatively low-density compared to other African cities meaning that on average people will have to travel longer distances to access a given share of jobs. Cape Town also displays more extreme patterns of residential segregation. As the population density map below shows, Cape Town's population is notably 'clumpy' in its distribution, with significant high-density zones located throughout the urban area. This is in large part an inheritance from the apartheid area which segregated communities spatially and in the process created a massively sprawled urban area. The inertia displayed by urban areas, means that such a trend cannot be reversed easily and that Cape Town is locked in to a low and unequal accessibility pattern for decades to come. Cape Town illustrates the importance of land uses in providing accessibility to households and the perils that come from misusing urban planning.

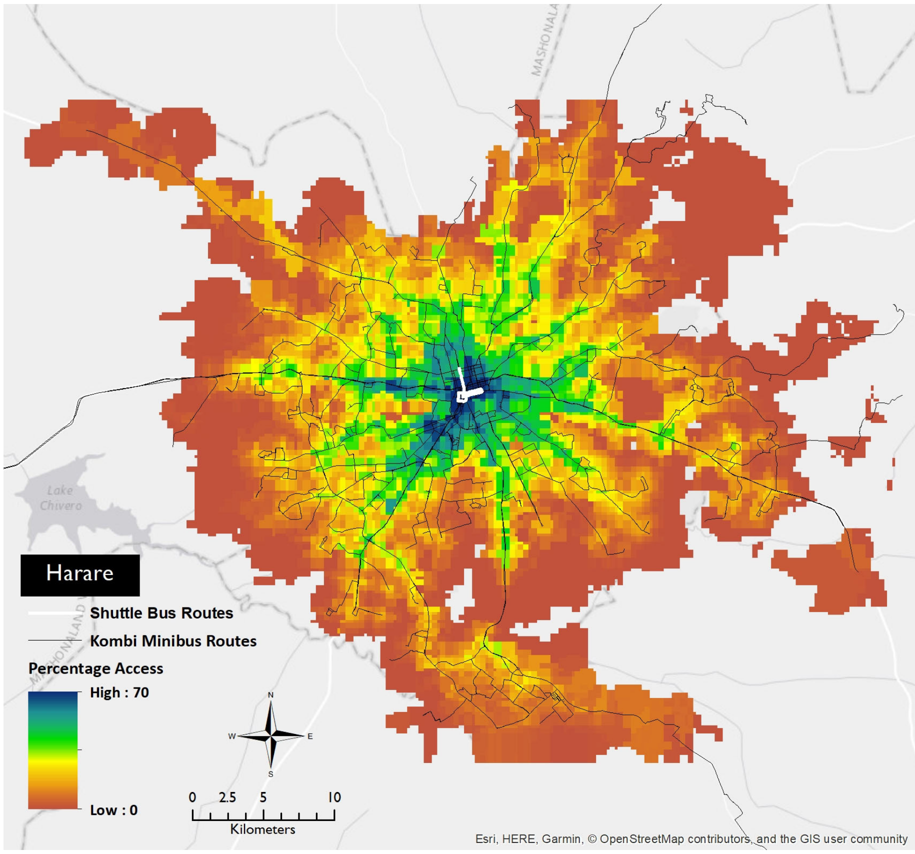



MAP 8: CAPE TOWN, ACCESSIBILITY TO EMPLOYMENT OPPORTUNITIES

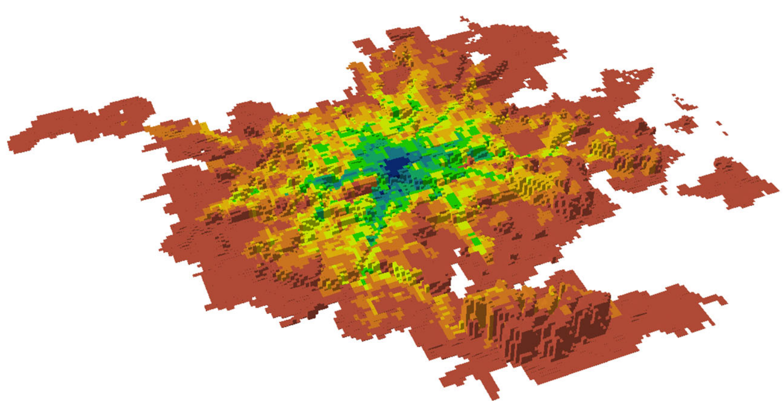


MAP 9: CAPE TOWN, POPULATION (HEIGHT) AND ACCESSIBILITY (COLOR)

### *5.2.3 Harare*




MAP 10: HARARE, ACCESSIBILITY TO EMPLOYMENT OPPORTUNITIES



MAP 11: HARARE, POPULATION (HEIGHT) AND ACCESSIBILITY (COLOR)

Harare's population is evenly spread out across different areas of employment opportunity accessibility, without major central peaks as is common in many cities – in fact, a number of peripheral regions have high substantial high-density concentrations, as can be seen in the 3-D Map 11 above. This, alongside the flat topography and radial road structure, explain the neatly ‘star’ pattern of accessibility in the city and its low levels of average accessibility and high inequality – but also high maximum access in the center.

## 5.3 In-between Cities

### *5.3.1 Bamako*

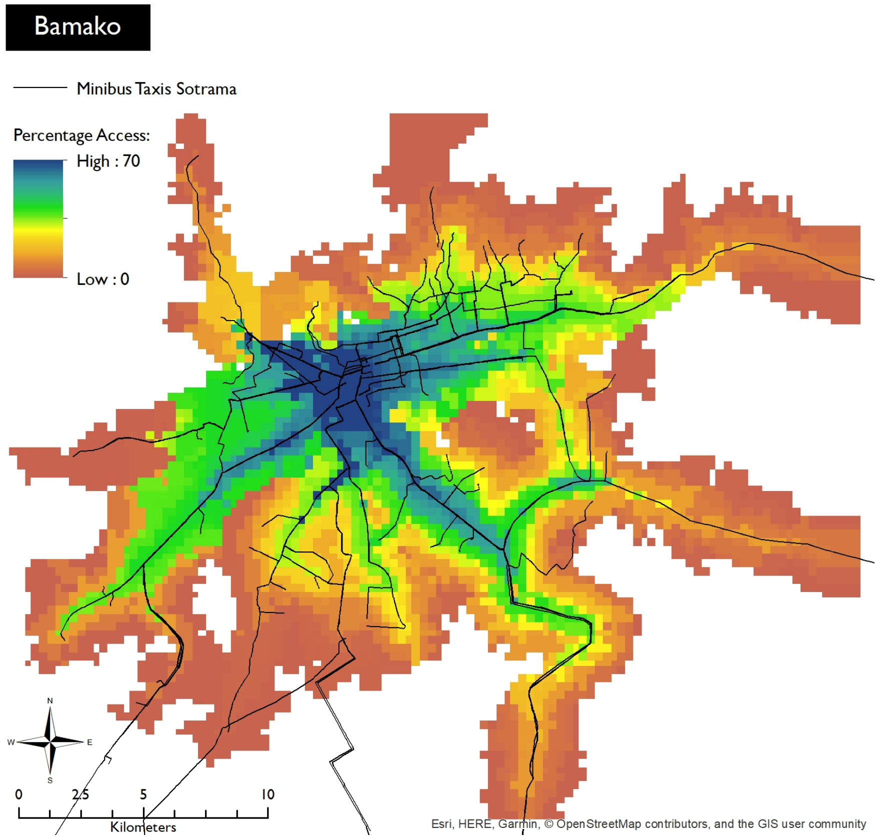
The transport data are based on the SOTRAMA network, which is composed of privately-owned minibuses traveling on different routes. The maps of the Sotrama network were produced and provided by the “Cellule de Préfiguration de l’Agence Urbaine de Bamako” (CPAUB) housed in the mayor of Bamako’s office. The original data, in Autocad format, were converted into a shapefile for the purpose of the accessibility analysis. While the routes are identified in the shapefile, public transportation speeds were not determined. So, the analysis makes some assumptions on average speeds that were discussed and validated with local experts. The Sotrama speeds are assumed to be linked to the road class they circulate on as follows:

| | **SOTRAMA - rush hour speeds** |
|---|---|
| **Primary** | 21 km/h |
| **Secondary** | 11.2 km/h |
| **Tertiary paved** | 9.8 km/h |
| **Tertiary unpaved** | 7 km/h |

