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Assessment of spatial distribution and accessibility level of healthcare facilities for a period of 30 years from 1990 to 2020; the case of Morogoro municipality, Tanzania

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Abstract

Background: About 1.3 billion people worldwide have no reliable access to healthcare facilities and the majority of these people are residents of Developing Nations including Tanzania. The distribution of most healthcare facilities in urban areas of developing countries is characterized by location disparity. This has given rise to geographic inequality. Healthcare facilities are essential for service provision in urban areas Unfortunately these services are inadequately found in people's settlements. This study aimed to assess the spatial distribution and accessibility level of healthcare facilities for a period of 30 years in an urban area.

Methods: Satellite imageries incorporate supervised classification and Kappa Index of Agreement methods were used to determine urban expansion over 30 years study period. A handheld global position system was used to geo-reference the coordinates locations of all healthcare facilities. Face-to-face interview with municipality health officers and facility in-charges was conducted to know the historical background information of healthcare facilities. The distribution and accessibility level of healthcare facilities was determined by buffering analysis in the ArchGIS program incorporated with WHO standards.

Results: From 1990 to 2020 built-up land increased from 3.9% to 18.9% and none built up land decreased from 96.1% to 81.9% of the total urban area of Morogoro municipality. A total number 69 of healthcare facilities location points were collected where 48 (69.6%) are dispensaries, 17 (24.6%) are health centres and 4 (5.8%) are hospitals. Out of the 69 healthcare facilities that are in existence, 79% are private institutions and 21% are government owned. Healthcare facilities accessibility decreased from 79.86% to 45.6% covering urban settlements area.

Conclusion. Despite urban settlements expansion and an increase in the number of healthcare facilities still, there is decrease in the accessible urban area to healthcare facilities. It is evident from the locations of the existing facilities that proper consultation and analysis were not carried out. The new health facilities must be located in underserved areas within urban settlements. Such planned facilities are required to be located and distributed according to geographic distance and population standards per health facility.

Keywords: Urban expansion, population, healthcare facilities, accessibility level

Background

The core concept of health utility delivery in cities is the distribution of healthcare facilities. For a long time, the spatial relationship between healthcare facility sites and geographic accessibility to those facilities has been a critical element for decision-makers, planners, and healthcare systems (Perry *et al*., 2000). Both industrialized and developing countries have noticed the spatial distribution of healthcare facilities (Wang *et al*., 2004) Spatial statistical methods, such as the nearest neighbour index, K-function, and the geometric centre has been used to evaluate the spatial distribution of health facilities (Shawky, M. 2016).

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Access to a reliable healthcare facility remains a challenge for about 1.3 billion people worldwide and the majority of people in developing countries (Cobbinah and Addaney, 2019; Knauer *et al*., 2017; Mahmoud *et al*., 2016; Shao *et al*., 2020; Yang *et al*., 2017). The basic concept of health utility delivery inside larger cities is the dispersion of healthcare facilities in metropolitan regions. The world is experiencing a significant change and urbanization is the chief modification by humans on natural surroundings. Developing nations are not an exception to this, they have experienced a high rate of urbanization; this includes Tanzania, whose rapid population increase and consequently, the urbanization creating a high demand for urban health care services (Sumari *et al*., 2017; Tumbo *et al*., 2018).

The rate of urbanization has accelerated dramatically over the world, and this acceleration has recently been seen in developing countries (Van Rompaey *et al*., 2012). The population of urban areas is expected to exceed 60% by 2030, As a result, urban expansion in the poorest countries is limiting the capacity of cities to provide basic services and facilities, degrading the quality of life, and the environment (Bihamta *et al*., 2015; Du *et al*., 2013; Odipe *et al*., 2018).

The main purpose of this study was to assess the spatial distribution and accessibility level of healthcare facilities in Morogoro Municipality, within 30 years (1990-2020). The objectives of this study included identifying the historical patterns and spatial locations of healthcare facilities within 30 years, and analysing the spatial distribution and accessibility level of healthcare facilities over 30 years study period in an Urban area.

Materials and Methods

Study design

This was a descriptive cross-sectional study using a quantitative approach. The face-to-face interview was used to collect information regarding background information for each health facility. A handheld global position system was used to geo-reference the coordinates locations of all healthcare facilities in the study area. The target population was finite to include 69 health officers in charge of all health facilities during data collection. A convenient sampling strategy was employed, whereby any health officer who was on duty and agreed to participate was included.

Study area

Morogoro Municipality was the selected study area where all health facilities were involved. This is one of the nine districts in Morogoro region in the Tanzania mainland. The municipality is the capital of Morogoro region and it covers 540 km^2, which is 0.74% of the total area of Morogoro region (URT, 2018).

