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Analysis of Geographical Accessibility to Healthcare Facilities Using Geospatial Techniques: The Case of Peri-urban Dwellers in Mbeya City

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Abstract

In spite of the tremendous achievements in the quality and quantity of health services attained globally, healthcare provision in developing countries remains a serious problem. Accessibility issues have been noted in peri-urban areas and measures to improve physical access to health services continue. This paper offers a comprehensive and analytical methodology of analysing geographical accessibility of healthcare facilities using geospatial techniques. The study employed ArcGIS Network Analyst to build a road network dataset and measure the shortest network-distance and travel-time to the closest healthcare via road networks. Walking speed was also assigned as 3km/hr throughout the whole network. Public transport speed limits of 30km/hr were assigned based on the roads speed limits of Mbeya City, without considering road condition and topography. A total of 70 healthcare facilities and 95 households' settlement points (incidents) were loaded as input in the ArcGIS analyst tool. The findings show that most health facilities are not easily accessible by walking; and that there is a poor spatial accessibility to health facilities and wellbeing among residents in the peri-urban area. Thus, the local government authority is advised to improve the road infrastructure to enhance accessibility to sparsely distributed healthcare facilities.

Keywords: *accessibility, geographical accessibility, healthcare, network analysis, population.*

1. Introduction

Healthcare is a broad range of health services provided by professionals in a community. It is an authoritative approach to providing 'health for all', and is usually recognized as a universal key for improving the wellbeing of the people in the world. Globally, the wellbeing of people and spatial accessibility to healthcare facilities are important features prompting economic growth and prosperity of any nation. It is desirable for a government to ensure high quality provision of equal and easy access to fundamental healthcare services to all citizens (Wang, 2011). Since geographic access is an essential feature of an overall health system, it important for health service researchers to develop accurate measures of physical access to health services. Poor physical access to healthcare facilities in peri-urban areas constrains, among others, preventive healthcare, and other healthcare services (WHO, 1993).

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Recently, there has been a growing concern among decision-makers, scientific researchers, and politicians on the use of GIS measures to improve healthcare delivery systems. Problems of healthcare quality and accessibility are fundamental issues in the provision of healthcare services. Accessibility to healthcare is a function of the number of healthcare facilities and their distribution, and affordability (Nwangwu, 2013).

Inequality and discrepancy in geographic accessibility might be a result of the way in which people and facilities are spatially arranged. Since healthcare delivery systems have been subjected to substantial economic pressure, healthcare facilities cannot be found in all places. They are at finite fixed locations, yet they serve populations that are continuously and unevenly distributed. As such, sometimes people must travel-distances longer than usual to access health services because of the location of facilities and poor road networks (Delamater et al., 2012; Allen, 2013). In the past, the situation was more compounded because the potential role of Geographical Information Systems (GIS) in improving access to public healthcare had not been fully realised.

Currently, the increasing availability of the GIS in health organizations, together with the proliferation of spatially disaggregate data, has led to several studies on developing measures to access healthcare services (Higgs, 2009). Moreover, with the advancement of GIS and computer technology, decision- and policy-making in the selection of facility sites can be enhanced into a larger dataset with more data structures, accurate spatial measurements, spatial analysis, and spatial modelling. Also, the capability of GIS to represent spatial objects as points, lines, or polygons has increased the flexibility of entity representations in facility location modelling (Indriasari et al., 2010). Thus, geographically-based healthcare research commonly utilizes methodologies and measurements attainable using GIS, which include network model (vector representation), and raster model (raster representation). These methods are used to measure distances and travel-time between the locations of health facilities and people.

Guagliardo (2004) describes accessibility as travel impedance (travel-distance or travel-time) between patient location and healthcare service points. He argues that accessibility and availability are not similar terms, and that accessibility may depend on the availability of services. In urban areas, where multiple service locations are commonly available, accessibility and availability should be considered simultaneously (ibid.). Thus, distance and time are both important factors of accessibility.

Regarding healthcare service utilization, accessibility is generally influenced by the spatial structures of the supply and demand of healthcare services, neither of which is distributed uniformly in space (Wang, 2011). Spatial accessibility denotes the relationship between the locations of supply and the locations of demand for specific services, taking into account existing transportation infrastructure and travel impedance.

Some researchers have used basic cartographic representations to map the availability of healthcare facilities and highlight glaring inequalities (Knox, 1979). Others have used sophisticated models to understand the effect of distance on spatial accessibility of healthcare facilities (Koening, 1980; Knox, 1979; Mitropoulos et al., 2006; Joseph & Bantock, 1984). Also, others have employed statistical methods to explain the existence of issues/obstacles that constrain the population from accessing healthcare services (Guagliardo, 2004).

Some researchers—e.g., Ozus (2004), Şentürk et al. (2011), and Dokmeci (2002)—studied the distribution of different types of healthcare facilities (physician, hospitals offices, and pharmacies) in Istanbul. On their part, using a regression analysis, Şentürk et al. (2011) established that the most important elements that influence the distribution of healthcare facilities are population, income, and education level. Moreover, they found that while state hospitals were more evenly distributed, private hospitals tended to concentrate in high-income districts.

Mbeya city—unlike Turkey and other developed countries—is a growing city with most of its population residing in the peri-urban area. Amer (1998) and Ahmed (2004) argue that over 70% of the population in cities like Mbeya are often characterised by poverty and unhealthy living conditions, and live in grossly overcrowded peri-urban informal settlements with poor access to health services. According to the 2012 National Census, Mbeya city had a total population of 385,279 inhabitants. In 2002, the population stood at 266,422. It is evident that there was 41.2 % increase in population over a ten years period. Peri-urban areas of Mbeya city often accommodate most of the population of the city. This situation calls for a study that tries to unpack accessibility to healthcare facilities. Using geospatial techniques, this study attempts to unravel the complexity of access to health facilities by peri-urban dwellers in Mbeya city through assessing physical accessibility to healthcare facilities, locating healthcare facilities, and measuring the travel-time and travel-distance between healthcare facilities and the locations of local residents.