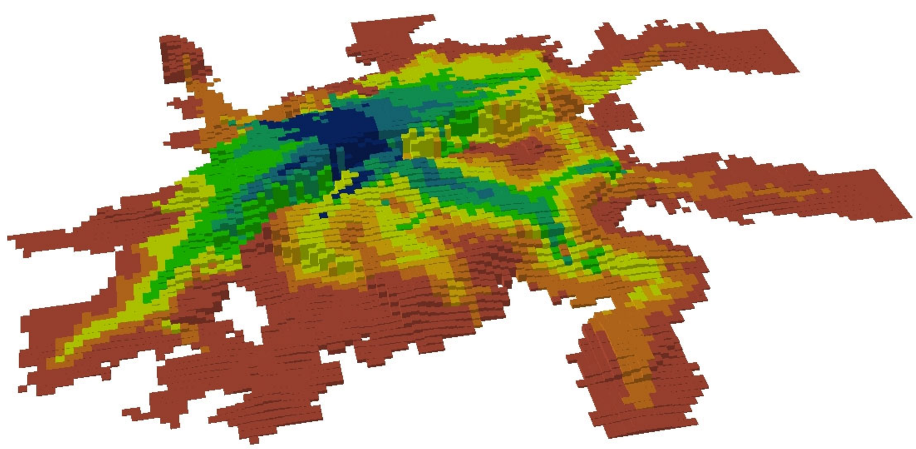
TABLE 6: SPEED ASSUMPTIONS DURING RUSH HOUR BASED ON ROAD CATEGORY IN BAMAKO

The employment data for Bamako are based on a business registry carried out in 2015, listing 8,808 firms for the Bamako urban area. The registries include all formal firms, and the wage bill is reported at the level of the firm (and not the plant). To account for this, the top 5% of firms with the biggest wage bills were dropped from the analysis, as these would run the greatest risk of reporting firm (and not plant) level data. In addition, large mining, extractive and security firms were dropped from the analysis, since it can be safely assumed that a large proportion of their operations take place outside the city.

The firms are geo-referenced at the neighborhood level. The data are somewhat limited, and only allow computation of the total number of firms and the total wage bill per neighborhood. Unlike the situations in Kigali (see above) Bamako’s central neighborhoods are small, few firms are tracked in the outlying areas, and most businesses are therefore tightly clustered in the analysis, which may also play a role in the high levels of accessibility found in the analysis. As well, the population distribution in the city is notably even, without a significant downtown peak.




MAP 12: BAMAKO, ACCESSIBILITY TO EMPLOYMENT OPPORTUNITIES



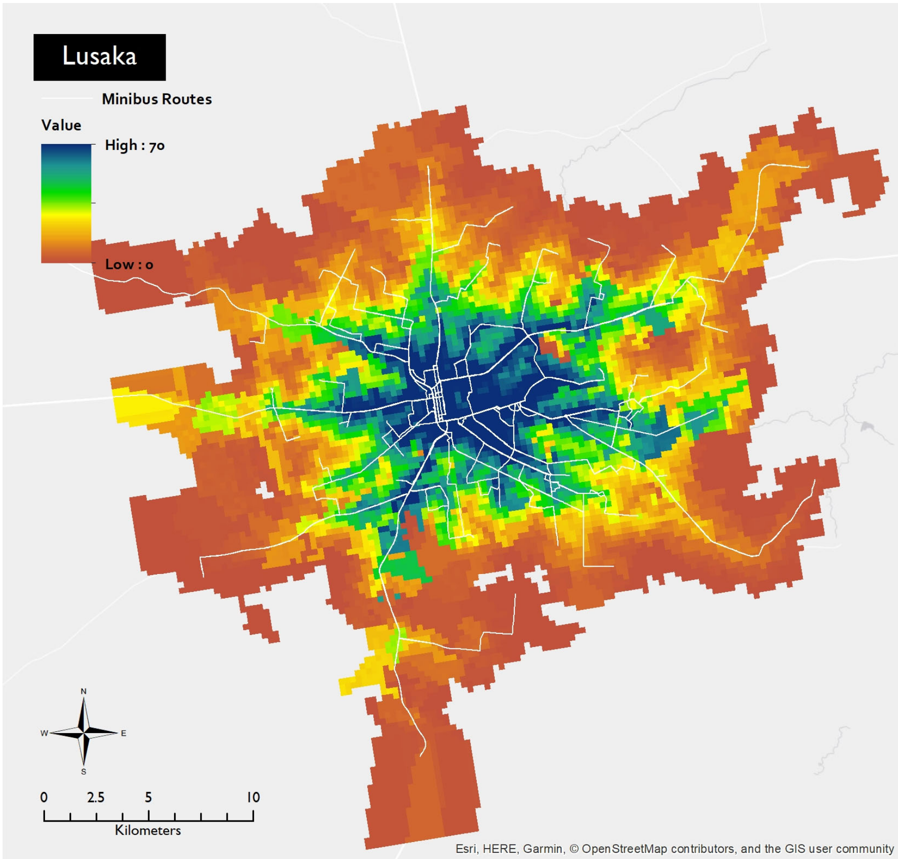
MAP 13: BAMAKO, POPULATION (HEIGHT) AND ACCESSIBILITY (COLOR)

### *5.3.2 Lusaka*

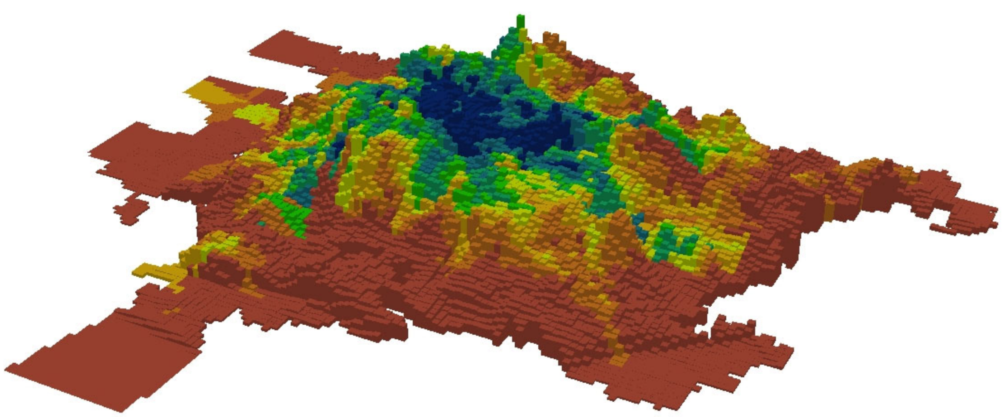
Transport data were gathered by WhereIsMyTransport during November-December 2017, and show 130 routes and 740 stops gathered into a GTFS feed.

Opportunity data are based on the EOA grid produced for this project.

Lusaka has some of the highest access levels in the study, with a 34% average and 86% maximum. This may be thanks to the radial structure of the city – allowing shorter travel distances to the CBD – and high density of EOA. The population density, on the other hand, is one of the lowest of any city in the study. Lusaka also has a relatively low proportion of its population falling within the analysis, with almost a third of the population of the city being beyond the 60 minute travel time cut-off.