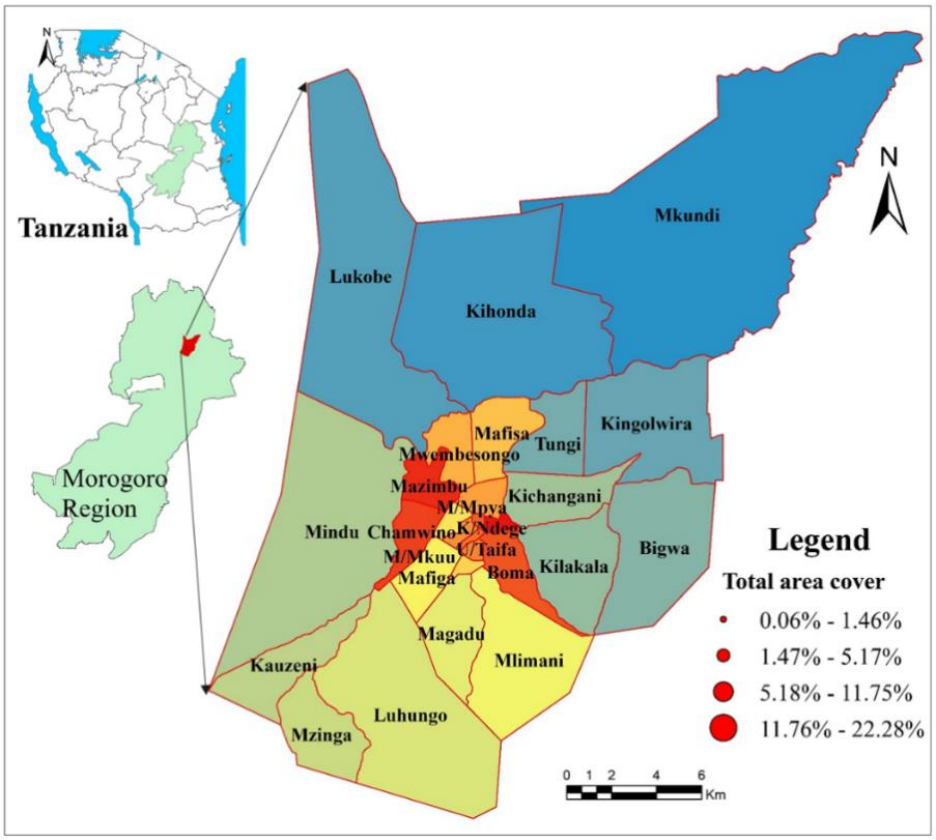

Figure 1: Location Map of Morogoro Municipality

Data collection

For this investigation, both spatial and non-spatial data were collected. Spatial data consists of remote sensing data for the years 1990-2000, 2000-2010 and 2010-2020 that was acquired from the United States Geological Survey Earth-Explorer (USGS-EE) website, Location point of healthcare facilities was acquired from the Field by GPS, administrative boundaries map of the study area from Morogoro municipality department of and urban planning. Non-spatial data include years the health facilities were developed and were obtained through face-to-face interviews population data of the study was obtained National Bureau of Statistics.

Image acquisition and processing

For the study area images were acquired from the United States Geological Survey Earth-Explorer (USGS EE) website. The images were specified together with data set from the United States Geological Survey Earth-Explorer (USGS EE) website. Data sets include Landsat collection 1 level 1, Landsat 4-5 TM C1 Level 1, Landsat 7 EMT+C1 Level 1 and Landsat 8 OLI/TIRS C1 Level 1. Downloaded images had several bands which were recomposed by using Arc GIS Software, whereby Landsat 4-5 TM C1 Level1, Landsat 7 EMT + C1 Level band 1 o band 7, and Landsat 8 OLI/TIRS C1 Level 1 bands 1 to band 7 and band 10 were combined by using Composite Bands tool in ArcGIS Program. The composed images were then clipped based on the study area and processed together to create a single raster dataset so that they can be managed, viewed, and query small to vast collections of raster and image data. Landsat 8 were used in this study. The Landsat images were acquired in 1990 (TM data): 2000 (ETM+ data): 2010 (ETM+ data): and 2020 (OLI data). All Landsat images were obtained from http://earthexplorer.usgs.gov/ website of the United States Geological Survey (USGS) from the path/row number 167/065. ENVI version 5.3 was used to

classify images, with ERDAS Imagine version 2014 being used to assess accuracy, and ArcGIS version 10.3 was used to process image data, visualize it, and create maps. All images were registered to UTM coordinate system with WGS 84 datum zone 37 South for consistency, after that the images were clipped based on the boundary of the study area.

Image classification and accuracy assessment

Image classification is defined as the process of categorizing all pixels in an image or raw remotely sensed satellite data to obtain a given set of labels or land cover themes (Gómez-Chova *et al*., 2017; Weng and Lu, 2009). According to Lu *et al*. (2004), the major step of image classification may include the Choice of a suitable classification method. In this study supervised classification method was selected as the method for classifying images of periods from 1990-2000, 2000-2010 and 2010-2020 (10 years in each category) into two different categories i.e., built-up area and un-built-up area classes. In this research, the Kappa Index of Agreement method for accuracy assessment was used. The Kappa Index of Agreement is a statistical measure adapted for accuracy assessment in remote sensing fields (Congalton *et al*., 2014). It is used to check the accuracy of classified satellite images versus some real ground-truth data as shown in equation 2.1

$$k = \frac{N\sum_{i=1}^{r} X_{ii} - \sum_{i=1}^{r}(X_{i+} * X_{+i})}{N^2 - \sum_{i=1}^{r}(X_{i+} * X_{+1})} \quad \ldots\ldots\ldots 1$$

Where k: is the Kappa Index of Agreement, r is the number of rows in the error matrix, xii: is the number of combinations along the diagonal, xi+: is total observations in row i, and x+i: total observations in column i. N: total number of cells. To verify how accurately the pixel was sampled into the proper land cover class, the ground truthing technique together with Google earth pro was employed. A handheld GPS (Garmin) was used for field data collection of location data (Coordinates) together with Google earth whereby a total of 200 points for two land use types (built up and non-built up) were collected on the field, each land use types carried 100 points collected from the field.

