SPATIAL DISTRIBUTION AND ACCESSIBILITY OF PUBLIC HEALTH SERVICES IN ADAMA CITY, OROMIA REGIONAL STATE, ETHIOPIA - A GIS APPROACH

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ABSTRACT
This study mainly focuses on the spatial distribution and accessibility of public health care centres in Adama City, Ethiopia. In general, haphazard spatial distribution is the main cause besides inadequate physical accessibility of public health centers in undeveloped countries worldwide for effective health management. To evaluate the spatial distribution and accessibility of healthcare centres in Adama City, geospatial techniques were applied. Spatial and collateral data were used to analyze service area-based accessibility in ArcGIS10.4. Field data were collected using GPS and ancillary data were collected from Adama Municipality of the City. Population density in various zones were considered while calculating the standards for services allocation in Adama City. In this study, it is found that 418,152 (66.80%) people live within the threshold distance of 2km of the health centres, while the rest of the population, 207,848 (33.20%), live outside the threshold distance from the health centres. The result indicates that a significant population (33.20%) remained unassisted with the existing health centres and 243,152 (38.84%) people are beyond the standards. The findings recommend additional health centres are to be established for better healthcare facilities besides the use of GIS to allocate the location-based services of health centers from the beginning of the preparation of masterplan for urban policy. The geospatial technology has proved to be the best in handling and address the health-related issues.

Keywords: accessibility, spatial distribution, GIS, health centres.

1. INTRODUCTION
Public health accessibility is one of the concepts that has been used for the last five decades. To take the medical help, accessibility can be measured for a place, and it involves measurements of physical separation of individuals and certain activities [1].

Access to a facility is a vital component in the healthcare system in many developing nations, and it has a direct influence on plagues and other diseases. Healthcare is one of the major important indicators of social and economic progress[2]. As a result, analyzing access to healthcare services contributes to a better understanding of how healthcare systems work within and across states.

According to [3], the World Health Organization has been assessing the ease of access to healthcare facilities in developing countries, operating in partnership with a number of educational administrations. They were using the standard Cost Distance feature available in the Spatial Analyst extension for ArcView3.x and also available in ArcGIS9.x[4] to evaluate accessibility. Aspects and meanings of the concept of access to healthcare facilities should once again be analyzed and combined into an agenda that considers healthcare strategy as a planned impact on health-related characteristics [5].

In healthcare structure, the access entity is a critical element of any country's healthcare services. Accessibility mainly depends on the availability and affordability of the service in a given area. Evaluation of spatial distribution and affordability of healthcare services adds to a broader consideration of operation and healthcare.
strategies. It implies planning and analysis of healthcare services depends upon geographic distribution of population, which in turn approachability of healthcare service. Population distribution on our Earth's surface is not equal, and people differ along many dimensions, including economic status, culture, gender, and age[6]. These affect the types of facilities they are willing, able to utilize, ability to travel to obtain healthcare service and their need for healthcare service. The Geographic Information System (GIS) can be used to explore geographical variation, essential to map healthcare services, and necessary to develop innovative indicators of healthcare service needs. Based on[6], healthcare centre accessibility is referred to as residents' capability to acquire a clear and explicitly stated rule of healthcare facilities. According to [7], spatial ease of access is implicated with the ease with which residents of a given area can reach a given healthcare service and hence, it takes a substantial essential physical element.

Health is considered a critical element of wellbeing and fiscal development. Hence, in the Third World Countries, to improve people's healthcare system, a planning scheme have been made on every occasion. Best spatial arrangement is required to expand geographical access to health services. It implies that the practical application of GIS has been used to perform spatial analysis of demand and supply [8].

The use of GIS-based accessibility analysis offers a valuable approach that can be used to support location planning in the urban healthcare sector [9]. Previous research supporting the use of this method had been undertaken by geographers and planners during the last decade. Developing sophisticated steps for different trip purposes, different travel modes and times, different age, sex, ethnicity and occupational classes, and distinct activity styles at each destination is becoming more popular[10].

Ethiopia is the world's most populated landlocked country and the continent's second-most populous country in Africa. To improve healthcare services in the country, the administration has to work with different stakeholders and use space technology to monitor day to day health issues. The administration has been devoted to refining necessary health facilities available to all peoples using decentralization, an inspiring corporation with the private domain and comprehensive partaking of stakeholders [11]. However, insufficient delivery schemes, poor service quality and weak infrastructure have delayed universal access to healthcare services in the country [12]. More or less uneven spatial distribution is the main causes of inadequate physical accessibility to the healthcare centers all over the country.

Data automation leads to greater efficiency in many workplace tasks. As a result, the aim of this paper is to use geospatial techniques to map the spatial distribution and accessibility of healthcare centres in Adama city in order to solve the problem. This study will fill the gap by applying geospatial technology to address the issue.