MAP 14: LUSAKA, ACCESSIBILITY TO EMPLOYMENT OPPORTUNITIES



MAP 15: LUSAKA, POPULATION (HEIGHT) AND ACCESSIBILITY (COLOR)

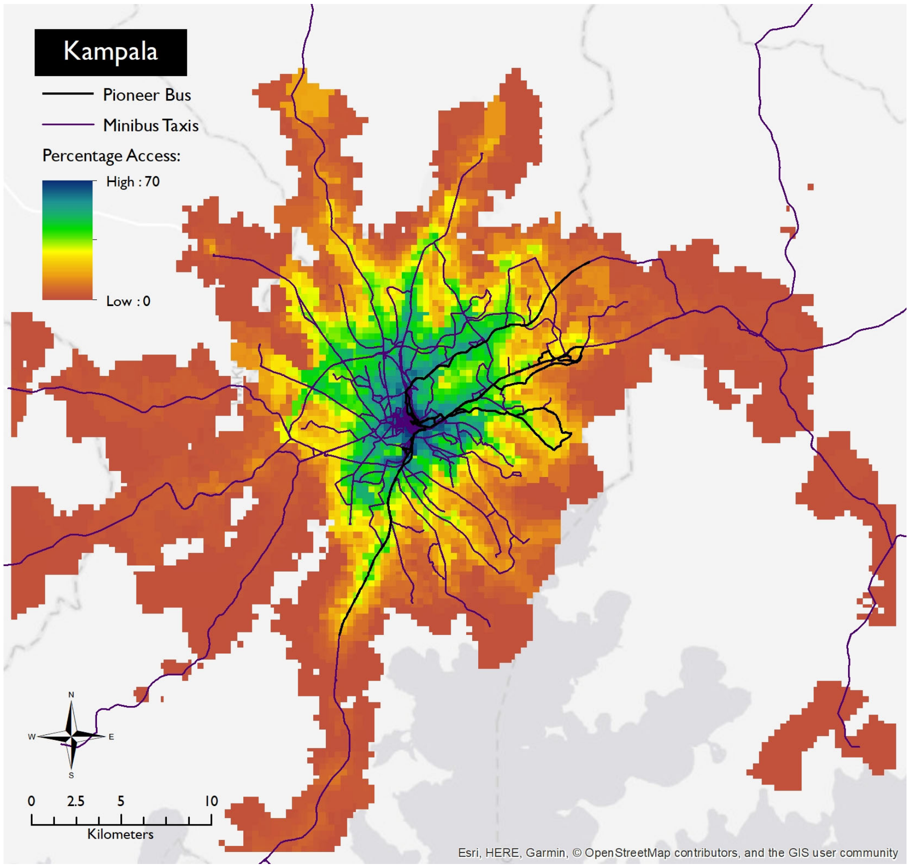
### 5.3.3 Kampala

The Kampala transport data were gathered by WheresMyTransport in September-October of 2017, for both systems operating in the city, Pioneer Bus services and informal minibus taxis. The two systems include 222 routes and 1656 stops.

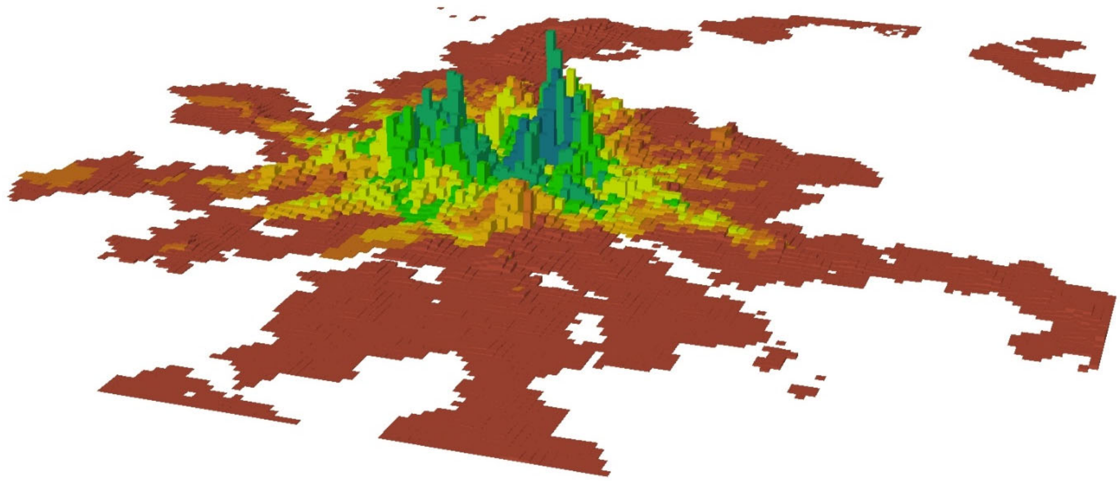
A single train route is intermittently in operation, from central Kampala eastwards toward Jinja, but as it has started and ceased operations a number of times in the past years, it is not included in this analysis.

Opportunity data are based on the EOA grids produced for this project.

Kampala has an average of 32% of opportunities accessible, and for the best located area, 71%. Like a number of other cities, Kampala has both a strong concentration of population within the central parts of the city, but also a 'hollow core' effect, where the highest-access geographic center of the city has low population densities.

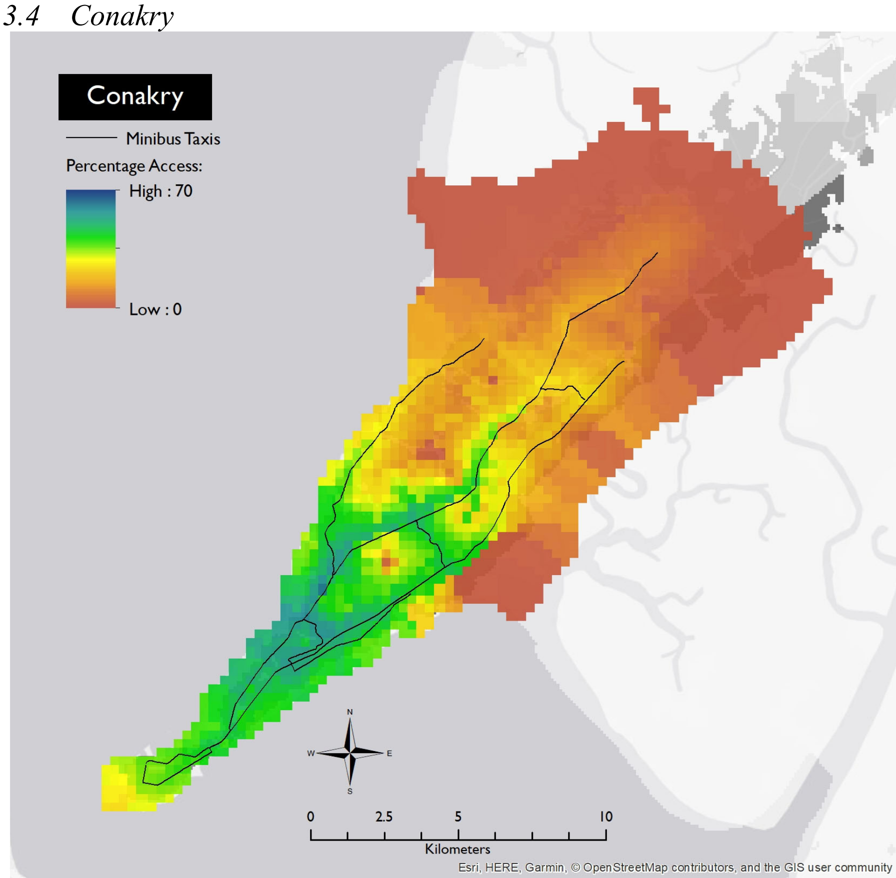



MAP 16: KAMPALA, ACCESSIBILITY TO EMPLOYMENT OPPORTUNITIES



MAP 17: KAMPALA, POPULATION (HEIGHT) AND ACCESSIBILITY (COLOR)

