

Final report

# Managing accessibility for sustainable development of Kigali, Rwanda

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# Managing Accessibility for Sustainable Development of Kigali, Rwanda

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## Introduction

The second Economic Development and Poverty Reduction Strategy of Rwanda, EDPRSII (Republic of Rwanda 2013), recognizes that healthy urbanization will be a key driver for sustaining growth and ensuring prosperity for its people. Currently one of the least urbanized countries in Africa, Rwanda is expecting an annual urban growth of 9 percent, with Kigali creating many of the 200,000 non-farm jobs required nationally each year, and absorbing much of the influx of rural migrants. Absorbing these new, and current, residents into the labour market will not be easy, however. Over 70% of residents live in informal settlements, land prices and house rents are rising, and access to jobs and social services are a challenge.

Kigali is a labor market, and its economic well-being will depend on people’s access to work, healthcare, education, and market-places. Kigali is also a community, and its success in that regard requires good access to meeting places like churches and the homes of friends and relatives across the city. To that end, one of the primary functions of the city administration is to sustain efficient and affordable public transport.

Access to a particular facility can be enhanced either by improving time and cost to reach there (e.g., by improving public transport services, road network, and pedestrian and bike facilities) or, by bringing the facility closer to the user. “Accessibility” measures the ease with which an individual or community can access opportunities (e.g., employment and community services), counting monetary and time costs. Cities across the world have begun to use Accessibility as a key metric to evaluate the efficiency and equity of transport supply and activity location. Using such a measure on regular basis helps to monitor performance and guide improvements. The practice ensures that the accessibility for economic and social opportunities do not deteriorate below an acceptable threshold, where they begin to affect the health of a city’s economy and community, particularly for those who are or will be heavily burdened with transport and housing costs.

Therefore, the primary objective of this study is to introduce Accessibility principles for improved planning and monitoring of interventions in Kigali. To operationalize the above, Kigali planners and decision makers need a simple tool which can measure the impacts of planned investments or policies on Accessibility. This can inform decisions about

transport sector interventions (e.g., transit fares and service levels, road capacity improvements, new bus route or BRT services, etc.) as well as activity location decisions (e.g., job centers, low income housing sites, schools, clinics, markets, open spaces, etc.).

The final output of this study is a basic Accessibility assessment tool. This paper discusses the tool, along with a few illustrations on how to use the tool for a project or policy evaluation.

By adopting Accessibility metrics, Kigali can also enrich its future Comprehensive Development Plans (CDPs), the five-year investment planning framework. In addition, the City will be able to nurture new ways to co-operate with relevant stakeholders and government agencies including the MININFRA's Regional Transport Development Authority (RTDA), Regional Housing Authority (RHA), Regional Utility Regulatory Authority (RURA), community service providers, and the public transport companies/co-operatives (e.g., KBS, RFTC and Royal).

This study was sponsored by the IGC, and conducted in close co-operation with the World Bank. During a week-long Kigali visit the team of IGC and a World Bank staff collected the readily available data to develop a basic Accessibility mapping tool. At the end of the trip the team had the opportunity to train the key staff (GIS specialists) of the CoK, RURA and RTDA, with the applications of software that are used to develop the accessibility assessment tool.

## Methodology: Developing an Accessibility Assessment Tool for Kigali

### Measures of Accessibility

The study uses the so-called *isochronic* measure of Accessibility, due to its intuitive appeal, ease of application, and visualization capability using the widely available GIS tools. The isochronic measure counts the number of opportunities (e.g., number of jobs, schools, clinics) that can be reached from a location using a particular mode of travel within a threshold of travel time or distance or cost.

For example, to measure job accessibility of a neighborhood, we count the number of jobs that can be reached from one neighborhood by bus within 45 minutes (or whatever time threshold is selected). One could alternatively count the jobs reachable within 60 minutes or 30 minutes, or by walking rather than using the bus, or during the more congested peak hour, for alternative/complementary accessibility measures for the neighborhood. Similarly, one can ask about destinations other than jobs: how many secondary schools are accessible within a specified walk or bus journey time, say, 30 minutes? What about hospitals, or markets?