2. Context and Methods

2.1 Context

This study was carried out in peri-urban Mbeya city of Mbeya region. The city is situated in the southwestern part of Tanzania. It is located between latitudes $8^{0}50'$ and $8^{0}57$ S; and longitudes $33^{0}30'$ and $35^{0}35'$ E. It has a total land area of $214km^2$, and borders Mbeya Rural District on all sides. It is the headquarters of the Mbeya region, in a Rift valley between two high mountain ranges (i.e., Mbeya Peak /Loleza and Uporoto Mountains) (Figure 1).

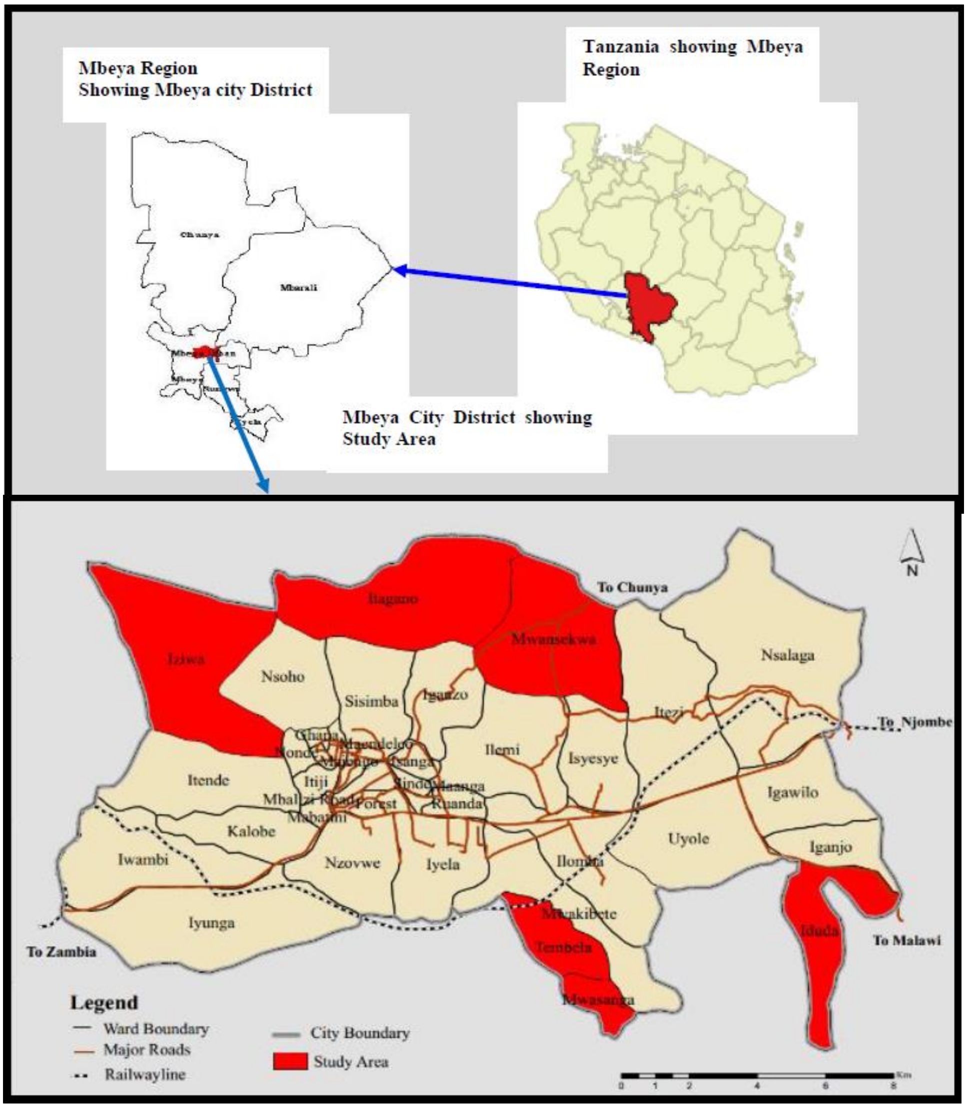

Figure 1: Location of Peri-Urban Areas in Mbeya City

2.2 Methods

This study used three types of data: location of population/settlements, location of health facilities, and road network as indicated in Table 1. The ArcGIS Network Analyst was used to build a road network dataset and measure the shortest network distance and shortest travel-time from each ward centroid to its closest facilities.

Table 1: Summary of Data Collected

	Types Data	Sources of Data	Year
Primary data	• Landsat Satellite Image • Number of Healthcare facilities available • Human population characteristics • Constraints facing the communities in the peri-urban area in accessing Healthcare facilities • Types of healthcare facilities • Transport modes and means characteristics, Speed limits, walking, bicycling, motorcycle, and • Levels of services/attractiveness of healthcare facilities • Travel impedance (distance, time, etc.) via transportation network, • Spatial accessibility from residential locations to locations of healthcare facilities	• USGS Website • Ministry of Health, Community development Gender, Elderly and Children • Global Position Systems • (GPS). • An in-depth interview with key informants • Field observation • Structured Questionnaire Interview • Personal discussion	2016
Secondary data	• Population Dynamics • Socioeconomic characteristics • Methods of measuring spatial accessibility	• District Socioeconomic Profile Report • National Bureau of Statistics (NBS) and Mbeya City Statistical Department • Files • Documents • Reports	2012
	Road Network shape file	Mbeya Urban Planning department	2018
	Administrative Boundary	Survey of Mbeya City	2015
	Digital Elevation Model	SRTM (30m)	2014

2.2.1 Remote Sensing and GIS Mapping

A physical survey of the settlement using remote sensing and GIS mapping was done to assess the current situation in comparison to the former. The study used LANDSAT satellite data of 2016 geocoded with Universal Transverse Mercator (UTM) projection, Arc 1960, and Zone 36S of 30m spatial resolution. During the survey, the researchers made observations of spatial accessibility to healthcare facilities by local communities in the peri-urban area, and how people expressed concern on the situation of spatial accessibility to healthcare facilities. This enabled the preparation of a land-use map, population density, healthcare facilities, and transport infrastructure.

