Walkability in the "Green City in the Sun": A Network Analysis of Nairobi

Background

Nairobi is the capital city (and largest) of Kenya. Popularly known as the "Green City in the Sun", Nairobi is one of the most rapidly urbanizing cities in East Africa. With a population currently at 3.1 million according to the 2009 National Census of Kenya, the population growth rate is 3 percent per year. While the *Nairobi Metro 2030* master spatial plan aims to transform Nairobi into a "global, world-class metropolis" by 2030, the city faces many challenges to becoming a more livable city. With over 60% of Nairobi's residents living in slums, infrastructure such as access to clean water and sanitation, health services, public transit, and police and fire stations can be included in measures of walkability.

What is Walkability?

Walkability is "a measure of the effectiveness of community design in promoting walking and bicycling as alternatives to driving cars to reach shopping, schools, and other common destinations," according to ESRI.[1] Promoting more walkable communities reinforces accessibility to services and enhances sustainability.

Key questions:

- Which wards of Nairobi City are the most walkable? The least walkable?
- What percentage of the population lives in the least walkable areas? Highest walkable areas?

Methods

Determining a walkability score requires creating service areas of relevant walking distances to destinations.

Step 1: 15 destinations were selected to be factors in the network analysis. I determined relevant walking distances (400 or 800 meters) to these facilities and chose to do a weighted network analysis and an un-weighted analysis. For the weighted analysis, I assigned different weights to each destination based on importance and knowledge of Nairobi (see table at lower right). I grouped certain destinations together, such as health and financial services.

Step 2: A network dataset was created in ArcCatalog, based on Nairobi's roads from a 2005 dataset.

Step 3: Nairobi City was used as the background raster (all cells = 0) and served as the snap raster for the analysis. Each raster grid cell size is 20 meters. The extent was Nairobi City level wards.

Step 4: Using Network Analyst tools, a service area was created for each destination, with a walking distance of either 400 m (1/4 mile) or 800 m (1/2 mile) from a road. In the polygon generation tab, I merged the buffers by break value into one polygon for each service type (Holbrow Method, 2010). All polygons were converted to raster cells.

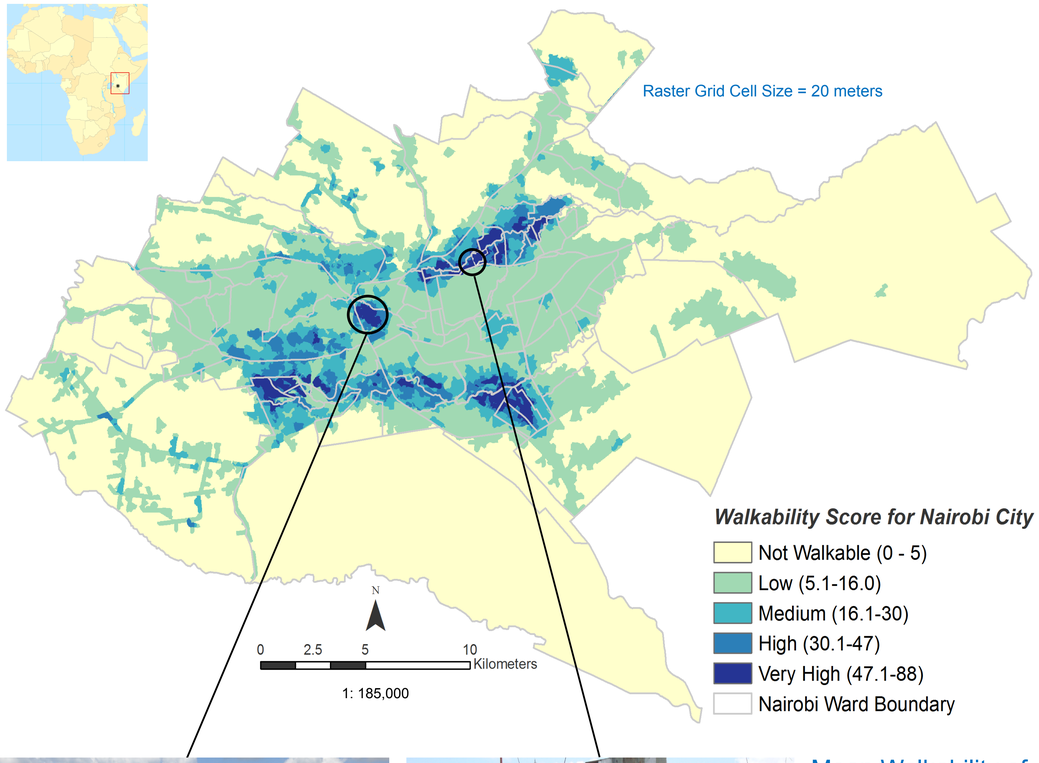
Step 5: All service area raster cells were reclassified with values of 1 and 0. NoData = 0, and everything within the service area polygons received a value of 1.