### Data and Software for Measuring Job Accessibility Using the Public Bus System

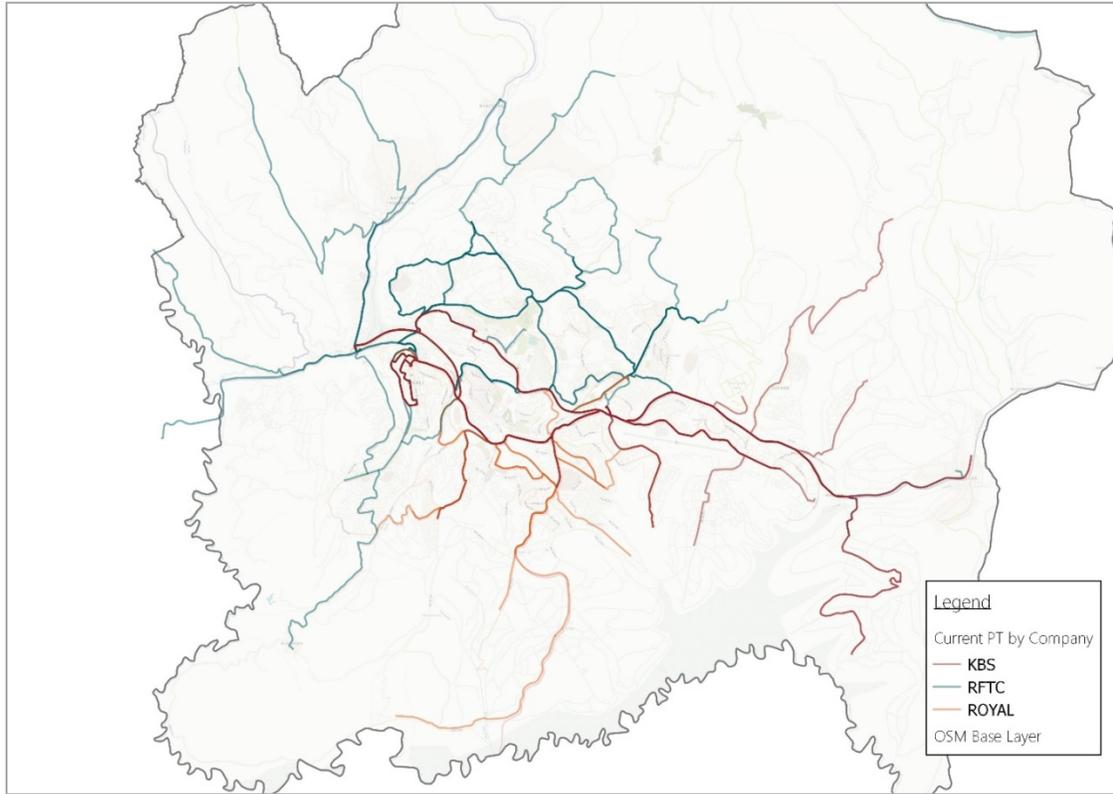
Considering the predominant use of buses and the government's priority for public transport oriented development in Kigali, the study focuses on developing a basic tool for measuring **job accessibility** by **public bus journey times**. However, the developed tool is flexible enough for future enhancements and new applications. Depending upon the availability of data, the same tool can easily measure accessibility by other modes (e.g., *walking* distance, or bus travel *cost*) and for other types of opportunities (e.g., access to colleges, specific type of jobs, markets, tourist sites, etc.).

The public bus system of Kigali is operated by three private service providers, Kigali Bus Service (KBS), the Rwanda Federation of Transport Cooperatives (RFTC) and Royal Express. The three operators serve seventy routes that connect the city center with the outer areas of the city (see Fig. 1). During a week-long trip to Kigali the study team contacted officials of the above three bus operators, RURA (the bus regulator), RTDA (regional road agency) and the city of Kigali (COK) to collect route specific bus service data by time of the day (peak and off-peak frequencies, route length and journey times). Bus service performance data was collected in a format which meets the industry standard (General Transit Feed Specification, GTFS). By adopting GTFS format the collected bus performance data can be used by most globally available software.

The spatial distribution of the current population and employment opportunities were extracted from the WorldPop site and the 2011 Kigali census and enterprise surveys respectively. The WorldPop provides population for each 100m X 100m grid covering the city (Fig. 2). While the enterprise survey provided firm employment (formal jobs) for 1162 villages of Kigali (Fig. 3). The absence of informal job data, a dominant source of the city's labor market, remains a major gap in the study. In its absence, we assume that informal jobs are currently distributed in a manner similar to formal firm level jobs, or that policy-makers are most interested in access to formal jobs.

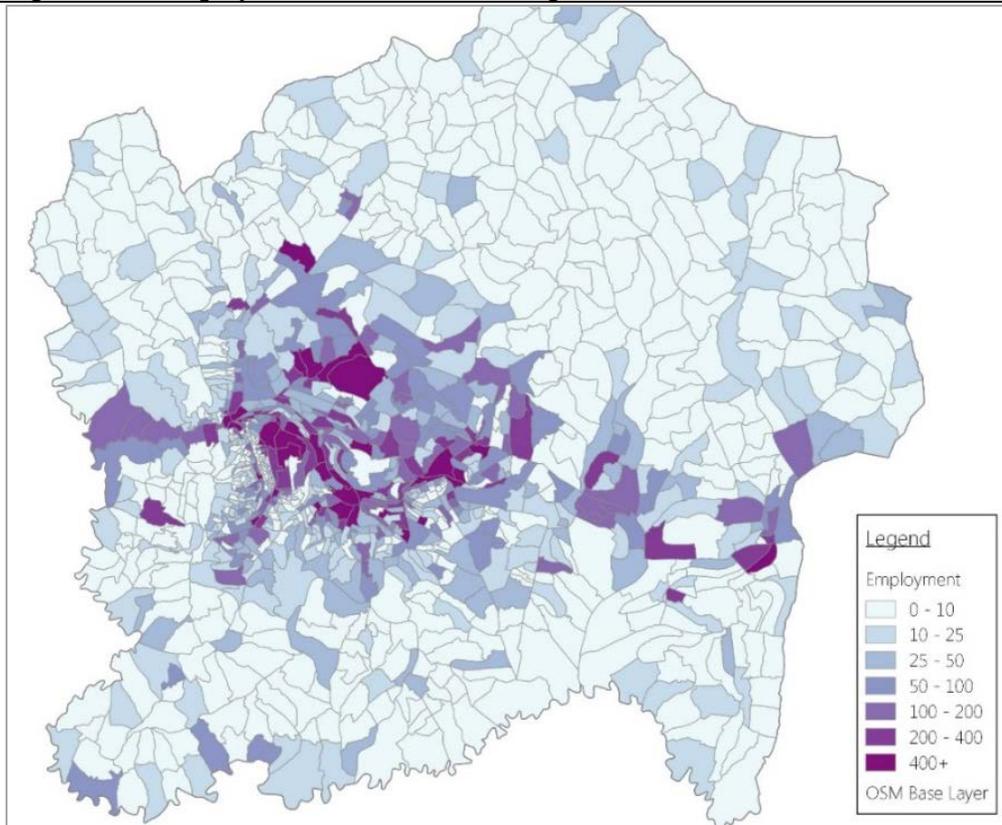
The World Bank staff assisted the IGC team with the creation of GIS shape files for all Kigali specific information including the population, firm employment, location of community facilities, and the road network using the Openstreet (an open source data on road network). The QGIS (open source software) was used for the visualization of all location and network specific information. To calculate the AM peak period bus travel times between various locations of Kigali, an interactive web based tool, Transport Analyst (OTPA, an open source, web-based tool developed by Conveyal), was used. Transport Analyst uses bus and road network data, bus service attributes, and locations of opportunities (in this case firm employment and population) to calculate the accessibility of each location in the city (100 sq. m. cells). To demonstrate the applicability of the accessibility measuring tool, a few investment scenarios were examined as discussed below.