### *5.3.4 Conakry*




MAP 18: CONAKRY, ACCESSIBILITY TO EMPLOYMENT OPPORTUNITIES

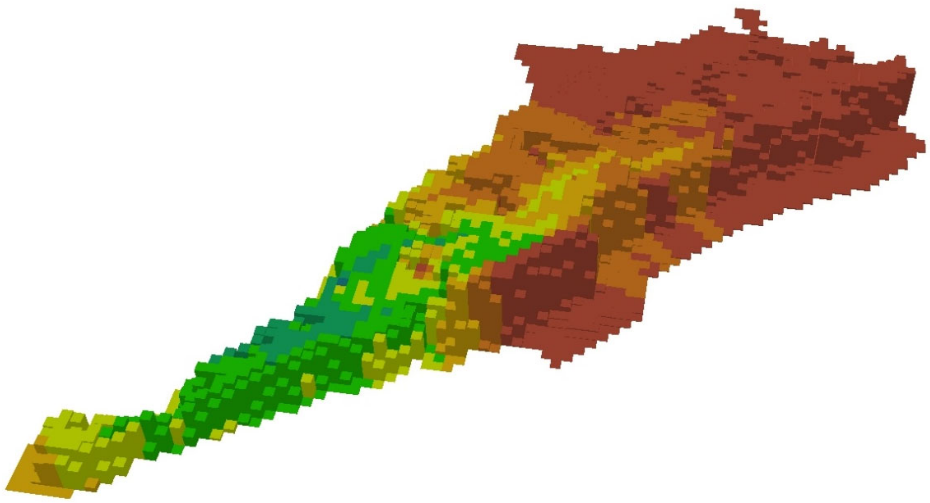
Transport data for Conakry are based on maps produced for the ongoing Plan de Déplacement Urbain (PDU) de Conakry, produced by the European Union and a 2006 study produced by SYSTRA, and digitized to 10 minibus routes with the following assumptions:

| | Speed | Headway | Number of Routes |
|---|---|---|---|
| **High Frequency** | 12 km/h | 5 minutes | 1 |
| **Mid Frequency** | 12 km/h | 10 minutes | 7 |
| **Low Frequency** | 12 km/h | 30 minutes | 2 |

TABLE 7: ASSUMPTIONS FOR THE COLLECTIVE TRANSPORT CHARACTERISTICS IN CONAKRY

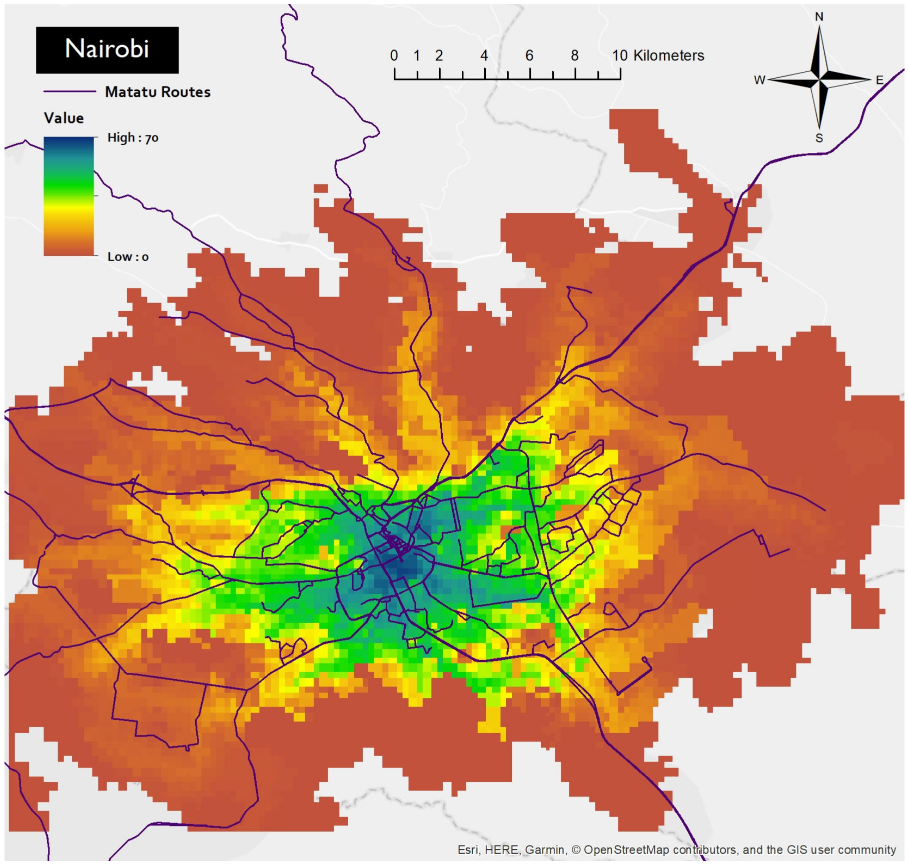
Opportunity data are based on the EOA grids produced for this project.

The average level of accessibility to job opportunities in Conakry is 29.4% and the Gini is 0.41. Much of Conakry's population is concentrated 'up' the peninsula, away from the main business district and with poor connectivity, provided by only a one minibus corridor. The highest access areas lie half-way along the peninsula, in an area where there is good connections in both directions, as well as the local concentration of employment opportunities.



MAP 19: CONAKRY, POPULATION (HEIGHT) AND ACCESSIBILITY (COLOR)

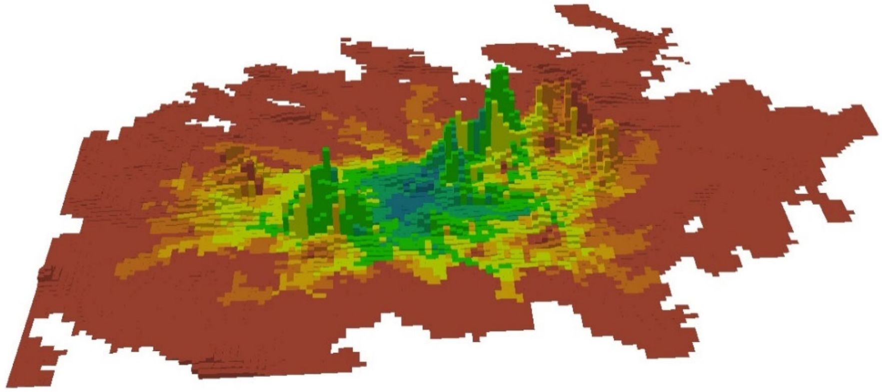
*5.3.5 Nairobi*




MAP 20: NAIROBI, ACCESSIBILITY TO EMPLOYMENT OPPORTUNITIES

The analysis of Nairobi in this report draws on the Digital Matatus GTFS, dated from September 2014. A second feed for the Nairobi local railway is also available, dating from 2013. This analysis finds a 28% average accessibility level, and 65% best accessibility for any location.

Nairobi is the largest city in the analysis in terms of population, and the second largest (except Cape Town) in terms of the territory falling within the analysis. In fact, Nairobi is the only city where minimal accessibility to the city captured the entire population, and in fact extended well beyond the World Bank population estimate. This is estimated to be 3.2 million, whereas over 5.5 million fall within the analysis. Despite this spread, Nairobi still has one of the highest population densities in the study, with significant areas of high-density population relatively far from the central business district and area richest with employment opportunities.



MAP 21: NAIROBI, POPULATION (HEIGHT) AND ACCESSIBILITY (COLOR)

## 6 CONCLUSIONS AND DISCUSSION

At the heart of using accessibility is a city's land use patterns and transport network. Using accessibility as a lens to investigate how cities match people with opportunities allows us to better understand the development pattern, service provision and equity of a city. The accessibility framework allows us to quantify how well a city's public transportation service is connecting its people to opportunities; and how equally this access is distributed among its residents.

This analysis highlighted a number of patterns and tendencies in the spatial development of cities. Broadly speaking, three typologies of distribution can be identified in this sample of 11 cities.

- Equitable Cities:
  Kigali, Douala and Dakar have low levels of spatial inequality in accessibility with Gini coefficients of 0.26 for Kigali, 0.30 for Douala, and just 0.18 for Dakar. But they differ drastically with regards to the average share of accessible jobs they can connect people to: Dakar is the best performer with 46.6%, Douala middling with 39%, and Kigali is the third worst with 15.2%.

- Inequitable Cities:
  Cape Town, Harare and Dar Es Salaam, meanwhile, display high inequality in access to employment opportunities with Gini coefficients of 0.60, 0.42 and 0.63. They are also some of the worst performers in connecting people with employment opportunities with average shares of accessible jobs standing at 6.5%, for Cape Town, 12.2% for Dar es Salaam and 20% for Harare.

- In-between Cities:
  Five cities in the analysis show a relatively similar profile of distribution of accessibility, with highly similar average shares of opportunities accessible by individuals, only ranging between 28% and 34% and intermediary accessibility inequality as measured by Gini coefficients (Bamako, Nairobi, Lusaka, Conakry and Kampala).