2.2.2 Data Processing

The datasets from the survey questionnaires, population censuses, and from satellite imagery were analysed quantitatively and qualitatively, using various processing techniques and analyses, according to the requirement of the study and the nature of data. Three facilities were selected for this study: public dispensaries located in the study area, such as primary healthcare centres, and the regional and referral hospital in Mbeya city. Other factors were travel-time and distance or time service catchment area; and origin and destination cost matrix network analyst tools to measure geographical accessibility to healthcare facilities in Mbeya city's peri-urban centroids via the road network according to the following description.

The analysis was done to evaluate physical accessibility to healthcare facilities by local communities in peri-urban areas by measuring the travel-time and travel-distance between healthcare facilities and the locations of the residents of peri-urban Mbeya city. Apparicio et al. (2008) debate that the shortest network travel-time is more accurate than any other distance measures. GIS-based network analysis settings and optimization routes to evaluate service provision (Delamater et al., 2012) required a road network dataset built in the Arc catalog (Arc map environment). The shapefile was integrated into ArcGIS after it was projected to Arc 1960 UTM Zone 36S. Systems and infrastructure data for the study area were extracted from it using a clip tool.

The shapefile acted as base data for determining how accessible was the transport infrastructure for the community in the study area given the location of their homes. The raster data of Mbeya City and ward boundaries were digitized based on a satellite image of 2017.

Data on public transportation network (e.g., bus routes) were collected to better understand the spatial layout of the transportation network across the study area during peak hours. Also, data on road network and associated speed limits were collected to measure travel-distance and travel-time between health facilities. The road network hierarchy were allotted an average vehicular speed (km/hour) for national highways, regional roads/highways, district roads, village/*mtaa* roads, and pedestrian routes (Ahmad, 2012). Walking speed was assigned a 3km/hr throughout the whole network. Public transport speed limits of 30km/hr were assigned based on the speed limits of Mbeya city's roads. The closest facility solver was used to measures the time, distance of traveling between demands point and supply point, and to determine which facilities were nearest to one other. Travel-time was calculated using the following formula:

> *Length / Speed*60. Length of the roads was divided by the specified speed on the roads and multiplied by 60 (minutes).*

In this study, accessibility was assessed by measuring the distance from residence to the healthcare facility, or by estimating travel time (Arcury et al., 2005; Love & Lindquist, 1995). The closest facility solver measured the time and distance of traveling between demand and supply points, and determined which points were nearest to one another.

Based on the speed, traveling time, and traveling distance, we calculated the closest facilities both in terms of distance and time (Wang, 2009). The population of different shortest routes of healthcare facilities was calculated. For health facilities, a driving time between 3, 5, 10, 15 and 20 minutes was used on the speed limit of 30km per hour. Network analyst tools were used to create the service area of these facilities. Using a recommended distance away from any healthcare facility of 4km—as recommended by the WHO (1997)—the appropriate drive-time was estimated. Several digital and non-digital datasets were collected and transformed into GIS data. Spatial analysis tools, including symbols, overlay operations; buffer operations and raster calculator were used during analysis. ArcGIS-based network analysis (time and distance service catchment area) were considered.

In the study, the origin and destination cost matrix was used to denote output areas as the origin (demand), and hospital (supply) using the ArcGIS-based network analysis. This calculates distance- and travel-time of different impedances. The study employed the OD cost matrix to find and measure the least cost paths along the network from multiple destinations. The straight lines connect origins and destinations, but the attributes table stores the network impedance (minutes or distance). The origin-destination matrix solver does not output lines that follow a network; the values are stored in the lines of attributes by indicating destination ranks.

The output areas were first converted from feature point to get the centroids. However, some out-areas were not located due to poor road network connectivity (for example, Itagano and Mwansenkwa wards), so their positions were adjusted around the closest road near the centroid area. The output areas that were less than or equal to 5,00m, 1,000m, 3,000m, 5,000m, 10,000m and greater than 15,000m were obtained. The origin and destination cost matrix generated the results more quickly, but could not return the true shapes or routes or their driving direction.

Settlements point/residential location (origin/demand) and health facility point (destination/supply point) were loaded from the analysis to measure accessibility. This, also, generated the results more quickly but could not return the true shapes, routes, or their driving direction (Longley et al., 2010; Delamater et al., 2012). This calculated distances and travel-time at different impedances.

In addition, the study used descriptive and inferential statistics. The descriptive statistics used include tables and percentages to depict the distribution patterns of healthcare providers. The distance traveled to a healthcare facility, transport attributes, and social-economic characteristics of the peri-urban population to healthcare providers in the study area were analysed. The spatial concentration of people, and levels of services/ attractiveness of healthcare facilities (Ahmad, 2012) were also included in analysis. The generated data were presented in the form of maps, tables, and figures.

Measures of accessibility also involved measures based on several facilities within specified areas: a buffer analysis was applied to define the proximity to healthcare facilities. The number of facilities within a specified travel impedance (for example, travel-distance, travel-time or travel-cost) is a method commonly used to measure spatial accessibility. The distance was measured either from the supply perspective, e.g., catchment area for a specific healthcare service; or from the individual users perspective, e.g., distance to the closest healthcare service facility. Apparicio et al. (2008) explain measures of spatial accessibility as the number of facilities within a specified distance; average distance to the 3 closest services; average distance to the 5 closest services; and average distance to all services.

Buffers were created around all facilities in the study area using Mbeya City planning standards with a radius of 1km in the catchment area of a healthcare facility. Areas beyond 1000m accessibility zone were used as reference for determining a potential location for additional healthcare centre by using multi-criteria evaluation (Arcury et al., 2005; Love & Lindquist, 1995).