Historical background and location of healthcare facilities

The geographic location of healthcare facilities was captured in the field by GPS. A handheld GPS receiver was used to geo-reference the geographical locations of the 69 healthcare facilities and the coordinates of all healthcare facilities were recorded. The healthcare facilities will be treated as point data for which feature data sets were created in ArcGIS 10.3 software that was used for analysis. The historical distribution of healthcare facilities from 1990 to 2020 was obtained through official interviews with healthcare facilities staff, municipality medical officers, and from all historical documents from Morogoro Municipal Council. Face-to-face interviews were conducted with all 69 health facilities whereby in each health facility operated one officer in charge was included in to interview to gather background information about the existing health facilities.

Spatial distribution of healthcare facilities

Spatial distribution helps to identify areas underserved as well as areas that are at risk of being underserved. The concept of accessibility is also connected to the concept of geographical location. To assess the spatial accessibility of healthcare facilities across the municipality, multiple buffering was used in the GIS environment First, land use/cover maps have to be reclassified into two categories (built-up and non-built-up land). Buffering analysis was then conducted for a 0.25, 0.5 and 1 km radius of the healthcare facilities following World Health Organization standards. Buffering analysis was applied in ArcGIS 10.3

software to determine the distribution and accessibility of healthcare facilities in Morogoro municipality where a 0.25 km radius was used for dispensaries, 0.5km was used for health centres and 1km was used for hospitals.

Healthcare facilities and population

The population is a fundamental input and an imperative element in planning for healthcare
facilities. It defines the number and level of facilities to be provided. The relationship between healthcare services and the population is an important area in healthcare practice. The specification of WHO is that for every 5 000 people, one healthcare facility is required for efficient service. According to Tanzania's specification a population range of 7 000 to 10 000 require 1 dispensary; 10 000 to 25 000 requires 1 healthcare centre and a population 25 000 to 120 000 and above requires 1 hospital (URT, 2011). These specifications were used to assess the existing population and health facilities in Morogoro Municipality. The population data used in this study were generated by the National Bureau of Statistics (NBS). The population estimates are constructed from available census data (URT, 2012).

Ethical considerations

Ethical clearance was obtained from Morogoro region commission (Ref. No: AB.175/245/01/98) and Morogoro district commission (Ref.No.AB210/249/01/163). The permission to conduct the study at all health facilities in Morogoro municipality was obtained from Morogoro Municipal director department of health (Ref. No R.10/MMC-99/167). All health officers in each health facility received information about the study while on duty, and they were provided with information on the potential risks and benefits of participating. To ensure confidentiality, a unique code was used on the data collection tools instead of individual names.

Results

Image classification output

The supervised classification method and image data provide tremendous results in detecting urban changes. For the years 1990, 2000, 2010, and 2020, the two LULC classes (built-up areas and non-built-up areas) were defined (Figure 2). Morogoro Municipality has experienced tremendous and very rapid urbanization. From 1990 to 2020 built-up increased from 3.9% to 18.9% of the total urban area of Morogoro municipality while non-built-up LULC class decreased from 96.1% to 81.9% of the total urban area of Morogoro municipality.