**Fig. 1: Current Public Bus Network in Kigali**



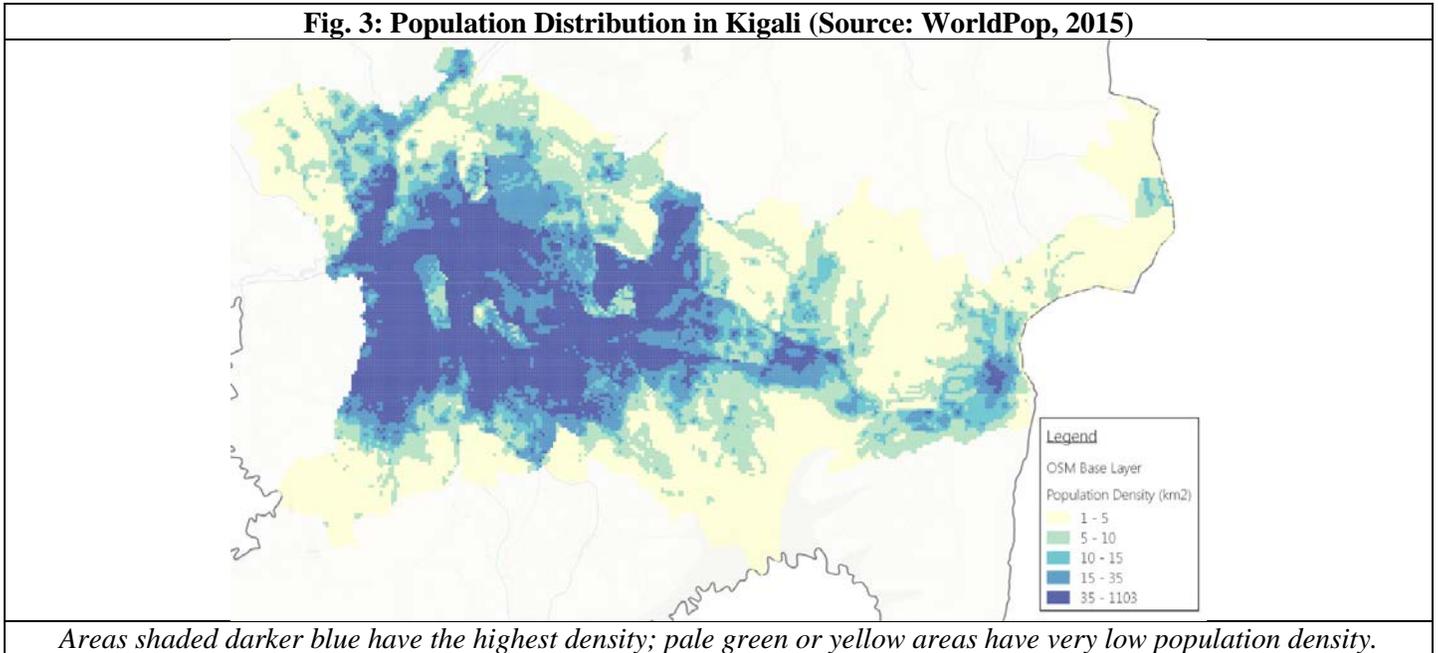
*This map shows the bus network in Kigali. Red lines are KBS bus routes, green lines RFTC routes, and orange lines Royal Express. The bold lines are the major, more regular routes, and faded lines are feeder routes.*

**Fig. 2: 2011 Employment Distribution in Kigali**



*This map of Kigali shows the number of formal job opportunities by sector, according to the 2011 Establishment Census*

**Fig. 3: Population Distribution in Kigali (Source: WorldPop, 2015)**



*Areas shaded darker blue have the highest density; pale green or yellow areas have very low population density.*