Similar to the measurement of travel-distance, measurement of car/vehicle-based travel-time along a road network between locations of healthcare facilities and all ward centroids were estimated using road-length and travel-speed. The road network dataset created for measuring travel-distance was also used to measure car-based service area (Ahmad, 2012). Travel impedance was measured in meters; with break distance values set at 500m, 600m, 1000m, 3000m, 5000m, 1000m, 15,000m and 20,000m.

Among these, 500m, 600m, 1000m and 5000m were used to identify areas that were accessible by walking; and 20,000m was set as maximum distance to avoid errors in the computation of service area. Likewise, in measuring travel-distance, U-turn was permitted at any road junction, while the direction was measured away from the healthcare facilities (Ahmad, 2012). Services based on car travel-time that were measured in break-time values of 3min (minutes), 5min, 10min 15min and 20min were generated for each type of facility.

Spatial information was used to establish services or catchments based on travel-distance using spatial analyst tools. Data were displayed visually before the exploration of some likely patterns that were generated after analysis (exploration of data after network/proximity analysis). Simple descriptive data analyses were then applied. Spatial exploratory techniques were used to identify and explain the variations in physical access of the population to the existing health facilities in the study area, and identify disadvantaged population using the closest facility measures in ArcGIS (Arcury et al*.,* 2005; Love & Lindquist, 1995).

Spatial accessibility from residential locations to locations of healthcare facilities and *mtaa*/sub-ward service area for each facility was determined using classifications based on literature and the World Health Organisation (WHO) standards as the limitation for determining the extension of catchment areas. A network service area was defined as the region that encompasses all accessible streets (that is streets that are within a specified impedance) used to visualize and measure accessibility.

3. Results and Discussion

3.1 Distribution of Health Facilities in the Study Area

The findings showed that the total number of healthcare facilities in the 6 studied wards available were 3, which were found in the three wards of Iziwa, Itagano, and Mwasenkwa, each with only one public dispensary. The remaining three wards -- Tembela, Mwasanga, and Iduda -- had no healthcare facilities and so rely on nearby wards. The findings also show that there was one doctor, two nurses and one midwife in each public dispensary, which moreover lack some diagnostic equipment, drugs, and had insufficient numbers of skilled staff. The shortage of health personnel such as specialized doctors, medical doctors, clinical officers, nurses, etc., limit the provision of quality health services, resulting into more risks of unhealthy society, higher mortality rates, and poor participation in production activities.

The Health Sector Strategic Plan III (July 2009–June 2015) stipulates that a dispensary is the first health post in the city referral system, and a health centre is the second medical appointment for cases that cannot be handled by dispensaries. Despite this provision of the strategic plan, the findings revealed that there were inadequate healthcare facilities, and spatial variations in the distribution of healthcare facilities. Additionally, poor road network compounds the problem of poor accessibility to healthcare facilities because of the difficulty that residents in peri-urban areas face when they need to access the available few distantly dispersed healthcare facilities (MCC, 2007). Figure 2 shows the distribution of health facilities in the study area.

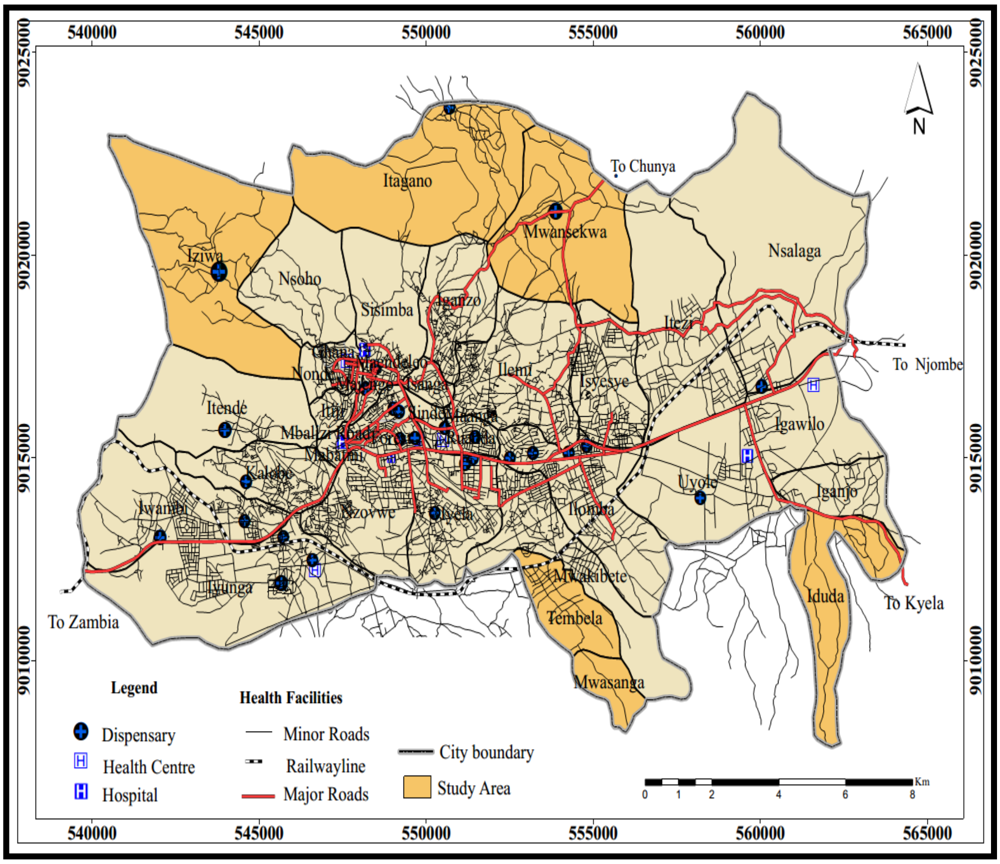

Figure 2: Distribution of Health Facilities

3.2 Travel (Driving) Distance to Healthcare Facilities

The findings showed that road networks connected to the study area starts from Mbeya city centre. The existence of the longest earth road network in the area indicates limitations of passability during rainy seasons. Table 2 shows the minimum, maximum, average, and standard deviation of travel-distances (measured in meters). It was noted that the total length of travel to the closest facilities ranged between 0.497km and 19.263km. Some respondents travel over 20km or more to access health services at the regional/referral hospital located in Mbeya city centre where equipment and specialists are available. Table 2 shows distances of nearest health facilities in meters.