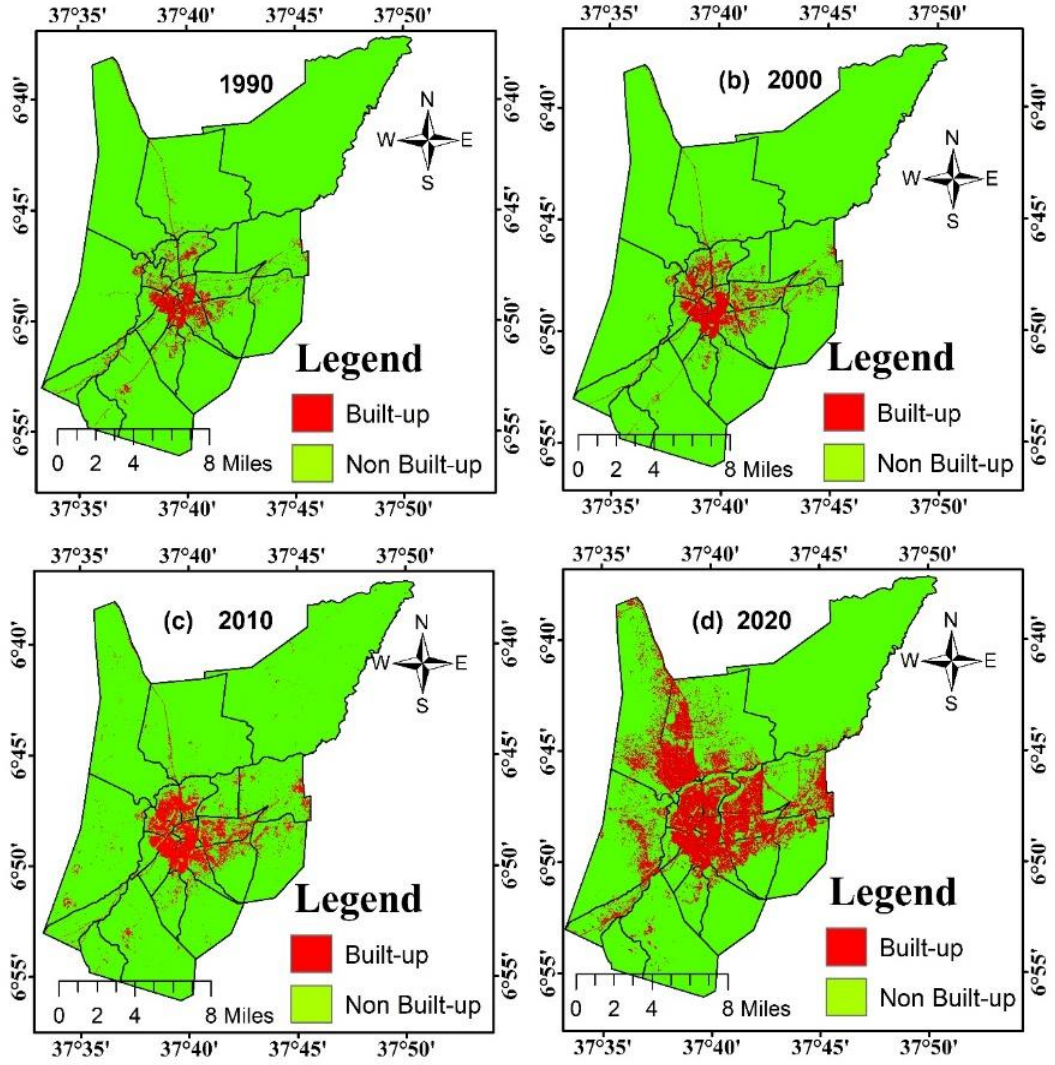

Figure 2: Change of built-up area in Morogoro Municipality from 1990 to 2020

Accuracy assessment

Accuracy assessments of classified images were performed. Accuracy assessment was performed using stratified random sampling and kappa coefficient and the overall accuracy percentage for all the classified images for the year 1990, Kappa Index of Agreement (KIA) was found to be 87.0%, for the year 2000 it was 83%, 89% for 2010, and 93% for 2020, the overall accuracy for the study period 1990, 2000, 2010 and 2020 are 95%, 92%, 94% and 97%.

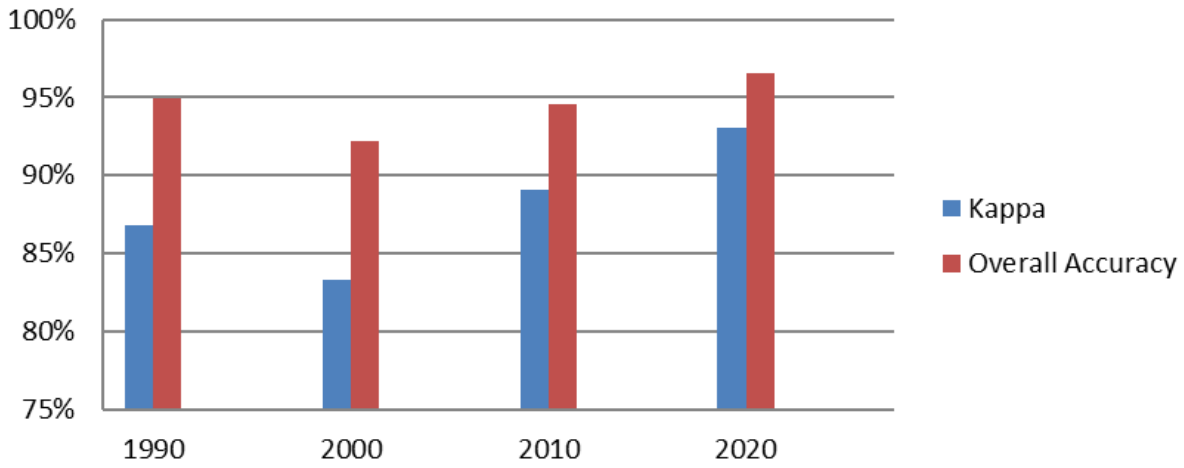

Figure 3: Accuracy assessments of the classified images based on the two classes

Distribution and historical pattern of healthcare facilities in Morogoro Municipality

Fig. 4 shows the distribution of healthcare facilities within wards of Morogoro Municipality. Northern, central and eastern wards are having the greatest number of hospitals per ward. Visualization was modified to show facilities with their year of registration in classes before 1990, 1991-2000, 2001-2010 and 2011-2021 study periods respectively.