When comparing across these groups, the five In-between Cities follow a very similar pattern of employment access per population, despite very different geographies, sizes and processes of economic development. They only begin to show differentiation when reaching the highest levels of accessibility, which serve only the top (in access terms) 30% of their populations. This may suggest, in comparison to the other two types of cities, that in fact the public transit system is relatively poor at affecting spatial mismatch for a large proportion of the population, and follows closely the existing residential and job patterns rather than being able to disrupt.

In terms of population distribution, while not universal, several cities show a distinct access hollow', where the densest populated districts cluster around, but not at, areas of maximum employment access. As accessibility is calculated for all employment opportunities, for locations with multiple clusters, and even multiple parallel transit routes (as in the case of Conakry) the best access levels may fall not on, but between them, in locations with good access to multiple transport routes and multiple employment centers, highlighting currently low-density areas with high development potential.

This is the first study applying a similar methodology across different cities and based on similar, if not identical, data, to produce comparable accessibility metrics in data-poor environments. As such, it allows an analysis of patterns and trends in spatial data, establishing both a relevant benchmarking process and the integration of individual geographic circumstances. This data set can be used, and further built on, to understand the interactions between distributions of jobs, people and transport and mapping out the dynamics and challenges of urban agglomeration in Africa. It can potentially serve as a component for transport planning, transit-oriented development, land use planning, and investments in increasing labor markets and employment opportunities in African cities.

Specifically, this initial benchmarking opens up a number of avenues for further policy oriented research and operational engagements. First, the simulation of counterfactual scenarios, by comparison to the baseline, can provide some orders of magnitude as to the employment accessibility impacts of urban plans and/or transport investments. This can be useful for local decision makers which aim to compare different projects or assess the benefits of a specific project.

Second, in follow-up work, we will seek to link urban form indicators (such as job-housing balance, land use patterns and others) to the performance of urban areas in terms of employment accessibility. We could equally attempt to quantify the requirements in terms of transportation infrastructure investments needed to offset the impacts of spatial structures that are less conducive to employment accessibility. This work would be meaningful for policy makers as it could provide some estimates of the benefits of acting on urban forms and of the costs of failing to do so.

Third, this work provides a solid basis for thinking about how access to employment opportunities impacts employment outcomes (status of employment, formal or informal job, wages…). Some recent works are going in this direction (Franklin 2015) and the constitution of this accessibility database could constitute the first step in expanding this growing body of literature over several African cities.

Last, but not least, in the context of defining metrics to inform the Sustainable Development Goals (SDG), in particular, SDG 11.2, we hope that this analysis can serve as a demonstration of the possibility (and relative ease) of computing accessibility to employment metrics, including in data scarce environments. SDG 11.2 reads "by 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons". One of the current proposed indicators to measure progress along SDG 11.2 is the percentage of people within 0.5km of public transit, running at least every 20 minutes. We argue that focusing on accessibility to jobs would be more meaningful as the goal of transit systems is ultimately to connect people to opportunities, including economic. While the calculation of employment accessibility is more difficult than that of the distance to transit stops, it is not out of reach, including in urban areas of the developing world.

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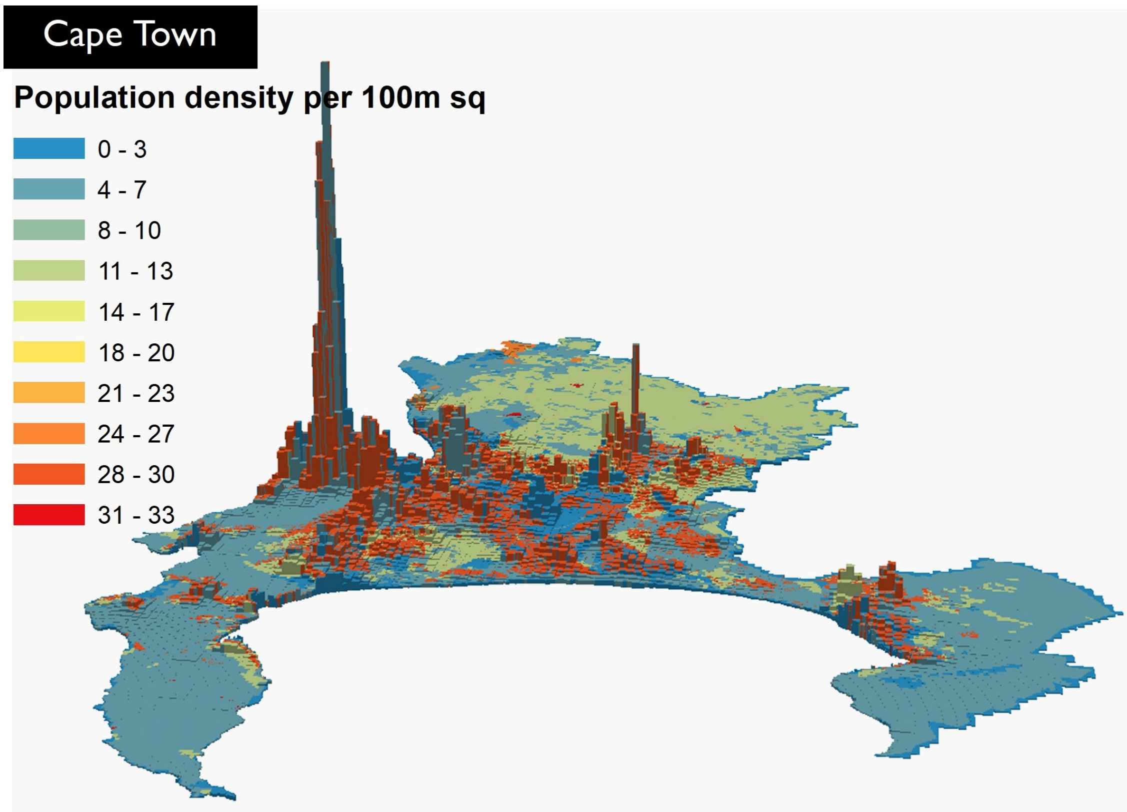
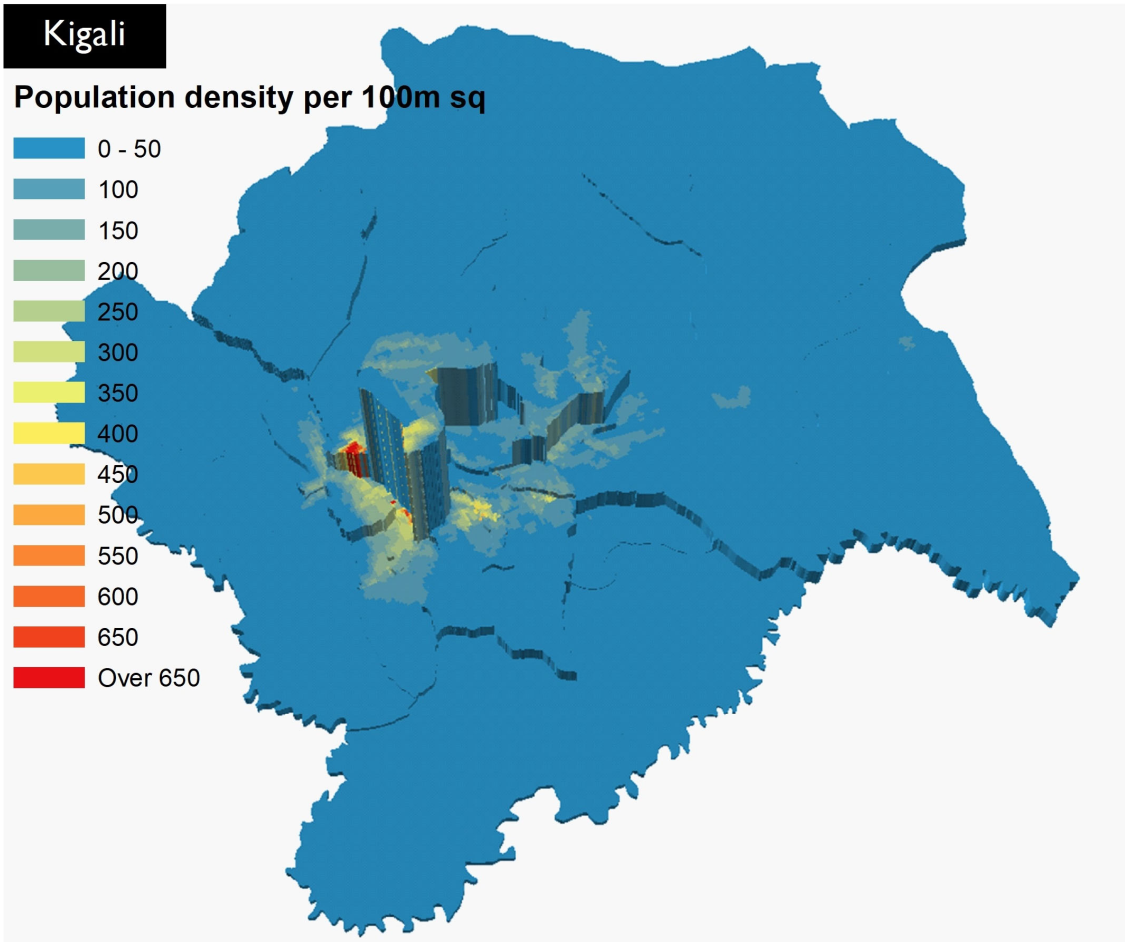
## 8 ANNEX