Table 2: Mbeya City Centroid to the Nearest Health Facilities Distance (*meters*)

Healthcare facilities	Minimum (m)	Maximum (m)	Average (m)	SD (m)
Dispensary	497	5,980	3,238	2,741
Regional Hospital	13,578	18,151	15,864	2,286
Referral Hospital	14,659	19,263	16,961	2,302

The findings showed that most health facilities were not easily accessible by walking. There is no planned route for public transport services in the study area. Therefore, residents must organize their own transport to access healthcare facilities. Also, the population was not distributed evenly across the sub-wards. The average distance traveled by respondents in Mbeya city peri-urban to dispensaries was 3.238km, and 16.962km to private or public hospital health care centres. According to Arcury et al. (2005) and Love and Lindquist (1995), the closest facilities display the best route to or from them, return travel cost for each route, and directions to each facility. Figure 3 shows the concentration of the closest facilities.

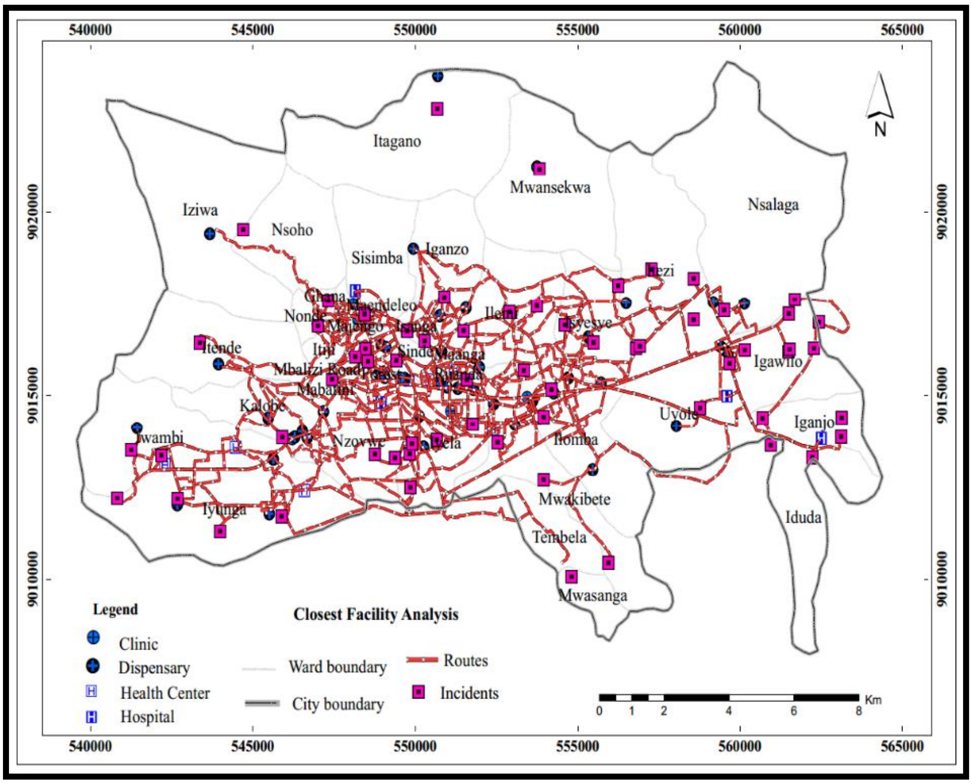

Figure 3: Closest Facility Analysis

Figure 3 reveals that many healthcare facilities are concentrated in the urban area. The pattern of distribution is widely spread or randomly dispersed. A network analysis shows that some residents travel more than the 4km distance specified by the WHO to access healthcare services. The ratio of health officers to patients was very low, which implies a shortage of health officers in healthcare facilities in the peri-urban area. Moreover, it was discovered that there is only one doctor that is serving each ward of the study area.

Mwaniki et al. (2002) argue that the effect of distance on the use of health services is affected by the time and cost of travel, topography, poor road conditions, and by the shortage of public transport. The results of the Origin Destination (OD) cost matrix analysis (Table 3) demonstrate the nature of people's access to healthcare facilities, particularly to specialist hospitals (Longley et al., 2010); Delamater et al., 2012). Table 3 displays the results of the OD cost matrix computed for distances between each origin and destination in line with proximity limit conditioned by working criteria. Network analysis was used since it considers all road networks, without considering only a straight distance from healthcare facilities (Wang, 2006).

Table 3: Network Analysis Travel-time (Speed Limit 30kmph)

Lines

ObjectID	Shape	Name	OriginID	DestinationID	DestinationRank	Total_DriveTmie
272	Polyline	Location 4 - Location 28	4	27	68	51.285849
3740	Polyline	Location 58 - Location 28	58	27	68	50.342991
204	Polyline	Location 3 - Location 28	3	27	68	49.838271
3536	Polyline	Location 54 - Location 18	54	18	68	48.899387
1904	Polyline	Location 30 - Location 28	30	27	68	48.554873
271	Polyline	Location 4 - Location 60	4	58	67	48.527123
270	Polyline	Location 4 - Location 30	4	29	66	47.902812
612	Polyline	Location 10 - Location 18	10	18	68	47.710379
3739	Polyline	Location 58 - Location 60	58	58	67	47.584264
269	Polyline	Location 4 - Location 36	4	35	65	47.488688

Table 3 shows that in the study area the longest and shortest travel-time from settlement locations to healthcare facilities was 51.285 minutes (drive-time), 25.64km (drive-distance), 0.125 minutes' drive-time, and (0.0625km) drive-distance, respectively. The shortest drive-time (0.125 minutes) was only limited to healthcare facilities available in the neighbourhood (public dispensary), where most services were inadequate and sometimes unavailable. The drive-time of 30-51 minutes was used by most peri-urban people to secure health service from the regional/referral hospital located in city centre.