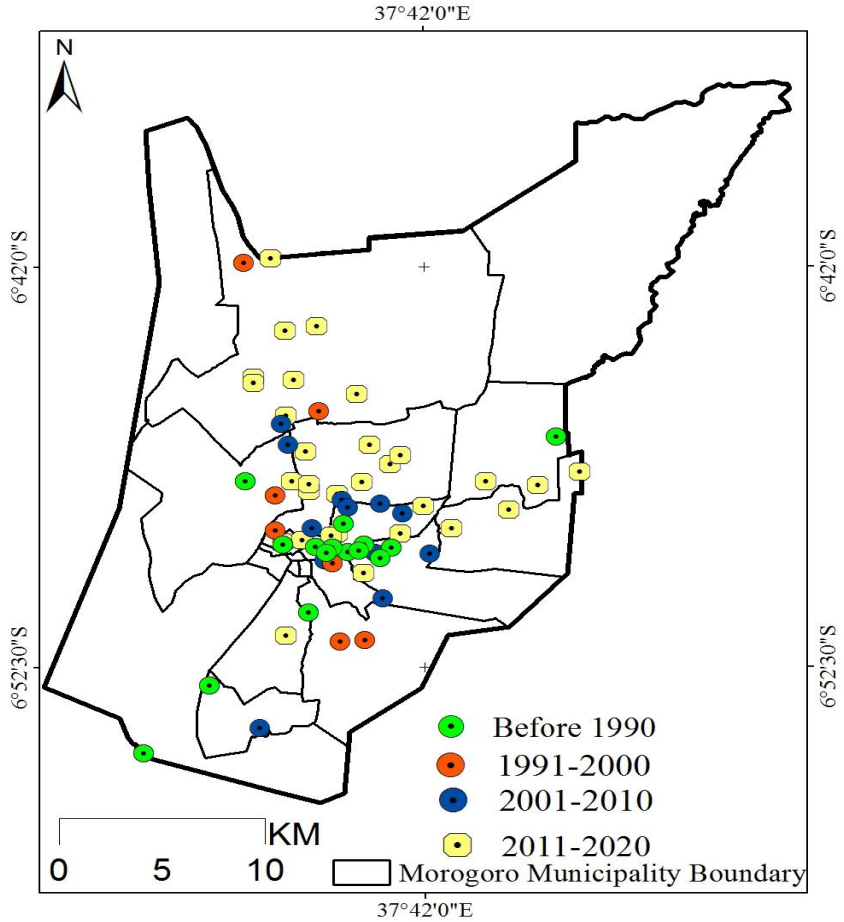

Figure 4: Distribution and location number of health facilities in the study area

Urban settlements expansion and healthcare facilities accessibility

To assess urban settlements' expansion accessibility to healthcare facilities, buffering of 0.25, 0.5 and 1km was done for the dispensaries, health centres and hospitals respectively. Figure 5 shows the changes in the accessibility area covered by the buffered area for the respective healthcare facilities from the 1990 to 2020 study period.