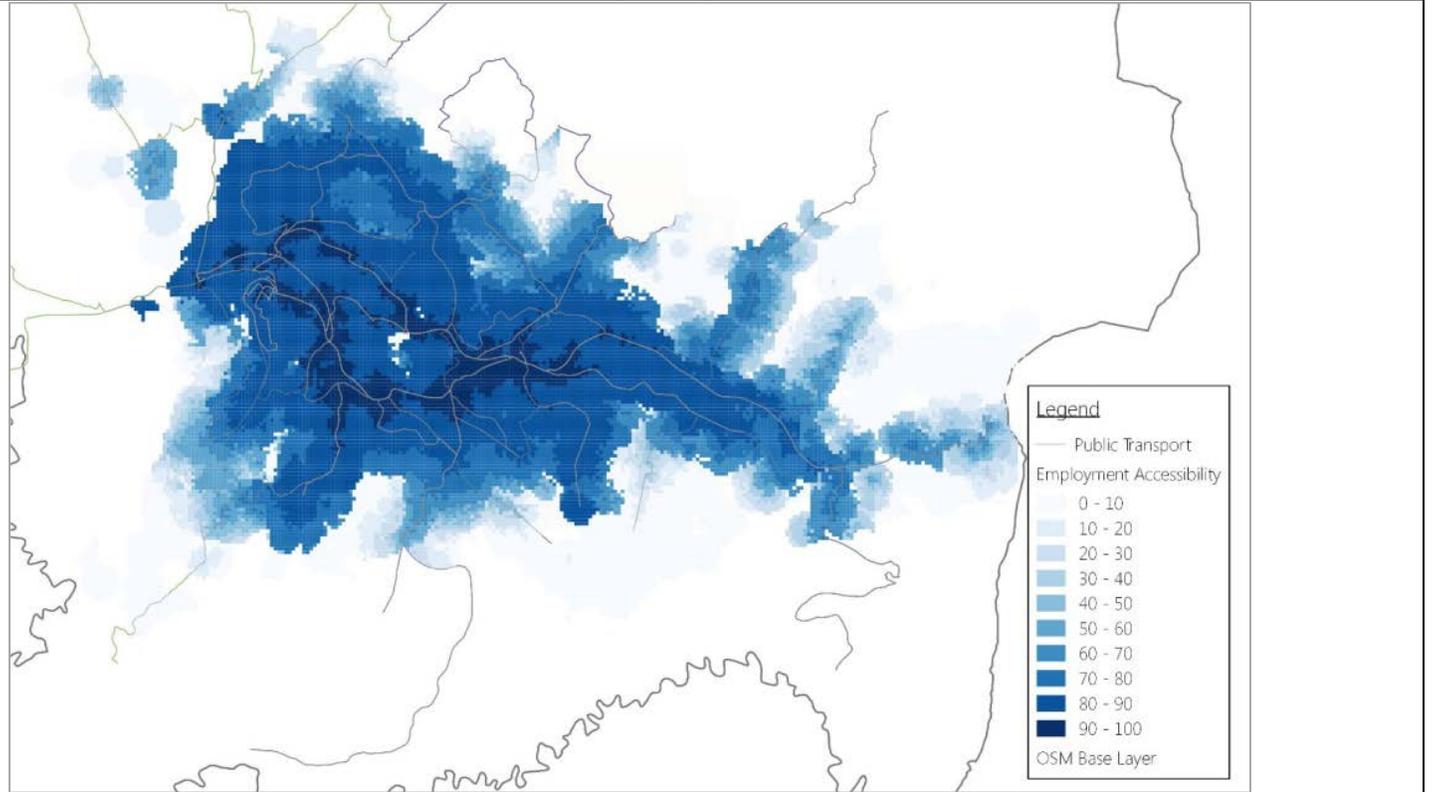
## Applications of Accessibility Assessment Tool

### Existing Job accessibility by Bus

**Job accessibility** is assessed assuming a journey time threshold of 60 minutes by bus during the morning peak hours. The results of analysis are displayed in Fig. 4. Due to the concentration of firms and population along the primary roads and bus routes within the central city areas (see Fig. 2 and 3), currently a high proportion (almost 64%) of city population is enjoying good access to employment (see the percentage of people with accessibility below the mean in Table 1). However, as one moves away from the main arterial road corridors and central area, overall accessibility begins to decline quite sharply (see Fig. 4).

Currently, traffic flow in Kigali is quite good; the usual peak hour congestion is observed near a few central city intersections and along certain sections of radial roads connecting the outer areas. For several routes, bus journey times reported by bus operators are low, but do not take into account the delays imposed on passengers waiting at the terminals. It is a common practice to delay departure of a bus until it is full or nearly full. Similarly, in cases of a few bus routes, the reported speeds are high, above 30kmph. Since high speeds mask waiting times, which are often significant due to the low frequencies of each bus service, we capped speeds to 30kmph. For future application of the tool, we recommend that the reported bus data must be reviewed for accuracies, and the effect of average waiting times should be incorporated in the estimation of bus journey speeds.

**Figure 4: Current Firm Employment Accessibility in Kigali**



*This map shows the percentage of formal jobs in the city available within a 60-minute bus journey, for each location (100mx100m square). The darker the shade of blue the greater the proportion of jobs accessible.*