Furthermore, the findings in Figure 4 show that origin (settlement point from Iziwa wards centroids) to destination point or health facility point (Mbeya Specialist Consultant Hospital) measures 16 minutes (8km). Figure 4 shows origin and destination cost matrix, demonstrating the nature of peoples' access in terms of distance to health facilities.

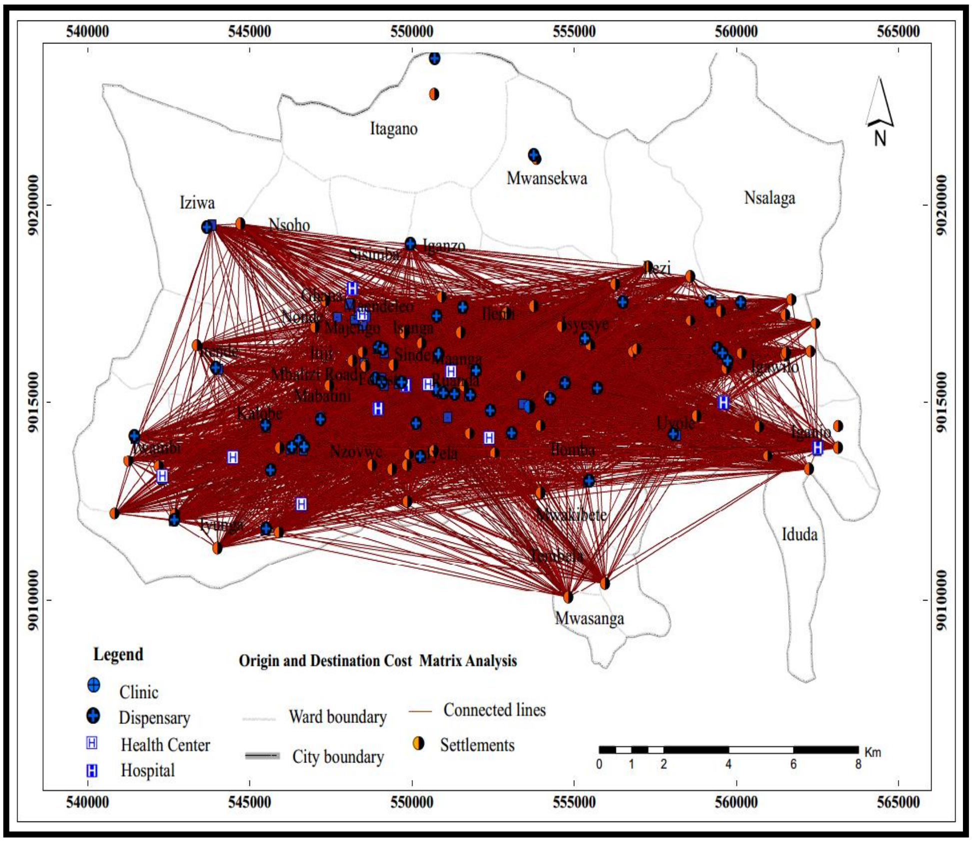

Figure 4: Origin and Destination Cost Matrix

The results of drive-time analysis indicate a clear marked disparity in terms of geographical access to healthcare facilities among the people in the study area. A healthcare facility that is a specialist centre has a profound impact on the lives of the people in the study area. The findings showed that a large proportion of the people is underserved with a drive distance of just 58% within 25.6km (Figure 4) (Wang, 2006).

3.3 Travel (driving) Time to Healthcare Facilities

Table 4 shows the minimum, maximum, average, and standard deviation of minutes it takes to reach healthcare facilities. It should be noted that spatial accessibility indicated by travel (driving) time might not represent actual spatial accessibility of the residents in the study area since most may not have a car, or be able to drive a car, at the time they need to visit a specific healthcare facility. In addition, poor road conditions and the nature of the topography of Mbeya region influenced the use of the 30km/hour speed limit. Table 4 shows the nearest health facilities travel-time in minutes.

Table 4: Mbeya City Peri-Urban Wards Centroid to the Nearest Health Facilities Travel-time

Healthcare facilities	Minimum (minutes)	Maximum (min)	Average (min)	SD (min)
Dispensary	0.9	6	3.45	2.55
Regional Hospital	27	36	31.5	4.5
Referral Hospital	29.2	38.6	33.9	4.7

3.4 Healthcare Facilities Area Based on Driving Time

The findings show that 0.9 minutes' drive-time polygon around a health facility can determine which residents are able to reach a health facility within 0.9 minutes (Table 4). For instance, a 6 minute's service area for a point on a network includes all the streets that can be reached within 6 minutes from the points shown in Figure 4. It was discovered from the findings that there were variations in physical accessibility to facilities because of variation in the services area.

Figure 5 shows variation of healthcare facilities in the served area based on drive-time. The pattern of spatial variation of population distribution, transportation infrastructure and distribution of healthcare facilities, among others, explain the existing spatial variation in the accessibility to healthcare facilities and locations where accessibility to healthcare facilities is relatively poor (Amad, 2012).