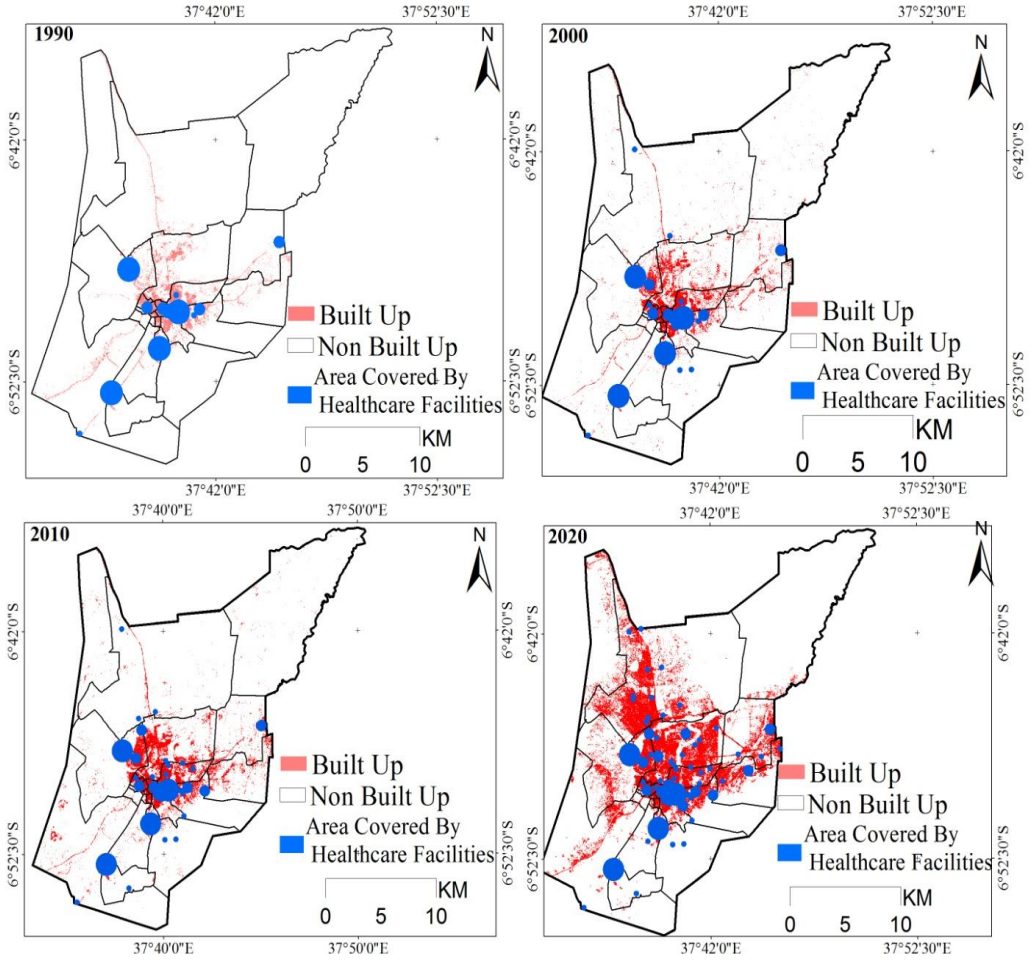

Figure 5: Distribution and accessibility of healthcare facilities in Morogoro Municipality

Table 1: Spatial accessibility of healthcare facilities in urban settlements from 1990 to 2020

Year	Types of health Facilities	Urban area covered by types of healthcare facilities in km²	% Covered	% Uncovered
1990	Hospitals	12.6	57.33	42.67
	Health Centres	4	18.23	81.77
	Dispensaries	0.9	4.3	95.7
Total		17.5	79.86	20.14
Total Urban expansion Area		21.91 km²		
2000	Hospitals	12.6	57.33	42.67
	Health Centres	5.3	24.17	75.83
	Dispensaries	1.9	8.78	91.22
Total		19.8	76.35	23.65
Total Urban expansion Area		25.91 km²		
2010	Hospitals	12.6	57.33	42.67

	Health Centres	7	31.99	68.01
	Dispensaries	3.8	17.5	82.5
Total		23.4	65.31	34.69
Total Urban expansion Area			35.86 km²	
	Hospitals	25	55.9	44.1
2020	Health Centres	10.7	23.9	76.1
	Dispensaries	9	20.1	79.9
Total		44.7	45.6	54.4
Total Urban expansion Area			97.99 km²	

Population and health facilities accessibility

In 1990 only 58.3% of the population was not accessible to health centre facilities and 16.7% was also inaccessible to dispensary facilities only a hospital was able to serve more than 100% of the existing population. But in 2020 there was an improvement in population accessibility to healthcare facilities whereby hospital and dispensary facilities were able to save more than 17.2% and 29.9% of the existing population in Morogoro municipality. The only challenge that remains on healthcare facilities is that 26.6% of the population is not accessible to health centre facilities. Figure 6 shows that in 2020 unsaved population by hospital and dispensary health centres facilities decreased while the unsaved population by health centres facilities increased. Hence it suggested that more health centre facilities should be established to balance population accessibility to all levels of healthcare facilities.