Step 6: Using the raster calculator in Spatial Analyst toolbar, all the raster layers were added up for each of the service area destinations to create a walkability raster service area based on 5 classifications. I conducted an un-weighted analysis first, and then a weighted analysis of all 15 destinations that added up to 1. The weighted analysis is shown at top center.

Step 7: Using Zonal Statistics as Table tool, I calculated the mean walkability of raster cells within each ward.

Step 8: The mean walkability scores were then calculated for Nairobi's 2009 Census population data by wards, and percentages were calculated for those wards in non-walkable to highly walkable areas.

Weighted Walkability Raster Network Analysis



Nairobi Central Business District (Source: Andy Sternberg via Flickr)

Mathare Valley in Nairobi (Source: Laura Kraft, 2010 via Flickr)

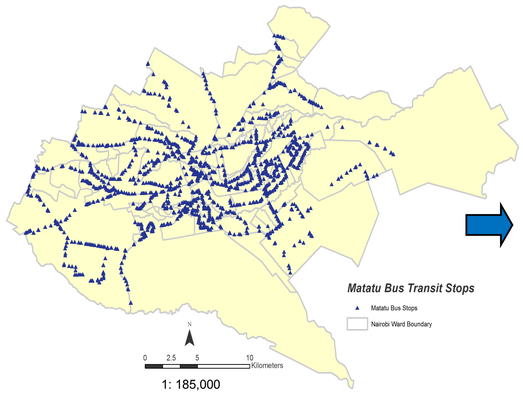
Mean Walkability of All Wards in Nairobi Weighted by Population:

16.9 (Medium)

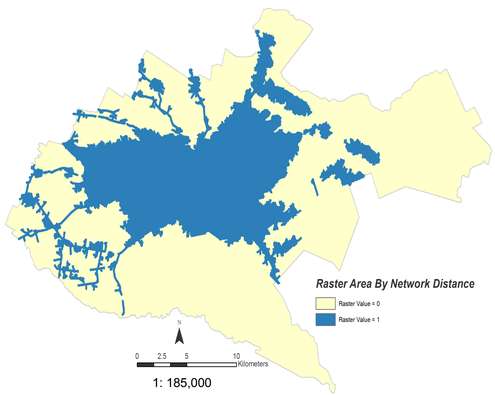
Highest Score:

88 (Very High)