### Future Job accessibility by Bus

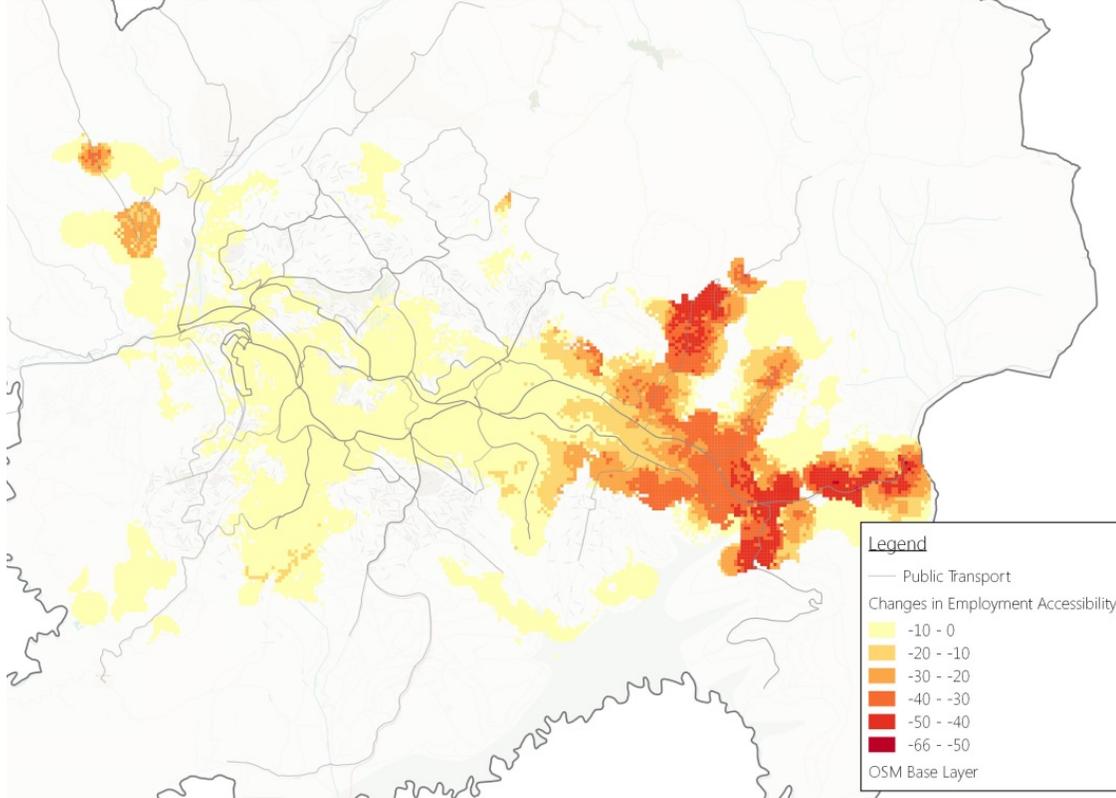
Between 2010 and 2014 the annual growth rate of registered vehicles in Rwanda has been 14.45% (National Institute of Statistics, 2015). Due to such a high rate of motorization coupled with more than doubling of Kigali's population by 2025, it is safe to say that in coming years city roads will experience an accelerated increase in traffic. Kigali's hilly topography limits scope for widening existing roads, and the areas with the highest expected future population growth have few and narrow existing roads. Increased traffic along major arterials will in turn deteriorate service levels and productivity of the current public bus system. In our view, Kigali is presently at a tipping point of an acceptable accessibility distribution, but further decline in road and bus system capacities will have severe consequences for households who will fail to access future opportunities, and for firms to access their consumers and labor markets.

To examine the implications of increased road traffic on the distribution of current access to firm employment by bus, the study considered three scenarios: 1) 20% reduction in current bus speeds; 2) 50% decline in bus speeds; and 3) capping max bus speed at 20kmph. Under the third scenario, the bus routes with reported average speed above 20kmph in the morning peak are capped at 20kmph all day. Most of these routes are serving outer settlements of the city where future growth is expected.

The results of the above three scenarios are displayed in Figures 5, 6 and 7. Our analysis shows that the average bus system accessibility to employment drops significantly under each of the three scenarios (see Table 1), particularly in the eastern areas of the city first, and then in areas surrounding the city in the north and south. Due to the concentration of jobs, central city sustains high accessibility in the short term as seen under the scenario 1, but the central area begins to

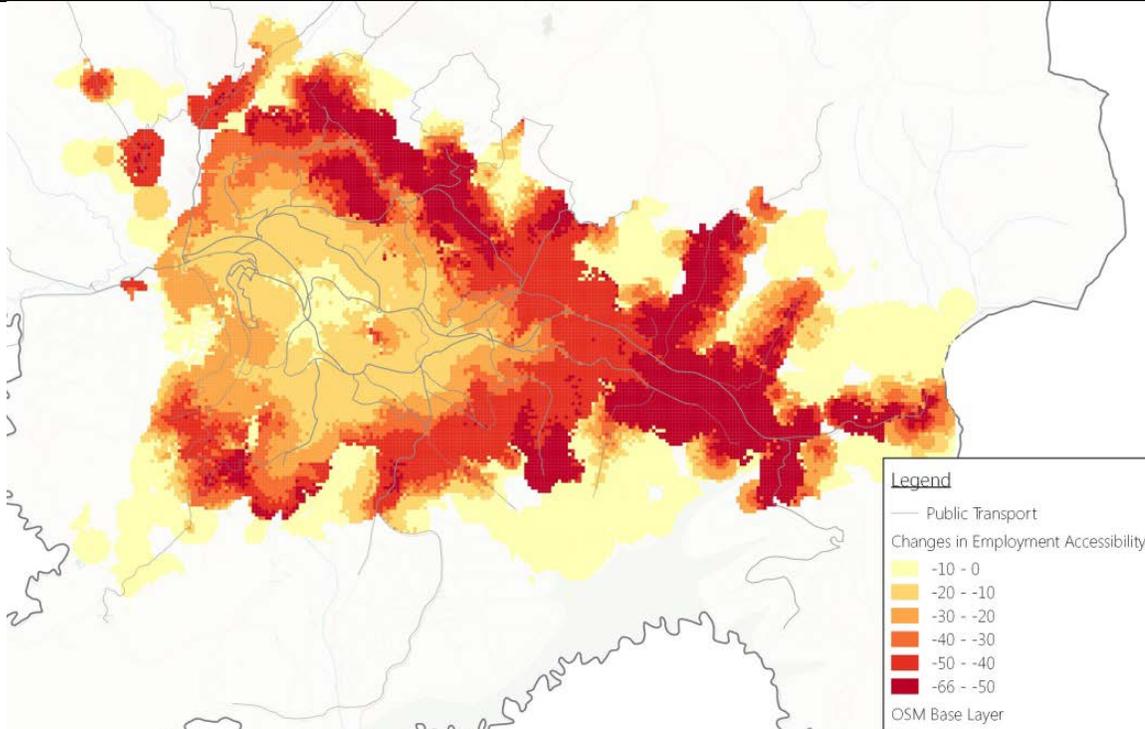
suffer from an accelerated traffic growth under the scenario 2. Areas affected by accessibility decline under the scenario 3 are similar to the scenario 2, though the impact of capping the bus speed is less severe.