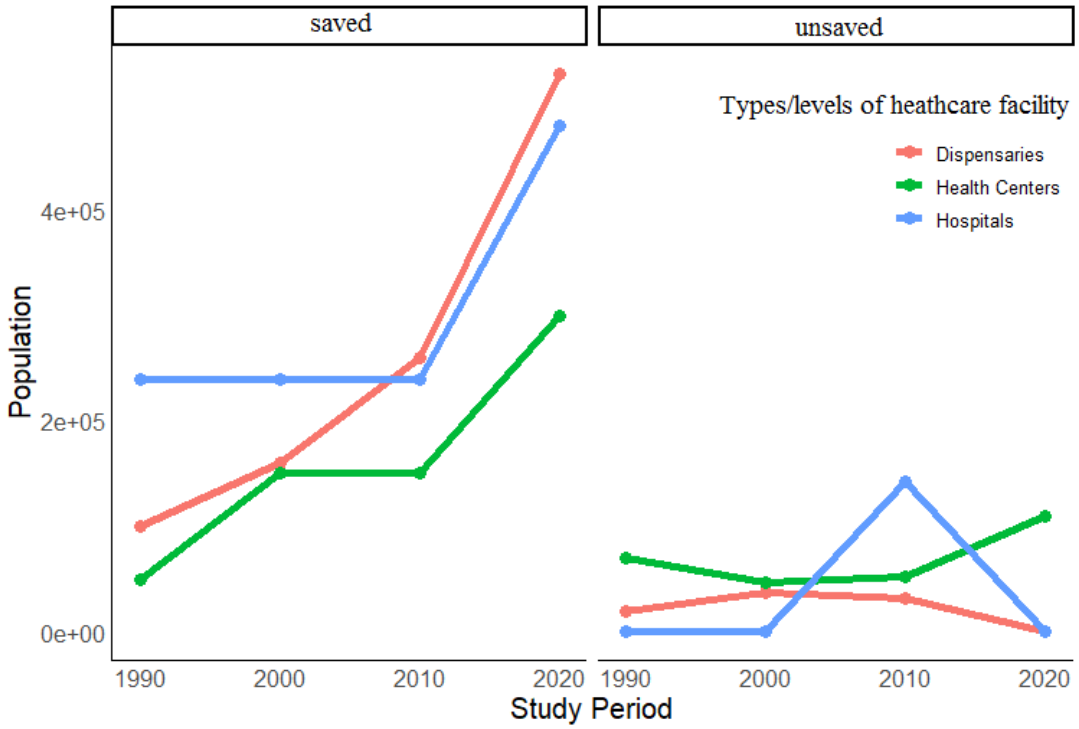

Figure 6: Population and healthcare facilities from 1990 to 2020 in the study areas

Healthcare facility-to-population ratios

Most health planners are concerned about providing an adequate number of healthcare facilities at each administrative urban unit. Healthcare facility distribution per 10 000 population is a useful standardized indicator in measuring levels of health

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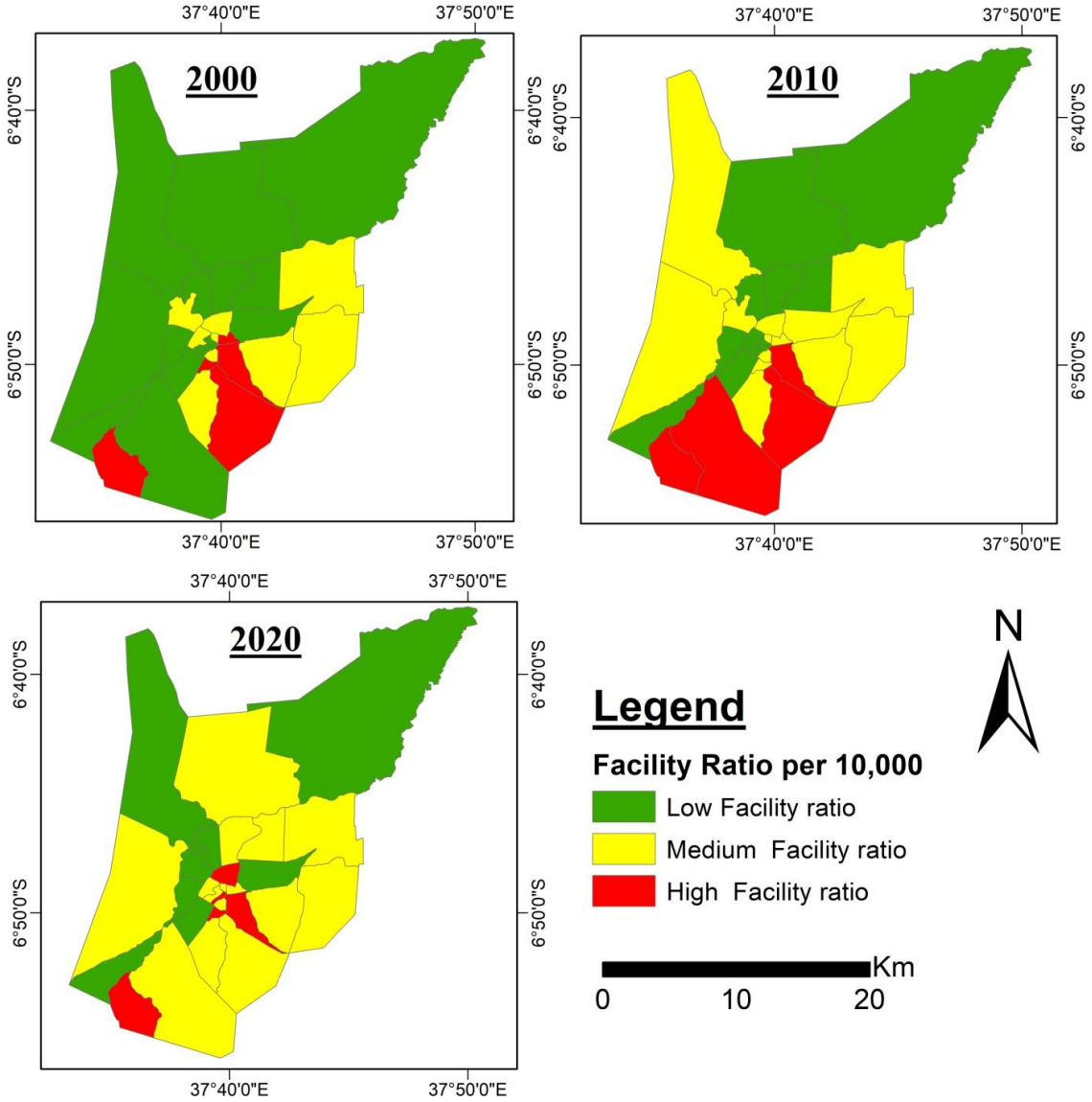
services accessibility by the population living within a geographic administrative unit indicator of the distribution of health facilities per 10 000 populations ratio was calculated simply by 10 000 × (Number of health facilities/Total population in each ward). Figure 6 shows that from 1990 to 2020 only two wards Boma and Mzinga in Morogoro municipality have been able to maintain a high facility ratio. This implies that population and healthcare facilities accessibility among these wards are growing simuntinousliy.