Matatu Transit Points

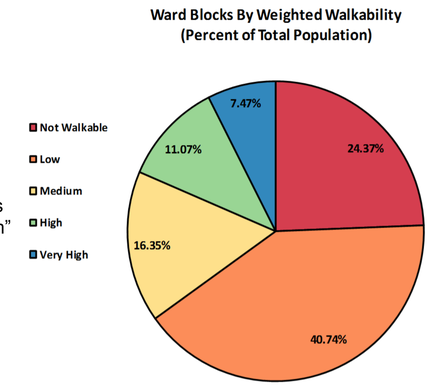


Matatu Service Areas



Results

Over 2/3rds of Nairobi's population lives in either non-walkable (24.37%) or low walkable areas (40.74%). The ward with the highest walkability score is Mabatini, located in Kibera slum (=88). The ward with the lowest walkability score is Ruai (=0), in the far northeast area of Nairobi City. The mean score of walkability for Nairobi's population among all 84 wards is 16.9, which is classified as a "medium" walkability score. Other highly walkable wards include the Nairobi Central Business District, and well-known informal settlement ("slum") wards of Kibera, Mathare Valley and Mukuru. This is a result of the fact that projects such as MapKibera Trust have used participatory GIS to map hundreds of amenities (re: "destinations" in this map) in informal settlement areas in Nairobi to demonstrate the need for basic infrastructure and urban service delivery. The differences in livability and walkability are demonstrated in the two photographs at left. While the living conditions in informal settlement areas are drastically lower, the "walkability" of these areas also demonstrates the reason why many are caught in a "high-price, low-quality" trap in Nairobi's slum areas, because of the need to access certain services.[2] There appears to be wide coverage for *matatu* bus stops, but the points demonstrate a high density of *matatu* stops near the Nairobi Central Business District, an area where there is tremendous traffic congestion.



Limitations

While OSM is a powerful tool, in some ways slum areas of Nairobi have been over-mapped as compared to other parts of Nairobi City. This skewed some of the point data in terms of service availability. The points also did not demonstrate the *quality* of the services provided (ex. health services or education). Further, while 2009 Census Data is available for population by ward, there are no recent sub-location and location administrative boundaries available for Nairobi that can be paired with the 2009 Census. Mapping the walkability by census sub-location would be more accurate in detail than by ward.

Destination	Walking Distance (Meters) ¼ or ½ mile	Weight
Community Destinations		
Education (Kindergarten, Schools, College, University)	400	8
Community Centers	400	3
Library	400	3
Places of Worship	400	5
Food Destinations		
Marketplace	400	5
Restaurants	400	3
Neighborhood Services		
WASH (drinking water, toilets [public/private])	400	5
Financial Services (Banks, ATM, Mobile Money Agents, Bureau de Change)	400	8
Health Services (Hospitals, Clinics, Pharmacies)	400	12
Fuel	400	5
Waste Management	400	6
Transportation		
Matatu Bus Stops	800	10
Bus Stations	400	5
Security/Disaster Response		
Police	400	10
Fire Stations	800	12
	Total Weight	100

Conclusion

As Nairobi aims to transform its infrastructure and construct more bypass highways by 2030, the walkability of slum areas raises the question of whether more urban infrastructure for sanitation, fire stations, and transit stops will reduce or increase the walkability of Nairobi's wards.

References:

[1] Rattan, Arjun, Anthony Campese, and Chris Eden. "Modeling Walkability." *Modeling Walkability.* ArcUser, 1 Jan. 2012. Web. 3 May 2014. <http://www.esri.com/news/arcuser/0112/modeling-walkability.html>.

[2] Gulyani, Sumila, and Debabrata Talukdar. "Slum Real Estate: The Low-Quality High-Price Puzzle in Nairobi's Slum Rental Market and its Implications for Theory and Practice." *World Development* 36: 1916–1937. *Elsevier.* Web. 3 Jan. 2014.

Cartography and Poster Design by Julia Leis

Poster Created: 5 May 2014

DHP 207 GIS for International Applications

Projection: WGS 1984 UTM Zone 37S

Data Sources: Digital Matatus (University of Nairobi/MIT Civic Design Lab, 2013); Columbia University/University of Nairobi (2008); 2009 Kenya Census Data (Kenya National Bureau of Statistics); Map Kibera (2009); 2013 Kenya National Election Data (via Mikel Maron); Tufts M: Drive.

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