Study Area
Adama is the third-largest City in Ethiopia and is located about 100km south of Addis Ababa along the main road to Harar. It is situated between 8°25'00" to 8°36'00" North Latitude and 39° 11' 57" to 39° 21'15" East Longitude at an average altitude of 1620m above mean sea level (Fig.1). The City is named after a generic small milky plant called Adami in Afan Oromo, to mean Cactus tree. The City is located in East Africa's Great Rift Valley region on the flat lowland between the mountainous ridges of Kechema and Kurfagutu[13].
II. METHODOLOGY, DATA PROCESSING AND ANALYSIS

Evaluating the distribution and accessibility of public health centres in the study area is done using service area analysis. Used distance measures from activity-based techniques of measuring accessibility in ArcGIS 10.4. The data required to carry out accessibility analysis using the service areas calculation is listed in Table 1.

Table 1. Data used

<table>
<thead>
<tr>
<th>Data</th>
<th>Source</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthcare centres</td>
<td>GPS Survey</td>
<td>Location of healthcare centres</td>
</tr>
<tr>
<td>Road</td>
<td>CAD data &amp; total station</td>
<td>Road network</td>
</tr>
<tr>
<td>Population</td>
<td>AMPPD &amp; Ethiopian Urban Expansion Initiative Report</td>
<td>Demand point</td>
</tr>
</tbody>
</table>

The data were generated and obtained from both primary and secondary sources. GPS Survey was conducted to measure the location data on existing health services (supply) in all the corners of the City as a primary data source, and additional road network data were collected using a total station. The data on the number and location of the public healthcare services and national standards were obtained from the Adama municipality and regional health bureau. The land use, road network topographic maps, city boundary, the master plan of Adama city and population density for each parcel per block is also obtained using different extraction methods from Adama city municipality CAD data as a secondary data source. The City's total population density collected from the regional statistics bureau and the same correlated and extracted from the CAD data. The population data, the demand point in the analysis, were estimated by the Ethiopian Urban Expansion Initiative Intern Report 2[14]. Therefore, the projected population of the City for 2030 is estimated to be 0.626 million.

3.1 Methods of Data Processing

In this study three thematic coverages i.e., locations, road network, and the demand point have been used. Subsequently, data used in modelling process for the generation of service area map. The minimum distance...
model processed the point data using Network Analyst Extension in ArcGIS 10.4 for generating service area polygon. Calculating the average weighted distances, travel distance to each healthcare provider defines geographical accessibility.

3.2 Methods of Data Analysis

A network dataset has been created in ArcGIS personal Geodatabase using Adama Street, (table 2).

### Table 2. Dataset created in the ArcCatalog window.

<table>
<thead>
<tr>
<th>Name of the Dataset</th>
<th>Feature Class</th>
<th>Forms of the dataset</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthcare Center</td>
<td>Point</td>
<td>Vector</td>
<td>Represents Healthcare Center location</td>
</tr>
<tr>
<td>Street Network</td>
<td>Polyline</td>
<td>Vector</td>
<td>Represents streets</td>
</tr>
<tr>
<td>Demand Point</td>
<td>Point</td>
<td>Vector</td>
<td>Represents population for each parcel</td>
</tr>
</tbody>
</table>

After creating the network dataset and the point dataset extracted to a geodatabase in ArcCatalog, ArcMap has been used to calculate the impedance values of service areas for each healthcare centre independently. The data used in this analysis have been extracted from Points of Interest feature class (figure 2).

**Figure 2.** Flow chart of data analysis method
Based on the parameters and values settled in ArcCatalog, service area calculation has been calculated. The service area map for each healthcare centre has been created using the facilities' norms and standards (table 3). The map highlights the spatial distribution and accessibility of the healthcare service in the City.

**Table 3.** Service area analysis settings for healthcare centres

<table>
<thead>
<tr>
<th>Facility</th>
<th>Impedance</th>
<th>Default Breaks</th>
<th>Direction</th>
<th>Allow U-Turn</th>
<th>Restriction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthcare centre</td>
<td>Distance</td>
<td>500, 1000, 2000</td>
<td>From the Facility</td>
<td>Every-where</td>
<td>One way</td>
</tr>
</tbody>
</table>

### III. RESULTS AND DISCUSSION

The existing public healthcare centre distribution and accessibility performed using service area analysis in the City.

Using service area analysis, the spatial distribution of existing healthcare centres was mapped (figure 3). The accessibility of a given public healthcare centres to the specified distance limit, as walking mode of travel, or/and based on the road network selected and population density was analyzed. Based on the norms and standards fixed by the Health Bureau, the travel distance threshold of 2,000 meters is applied [15].
According to the national health policy, which aims to facilitate "access to care" through a centralized system of government, a primary health care unit, consisting of one health centre and five satellite health posts, serves 25,000 people [16].