Population to healthcare facility ratio (wards with very low population sizes are geographically very large) 1990 to 2020

Discussion

Urban expansions

In identifying urban changes, the supervised classification algorithm and remote sensing data produce outstanding results, due to the definition of the two classifications (built-up and unbuilt-up areas). This study has demonstrated the enormous and extremely quick urbanisation of Morogoro Municipality.

Similar to other urban areas, built-up areas expanded from 3.9% to 18.9% of the total urban area between 1990 and 2020.(Muiruri, & Odera 2018) a rise in the built-up area, which went from 18% to 49%, (Sumari *et al*.,2020) urban expansion increases pressure on existing infrastructural facilities and institutions leading to a shortage of services.

Distribution and historical pattern of healthcare facilities

Until the end of the 20th century, Morogoro municipality had only 24 healthcare facilities which is about 34.8% of the total number of healthcare facilities which are still present to date. Boma ward was the ward with the greatest number of healthcare facilities (4) compare to other wards. From 2010 to 2020 about 33 new health facilities were established in Morogoro municipality which makes more than a 91.7% increase to the 36 healthcare facilities which were already in existence before 2010. Until August 2021 only Mkundi and Kauzeni wards didn't have any healthcare facilities. The results of this study indicate dispensaries to be the dominant type of healthcare facility in Morogoro Municipality.

About 69.6% of the healthcare facilities in Morogoro Municipal are dispensaries which is equivalent to 48 of 69 healthcare facilities. On the other hand, health centres and the hospital takes about 24.6% and 5.8% respectively which is equivalent to 17 health centres and 4 hospitals in Morogoro municipality. At the beginning of the study period i.e. before 2000, the majority of the healthcare facilities in Morogoro Municipality were held by the Government. Before 1990, 73% of health facilities in Morogoro Municipal were owned by the government while only 27% were owned by private institutions and non-governmental organisations. The number of private healthcare facilities showed a marked increment during the period 2010-2020, in which 79% were privately owned and only 21% were government-owned, however, this differs from Mtwara where the majority of health facilities (97%) are government owned (mremi *et al*.,2018).

Urban settlements expansion and healthcare facilities accessibility

Distribution and accessibility of healthcare facilities in urban settlements are not growing simuntinousliy, (S. Mansour .2016). The percentage of urban settlements covered by the level of healthcare facilities is decreasing while urban settlements that are not covered by the level of healthcare facilities increasing. During 1990, about 79.86% of the urban settlement had access to reliable healthcare facilities.

But in 2020 urban settlements have been decreasing only 45.6% of urban settlements had access to reliable healthcare facilities. Figure 4 levels of healthcare facilities decreased from 79.86% to 45.6% covering urban settlements area with healthcare facilities. In 1990 hospitals covered 12.6 km^2 health centres 4 km^2 and Dispensaries 0.9 km^2 which is 79.86% of total urban expansion settlements. In 2020 hospitals covered 25 km^2 health centres 10.7 km^2 and Dispensaries 9 km^2 which is 45.6% of total urban expansion settlements. This means that about 54.4% of the area of the urban settlement in Morogoro municipality is not living in an accessible area to health facilities. This implies that low-income communities will be difficult to find a means to reach the health facility, especially in case of emergency compared to the high-income community (mremi *et al*.,2018).

Population and health facilities accessibility

The population is a fundamental input and an imperative element in planning for healthcare facilities (S. Mansour .2016). In Morogoro municipality has been revealed that population accessibility to healthcare facilities depends on levels of healthcare facilities e as hospitals, health centres and

dispensaries. Improvement of the population's access to health care facilities over 30 years study period. In 1990 only 58.3% of the population was not accessible to health centre facilities and 16.7% was also inaccessible to dispensary facilities only a hospital was able to serve more than 100% of the existing population. in 2020 unsaved population by hospital and dispensary health centres facilities decreased while the unsaved population by health centres facilities increased. Hence it suggested that more health centre facilities should be established or some dispensaries should be upgraded to balance population accessibility to all levels of healthcare facilities.

Conclusion

A reliable healthcare service is crucial for the well-being of the community. This study was conducted to assess the distribution and accessibility level of healthcare facilities in Morogoro municipality. Despite urban settlements expansion and an increase in the number of healthcare facilities still, there is a decrease in the accessible urban area to healthcare facilities. It is evident from the locations of the existing healthcare facilities that proper consultation and analysis were not carried out. Therefore, policymakers and government agencies must ensure proper consultation before making decisions.

Hence, it is recommended that the new health facilities must be located in marginal and underserved areas. Such planned facilities are required to be located and distributed according to geographic distance and population standards per health facility. However, having access to health facilities in the right places does not ensure that communities will receive high-quality healthcare services. Therefore, future studies should concentrate on how efficiently and effectively healthcare facilities provide high-quality healthcare services.

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