The following 3D maps show on the same figure the distribution of employment densities (or proxy for employment densities) – through pixel heights – and the population densities – through color codes. These figures are useful to visually capture for each city whether there exists a spatial mismatch between employment and population concentrations or conversely whether there is a more even job-housing balance.

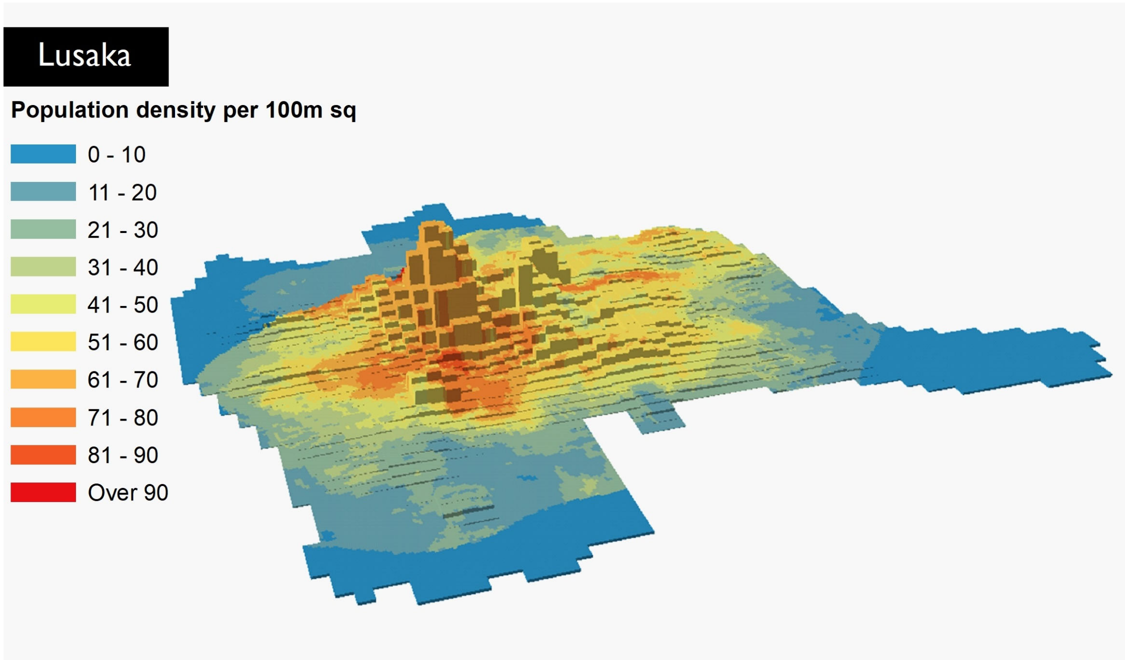
Population density (color) and employment opportunity densities (height) are not directly comparable between different maps and cities, and have a wide variety due to need for effective visualization.