**Fig. 5: Scenario 1: Changes in Employment Accessibility Distribution with 20% Drop in Bus Journey Speed**



*This map shows how different areas of Kigali would be affected by a 20% increase in bus journey times. It considers specifically residents' access to jobs. Areas shaded red or dark orange would lose access to 40-60% of jobs in the city.*

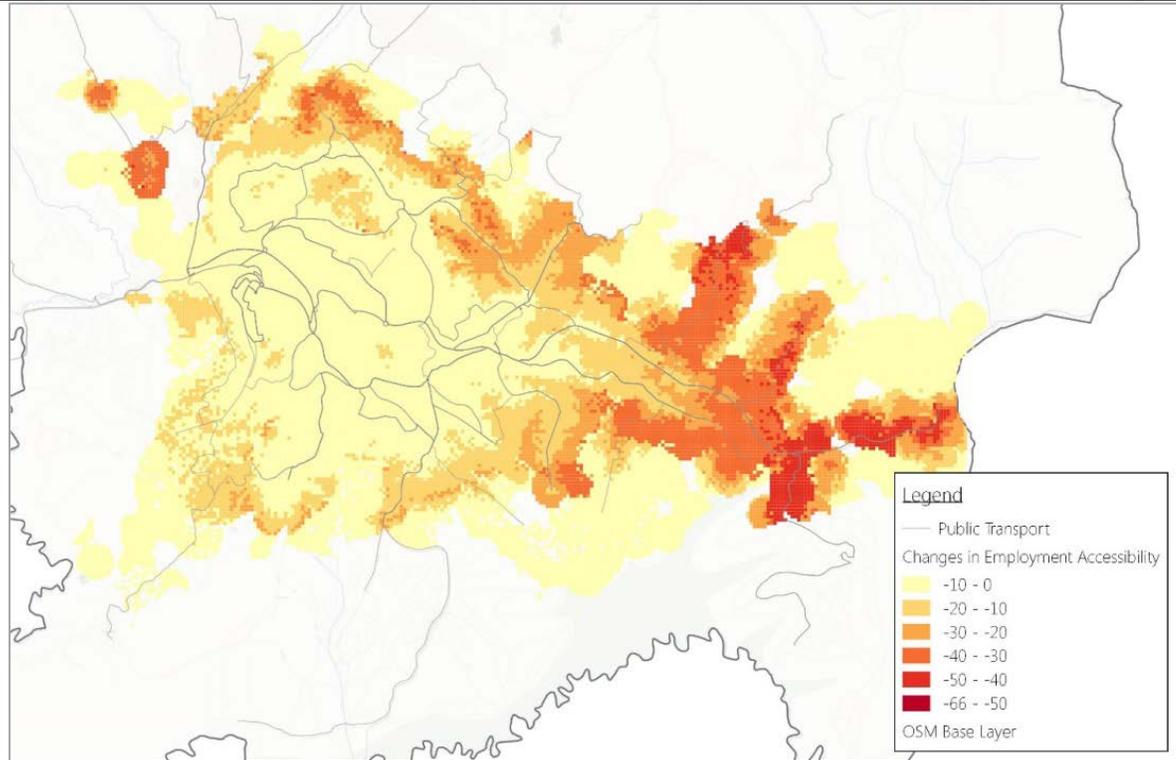
**Fig. 6: Scenario 2: Changes in Employment Accessibility Distribution with 50% Drop in Bus Journey Speed**



*This map shows how different areas of Kigali would be affect by a 50% increase in bus journey times. It considers*

*specifically residents' access to jobs. Areas shaded red or dark orange would lose access to 40-60% of jobs in the city.*