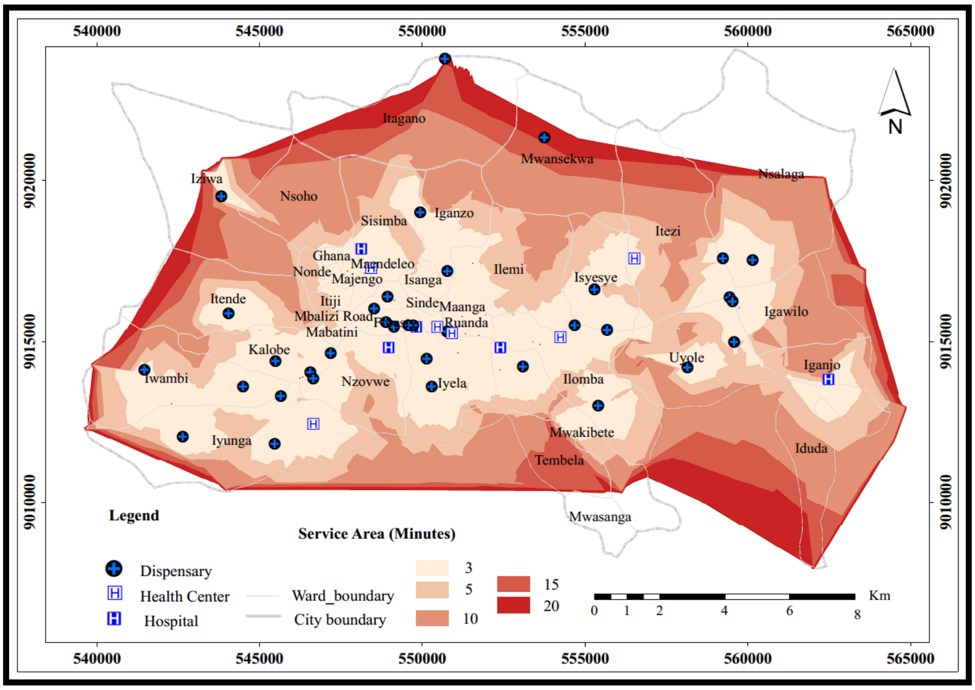

Figure 5: Variation in The Served Area of Healthcare Facilities Based on Drive Time

Furthermore, the study discovered that the minimum driving-time for people within the peri-urban area to access the closest facility was 0.9 and 6 minutes to access healthcare services in a public dispensary located in their neighbourhood, and 27 and 29.2minutes to access health services in the regional/referral hospital, respectively.

3.5 Healthcare Facilities Service Area Based on Driving Distance

Figure 6 shows a services area based on recommended driving distance generated at a distance of 500m, 1000m, 3,000m, 5,000m, 10,000m, 15,000m, and 20,000m away from the facilities. The service area from the studied wards were within 4km as recommended by the WHO standards. The WHO stipulates that each service area should cover 4km catchment area with a population of 60,000 for primary healthcare services. Concentric service areas show how accessibility varies with impedance.

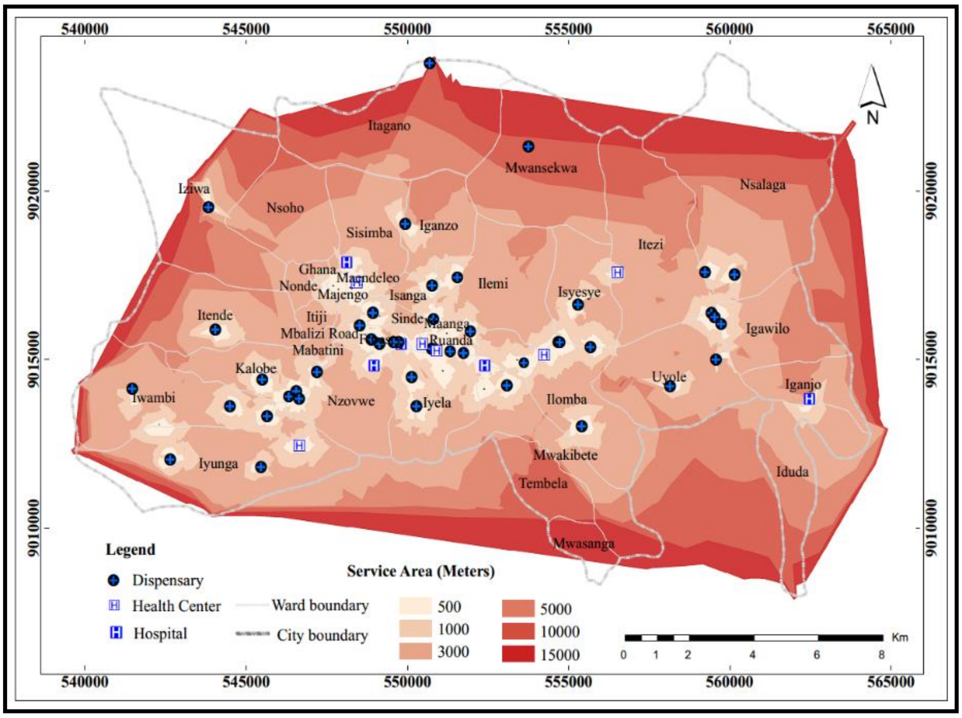

Figure 6: Map of Variation in the Served Area of Healthcare Facilities Based on Travel-distance

From this study, the creation of service area was used to identify how much land, people, or anything else is within a neighbour or region. The findings reveal that total population density was estimated to be 13,407person/km^2, and the average population density per ward was 2,234 people/km^2.

3.6 Walking Service Area and Its Implication

Walking service area was created at a distance of 1km, 3km, and 5km away from all healthcare services in peri-urban Mbeya city. The average walking speed was 5km/hr. This implies that a patient living within the buffered zone will spend between 15-60 minutes to get to a public dispensary, except for the effect of barriers such as the terrain. Figure 7 shows proximity to healthcare services in the study area.

Figure 7 indicates that there exists a spatial variation in the distribution of the population and associated demographic and socio-economic characteristics. Most residents from peri-urban areas—e.g., Iduda, Mwasanga, Tembela, Itagano and Mwasenkwa—walk more than 5km to procure health services in public dispensaries.