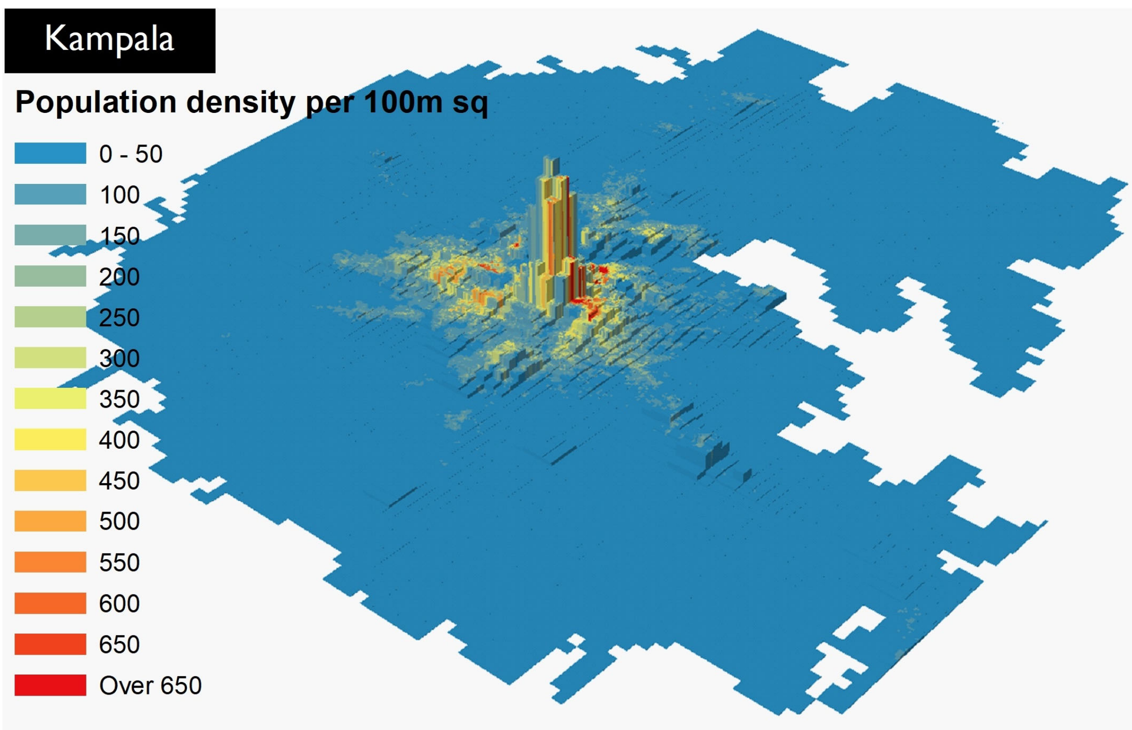


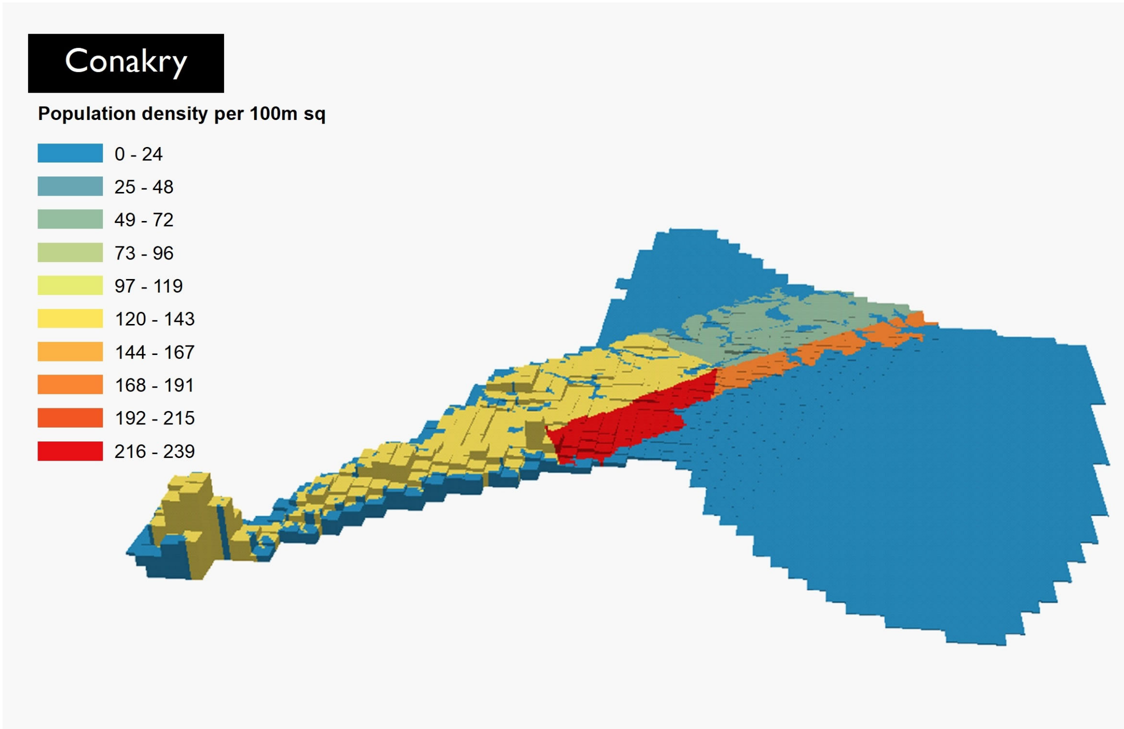

The map of Cape Town above shows the concentration of employment opportunities (height) and of population density (color). Note the much lower population densities of Cape Town compared to most African cities, but the much more extensive inhabited area, spreading far beyond the central city.

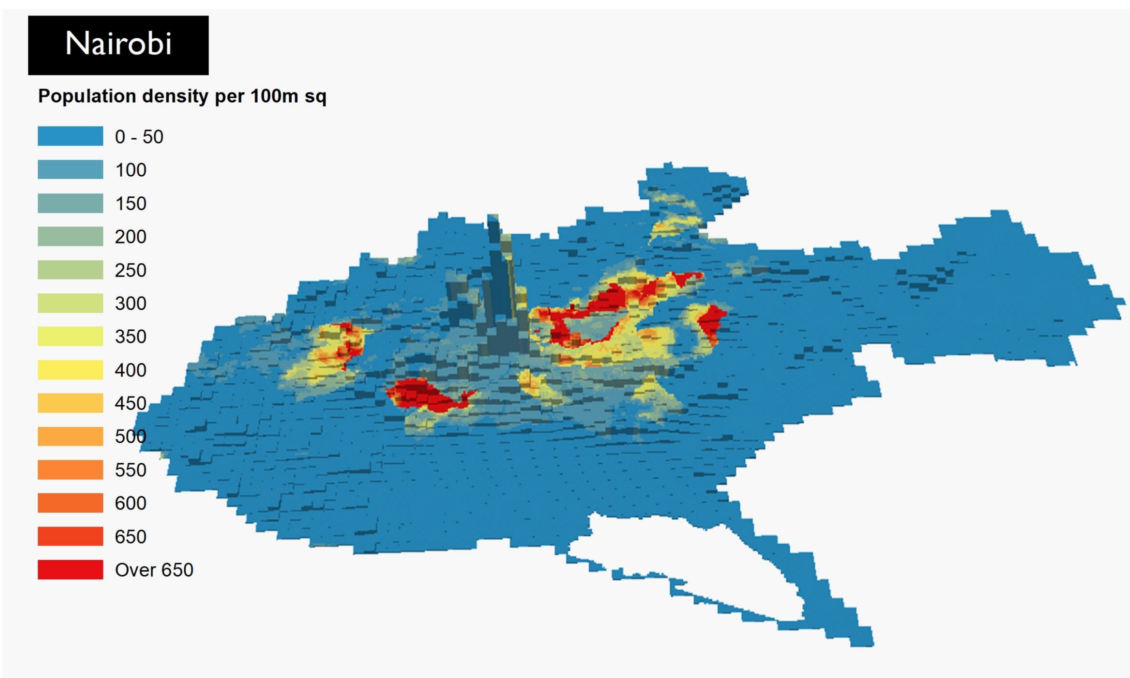



The 3D map above shows population density (color) and distribution of jobs (height) at the sector level in Kigali district. As can be seen, jobs are clustered at the city center, while population is relatively more distributed, though much of the area within the analysis, although within the district of the capital city, is relatively thinly populated.

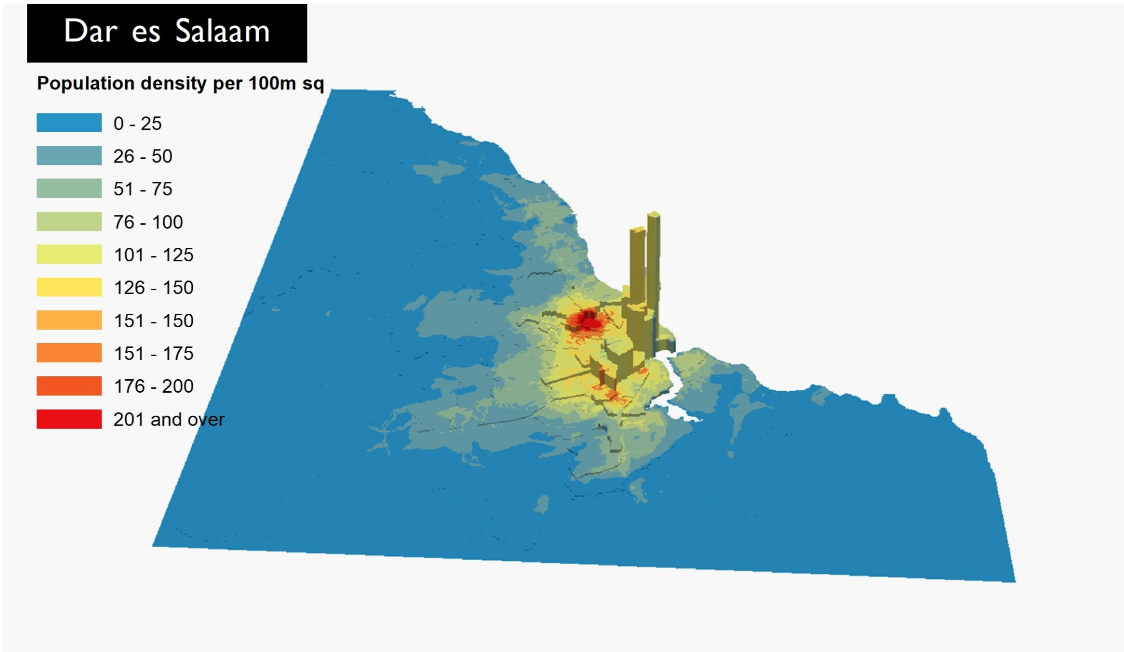

Lusaka
Population density per 100m sq
0 - 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 70
71 - 80
81 - 90
Over 90