Table 4. Summary of accessibility to existing health centres within 2000m.

<table>
<thead>
<tr>
<th>ID</th>
<th>Name of Health Center</th>
<th>Served Population</th>
<th>Served Population (in %)</th>
<th>Total Distance (in Meter)</th>
<th>Total Weighted (in Meter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Adama Health Center</td>
<td>47760</td>
<td>7.63</td>
<td>6799801.46</td>
<td>33999007.32</td>
</tr>
<tr>
<td>2</td>
<td>Anole Health Center</td>
<td>11720</td>
<td>1.87</td>
<td>1607450.18</td>
<td>8037250.91</td>
</tr>
<tr>
<td>3</td>
<td>Bifu Health Center</td>
<td>87456</td>
<td>13.97</td>
<td>14214360.40</td>
<td>71071802.00</td>
</tr>
<tr>
<td>4</td>
<td>Boku Health Center</td>
<td>83400</td>
<td>13.32</td>
<td>10982877.39</td>
<td>54914386.96</td>
</tr>
<tr>
<td>5</td>
<td>Denbela Health Center</td>
<td>77120</td>
<td>12.32</td>
<td>12695820.71</td>
<td>63479103.55</td>
</tr>
<tr>
<td>6</td>
<td>Geda Health Center</td>
<td>77528</td>
<td>12.38</td>
<td>11672096.05</td>
<td>58360480.23</td>
</tr>
<tr>
<td>7</td>
<td>Hawas Health Center</td>
<td>33168</td>
<td>5.30</td>
<td>5271057.33</td>
<td>26355286.64</td>
</tr>
<tr>
<td></td>
<td>Total Number of populations</td>
<td>418152</td>
<td>66.80</td>
<td>63243463.52</td>
<td>316217317.60</td>
</tr>
</tbody>
</table>

Figure 3 shows that 418,152 people live within the distance of 2,000m to the health centres. The percentage of people who lives within the threshold distance (2,000m) is 66.80%. The rest of the 207,848 population (33.20%) live farther away from health centres. This means that 33.20% people don't have a good accessibility to the health centers facility in terms of distance, except for Anole health centre. The rest of the people with the above norms and standards, as stated below in table 5. It implies distance is the real problem, for neglecting the health services. The number of people that served within a threshold distance (2,000 m) hampers the people to access the health centre. Moreover, the geographic distribution of the existing healthcare centres has an impact on accessibility.

Table 5. Norms and Standards for Public Health Services.

<table>
<thead>
<tr>
<th>Type</th>
<th>Required area (ha)</th>
<th>Catchment area(Radius)</th>
<th>Catchments population</th>
<th>Detail considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Center</td>
<td>1ha</td>
<td>≤2km</td>
<td>25,000</td>
<td>Within the serviced area Accessible along collector roads, far from dumpsters, noisy activities</td>
</tr>
</tbody>
</table>

Source: [15]

Figure 4. Map of existing health centres versus served population in Adama city.
As we see from the above figure 4, there are seven health centres located in the study area. One can easily observe that: Adama Health Center 22760, Biftu Health Center 62456, Boku Health Center 58400, Denbela Health Center 52120, Geda Health Center 52528andHawas Health Center 8168 people appears to be displayed beyond the reference point (3.99%). It means that approximately, 243152 people due to overloaded and 207848 because of beyond the standard a total of 451,000 will have no access in these health services.

IV. CONCLUSIONS AND RECOMMENDATIONS

In this study, the spatial distribution and accessibility of public healthcare centres in Adama City, Ethiopia, were evaluated. Geospatial tool, maps and tables were used to analyze service area-based accessibility analysis of data using ArcGIS 10.4 version. It found that spatial access mainly depends on the distance to the nearest public healthcare centre. It suggested using network-based service area analysis for optimum distribution and measurements of spatial accessibility in the City. The findings revealed a gross inadequacy distribution of healthcare centres in the area. The existing distributions of healthcare services are leading to limited physical accessibility, and it had an originator impact on the City’s growth. The concentration of healthcare services in a specific area, poor accessibility, and lower healthcare services increase society's health and social inequalities.

From the result obtained, the study recommends that:

The concerned institution advised to make use of this research findings while preparing development planning in the City and in future.

According to the proposal of this study, a City authority must here mark preserve areas for healthcare facilities in collaboration with the residence.

While undertaking planning exercise in the City, the principle of safety, affordability and rapidity must be considered by planners using GIS.

Equal access is achieved by allocating new healthcare centres in the disparity area.

REFERENCES