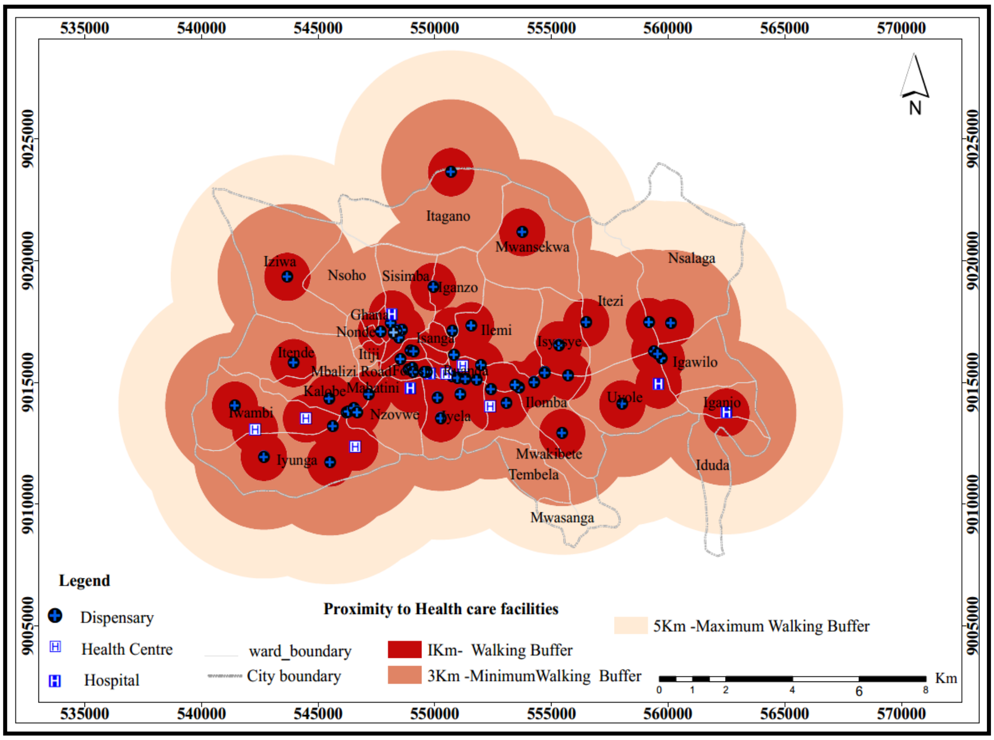

Figure 7: Proximity to Healthcare

3.7 Transport Cost to Healthcare Providers

The findings show that public transportation services are inadequate for the population living in the area. There is no planned route for public bus services, rather there are private cars and motorcycles, which make two trips per day. The physical location of healthcare centres relative to some other factors such as the location of residence, transport cost, conditions of roads and many other logistic difficulties affects people's access to healthcare services. Table 5 shows that 23.1% of patients who attend public dispensaries commute on feet; while 8.4%, 42.1%, and 26.3.8% rely on bicycles, motorcycles, and vehicles, respectively, to go to a public dispensary or private/public hospitals in the Mbeya urban area.

Table 5: Model of Transport Respondents

Transport mode	Respondents	Percent
Walking	22	23.1
Bicycle	8	8.4
Motorcycle	40	42.1
Vehicle	25	26.3
Total	**95**	**100.0**

The findings imply that poor road conditions, the nature of the infrastructure, and the topography of the study area—e.g., steep slopes, undulated and dissected plains, etc.—do not favour the use of motor vehicles to visit healthcare centres. Likewise, while motorcycles could be the fastest mode of transport in the study area, weather conditions such as heavy rains make it difficult to use such means of transport when it rains. In addition, the use of motorcycles was not a reliable means of transport to the regional/ referral hospital in Mbeya city for emergency cases like accidents or complicated pregnancies.

Furthermore, the findings show that 23.1% of the respondents who walk to healthcare centres mostly live close to the facilities. According to Luo and Wang (2003), a poor population is more likely to use the nearest healthcare facility regardless of discrepancies in the standards of care. This makes the optimal placement of the healthcare facilities in low-income settings particularly important. Therefore, it is vital to place healthcare facilities in such a way that their location will maximize access by the poor population.

4. Conclusion

Network analysis is the best method for describing a realistic geographical accessibility to healthcare facilities. This is because a service area is demarcated based on time and distance, hence it is supportive to calculate travelling distance from demand points (sub-ward centroid/settlements) to health facilities.

While absolute equal spatial accessibility is not always attainable, it can help plan and built a system of healthcare facilities in such a way as to permit the highest spatial accessibility for a maximum number of the populace. In the study area, nearly 2,076 households (96.9%) of the total population of 2143 household were living in disadvantaged location (low spatial accessibility), which is beyond the 4kms distance radius recommended by the WHO (2015). Some residents had to travel over 15-25kms (drive-distance) or 30-51minutes (drive-time) to secure health service from regional or referral hospitals located in the city centre. This implies that there is a poor spatial accessibility to health facilities in the peri-urban area of Mbeya city. As noted earlier, the lack of qualified staff, drugs, and equipment even in the few available healthcare centres in the study area further compounds the problem of healthcare delivery.

Based on the observed spatial distribution of healthcare facilities, settlement services and population patterns, there is need for optimized healthcare system especially in peri-urban areas. Thus, the study recommends that the local government authority in the area should increase the number of health facilities, equipment, drugs, and medical personnel; and also improve road infrastructures to make healthcare services more accessible to the people in the peri-urban area. In this regard, there is need of strengthening private-public partnership to strategically construct more dispensaries, health centres, and hospitals so that residents can have access to these facilities and services within a minimum distance. This will in turn improve the provision of quality health services, hence ensure having a healthy society that can fully participate in production activities.

Moreover, the study has established that the use of GIS can improve spatial access to healthcare services in peri-urban areas by informing spatial planning methods that can identify areas and populations that are not well-assisted by a given set of provisions. Thus, health planners and policymakers can use this as a planning method to improve spatial performance.

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