**Fig. 7: Scenario 3: Changes in Employment Accessibility with Bus Speeds Capped at 20kmph**



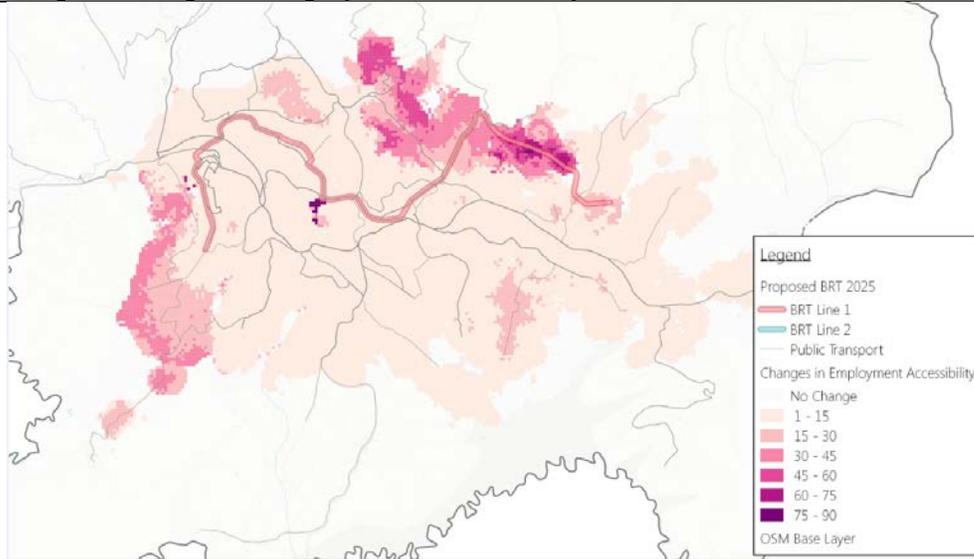
*This map shows how different areas of Kigali would be affected by congestion that caps bus speeds at 20kmph. It considers specifically residents' access to jobs. Areas shaded red or dark orange would lose access to 40-60% of jobs in the city.*

### Impact of the Proposed BRT System on Existing Employment Accessibility: An illustration

The 2025 Kigali master plan (COK, 2013) proposes two BRT corridors to nurture a transit oriented development of city. To illustrate the possible uses of the Accessibility tool, the study examined the impact of building each of these two BRT corridors separately and jointly on the current distribution of firm employment accessibility. As relevant future data (distribution of employment and population, and bus system performance characteristics under the 2025 traffic conditions) become available, a similar analysis can be undertaken for the 2025 conditions. Since in the coming months, CoK is planning to undertake a feasibility study for the BRT system, the above tool will be useful in examining the distributive impact of BRT corridor alternatives, in terms of accessibility impacts that each alternative will have on the majority in reaching different opportunities (jobs, hospitals, secondary education, colleges, etc.).

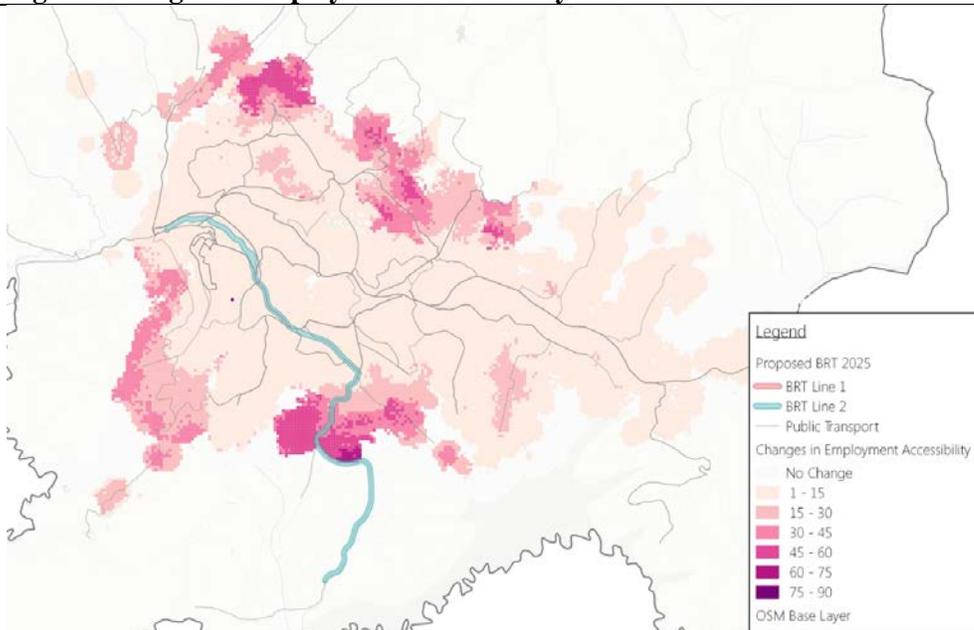
We assumed that the travel speed and frequencies of the proposed BRT system will be similar to those of successful BRTs in other countries (e.g., Transmilenio in Bogotá). New travel times between the zones affected by the BRT corridors were computed. No change was made to the current bus routes and their performance levels. The results are displayed in Figures 8, 9 and 10, and the average accessibility following the introduction of each of the two BRT corridors and the full system, is shown in Table 1. With the implementation of the two BRT corridors the outer areas in the north and south of the city will benefit the most. There will be limited accessibility improvements in other parts of the city such as the eastern areas, where the growth pressure is currently high. If the future growth occurs in areas that will benefit from BRT services, the estimated mean accessibility will improve, and the proportion of population below mean accessibility will decline compared to the estimated values shown in Table 1. Similarly, by integrating the proposed BRT lines with a restructured bus network overall employment accessibility can be further improved. New alternatives of BRT lines, if considered, will also help to optimize the future performance of overall public transport system.