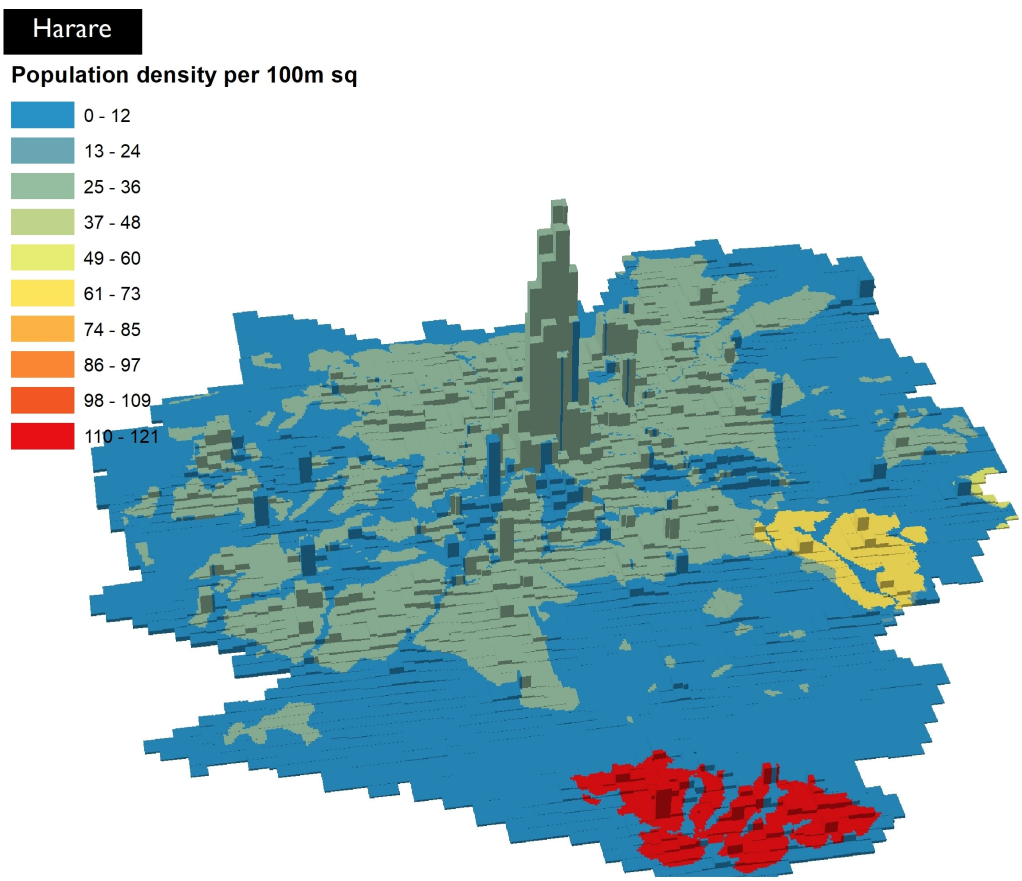

Kampala
Population density per 100m sq
0 - 50
100
150
200
250
300
350
400
450
500
550
600
650
Over 650

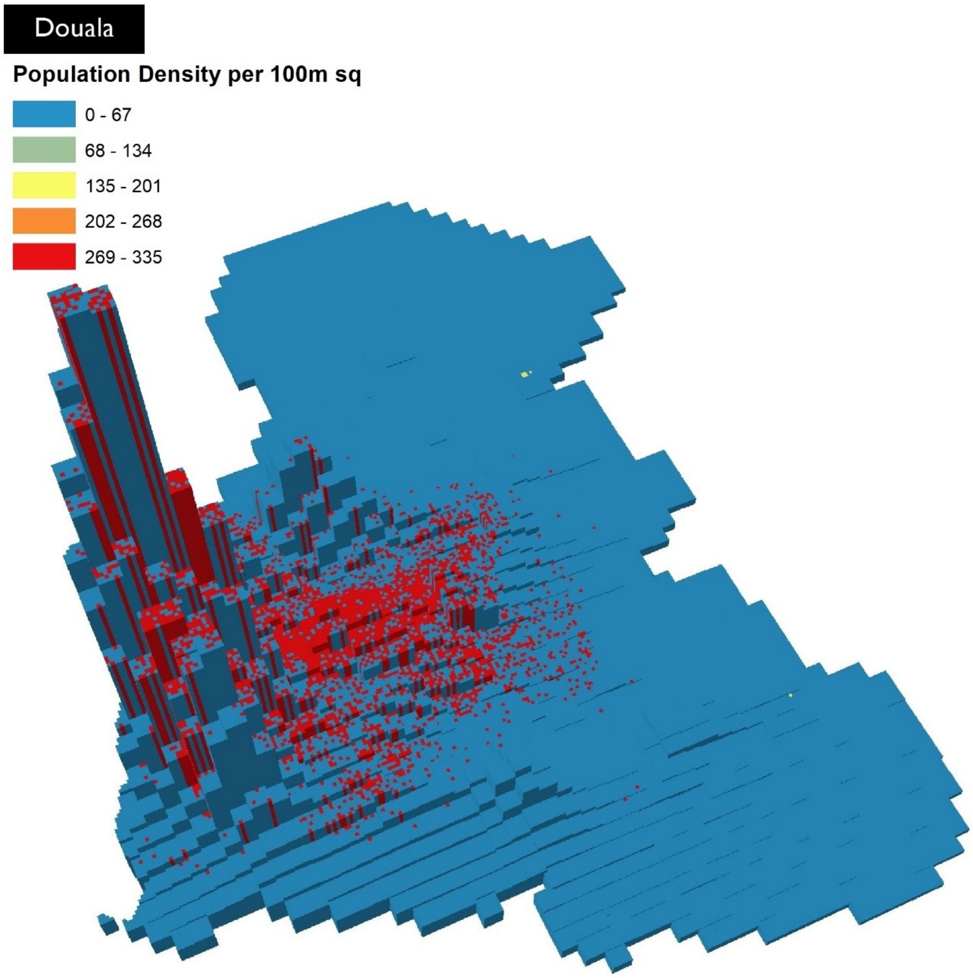


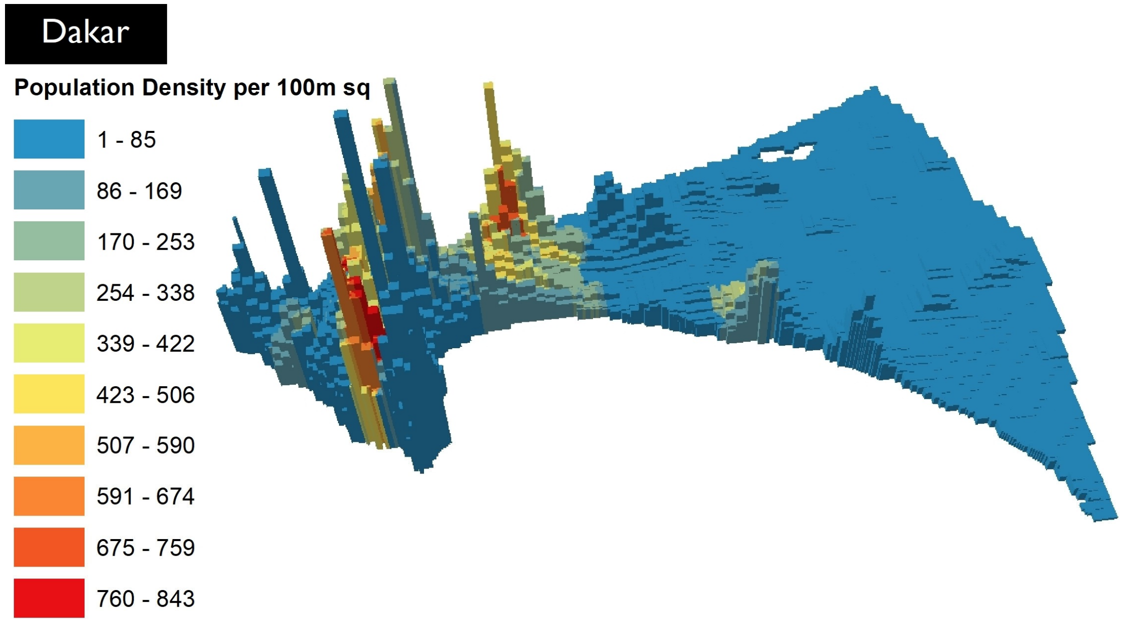

The map above shows the population density (color) and the concentration of employment opportunities (height). The highest density areas, in terms of population, notable fall distinctly outside the concentration of jobs. The map below shows the level of accessibility (color) and the concentration of population (height).


Dar es Salaam
Population density per 100m sq
0 - 25
26 - 50
51 - 75
76 - 100
101 - 125
126 - 150
151 - 150
151 - 175
176 - 200
201 and over


Harare
Population density per 100m sq
0 - 12
13 - 24
25 - 36
37 - 48
49 - 60
61 - 73
74 - 85
86 - 97
98 - 109
110 - 121




As can be seen, in Douala jobs are clustered in the CBD and on the East side of the estuary, while population is distributed much more widely. The ‘patchiness’ of very high and very low population densities reflects unusual patterns in the WorldPop data, but can serve as an indicator for population distribution.




In Dakar, population and jobs are visibly clustered closely together, in many parts of the city. This may contribute to Dakar's high employment accessibility levels.