**Fig. 8: Changes in Employment Accessibility with BRT 1**



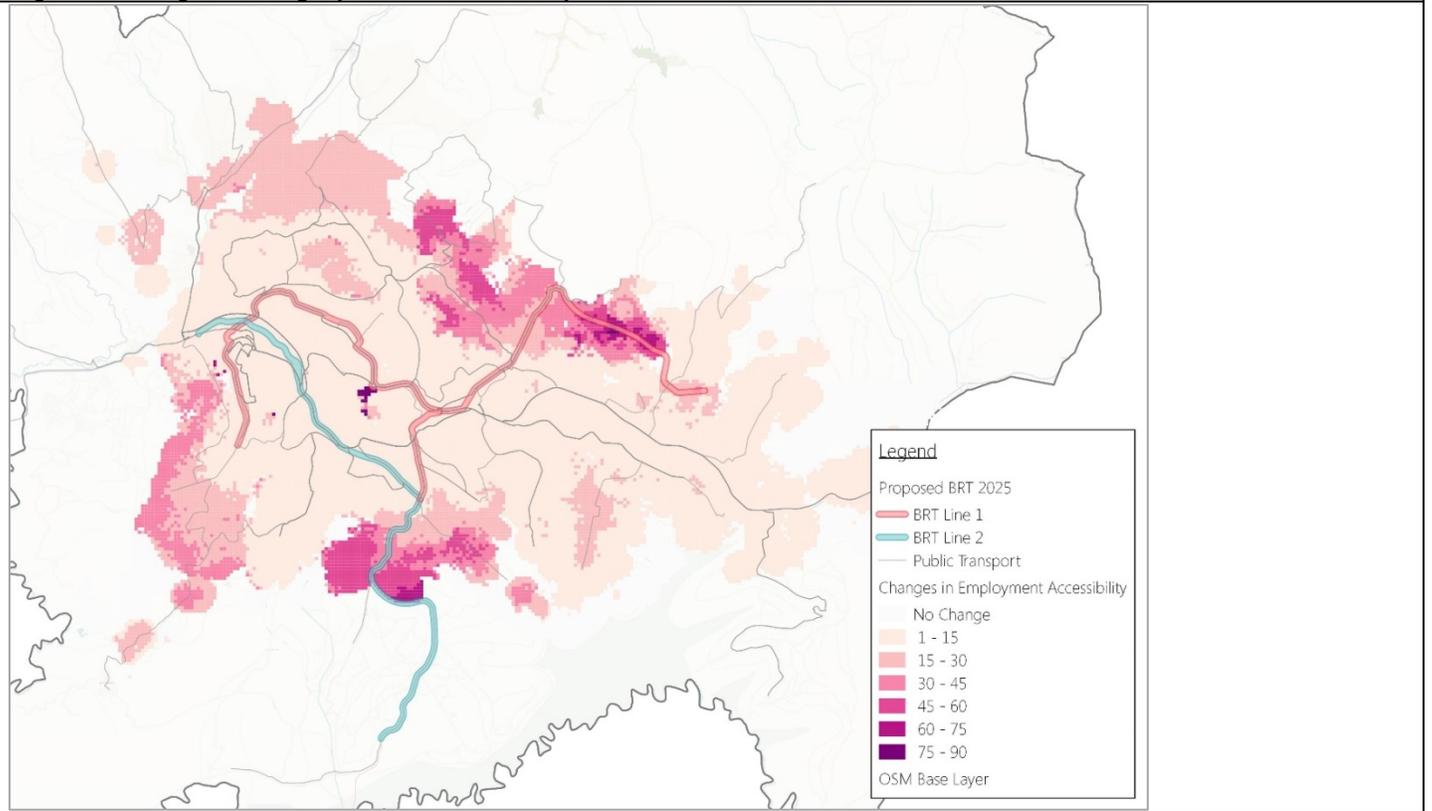
*This map shows the improvement in accessibility under BRT 1. Areas shaded darkest enjoy the greatest increase in access to jobs, from 30-90%.*

**Fig. 9: Changes in Employment Accessibility with BRT 2**



*This map shows the improvement in accessibility under BRT 2. Areas shaded darkest enjoy the greatest increase in access to jobs, from 30-70%.*

**Fig. 10: Changes in Employment Accessibility with BRT 1+2**



*This map shows the improvement in accessibility under BRT 1 plus BRT 2. Areas shaded darkest enjoy the greatest increase in access to jobs, from 30-90%.*

**Table 1: Summary of the 2016 Firm Employment Accessibility by Public Transport during AM peak in Kigali**

Scenarios	Average percentage of jobs accessible by bus in one hour	Average percentage of people living below the accessibility mean
Base Case: Current bus system performance	58%	36%
1. Journey speed decline by 20%	49%	42%
2. Journey speed decline by 50%	39%	47%
3. Journey speed capped at 20kmph	52%	40%
4. With BRT 1	58%	33%
5. With BRT 2	59%	34%
6. With BRT 1+2	60%	33%

## Way Forward

In recent years the traditional methodologies for appraising and prioritizing urban transport investments have come under criticism for their focus on mobility instead of access to opportunities that a city offer to its residents and firms. In general, city leaders and residents wish to know how a transport and/or land use intervention will reduce spatial inequities in accessing opportunities and essential services. In response, cities are adopting Accessibility principles in planning, prioritization, design, and monitoring of their projects and policy measures. The current study for Kigali, a small and quick response intervention, was undertaken to raise awareness among the City and the Rwandan government officials on why Accessibility is an important metric for planning, decision-making, and monitoring Kigali's performance.

We hope that the city will further enhance this tool using more accurate data on bus journey speeds (including waiting times). Recognizing that the low income population in most developing world cities value travel cost more than travel time, an accessibility analysis using the bus fare level will be of great value and can be integrated into the Kigali tool. Moreover, for the assessment of land use policies the accessibility tool will permit evaluation of site selection policies for affordable housing projects, new employment centers and community facilities. The city authorities will find the visualization capability of the tool valuable in having effective communication with relevant stakeholders and the public in general.

This note is accompanied by a guide on using the online Accessibility management tool. For further support, please contact [rwanda@theigc.org](mailto:rwanda@theigc.org)

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