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GPS SUPPORTED ASSESSMENT INTEGRATED WITH GIS SERVICE AREA ANALYSIS OF HEALTHCARE INSTITUTIONS OF BASONA WERANA IN COMPARISON WITH DEBRE BERHAN

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Abstract. The study is principally aimed to assess and analyse the spatial location of the health institutions from lower-level Health Posts (HPs) to higher level Referral Hospitals (RHs) in both Zonal Capital Debre Berhan Town (DBT) and the surrounding Rural Basona Werana Wereda (BWW) which includes both government and private owned using Global Positioning System (GPS) equipment and ArcGIS software. The methodological procedure encompasses adjustments of data before use for the analysis, data processing, analysis and final result. On this basis, it could become possible to identify the spatial locations of the health institutions in BWW and DBT including residential areas in both districts. Built up road network data set enabled generation of possible service areas and as a result higher Clinics, Health Centres and hospitals are either nearly or fully provided for urbanized population of DBT while they are either extremely rare or not provided in the rural population of BWW. Absence of road infrastructures and transport facilities also intensified the rural health service access. The study suggests involvement of scientific approaches of GPS, GIS and other relevant technologies towards health policy implementation will be a remedial action for the government and stake holders of the health sector.

Keywords: GPS, GIS, service area analysis, proximity analysis, health institutions, BWW, DBT.

Introduction

The primary health care distribution and accessibility has imposed different challenges across the globe from the recent decades (World Health Report, 2008) under which especially the poor and developing countries take the first line to share the anomalies indeed. Ethiopia is one of the developing low-income countries with low health services accessibility and coverage as any of the Sub-Saharan African country. As to Richard G. Wamai (2004) even stated, Ethiopia has poor health outcomes even by sub-Saharan Africa's standards characterized by many decades without a national health policy, weak healthcare system infrastructure and low government spending. Wamai added, a mid-term review of Health Sector Development Program (HSDP-III) shows a near 100% in health coverage as indicated by the availability of primary health services (health posts, health extension workers and kits for essential health services) but outpatient utilization rate per person per year is only 0.32, far short of the target of 0.66 with only about a year left to 2010. In the 2018 review report of the 2nd Growth and Transformation Plan (GTP II) of the Federal Democratic Republic of Ethiopia (FDRE), the national primary health care coverage 100 percent completed in 2015/16 whereas the need in the 2016/17 fiscal year was to the development and upgrading of the health infrastructure, along modifying service qualities. The paper states, in the 2016/17 fiscal year, 16,660 health posts (up from 16,480 in 2015/16), 3,622 health centers (up from 3,562 in 2015/16) and 266 hospitals (up from 241 in 2015/16) were providing health care services nationally (National Planning Commission, 2018). Of course, the figure when compared to the former GTP (Ministry of Finance and Economic Development, 2014) shows little increment where there have been 16,048 health Posts, 3100 Health Centers, 127 Hospitals in 2012/13 at Country level. On the Other hand, Population, Health and Environment (PHE Ethiopia Consortium, n.d.) stated, the core elements of the GTP health strategy are: decentralization of the health care system, development of the preventive, promotional and curative components of health care, assurance of accessibility of health care for all segments of the population and the promotion of private sector participation in the health system (p. 5). Bekele and Lakew

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(2014) also recommended as, the government should promote and provide basic and primary healthcare interventions to be accessed by the general community (p. 4).

1. Background of the research problem

GIS is fast becoming a vital tool in healthcare applications covering database management, planning, risk assessment, service area mapping and location identification (Mushonga et al., 2017). The problem this study came up with is how the stated health services are distributed (i.e., how they are spatially located) and how they are accessed by the addressed population of their localities. Although GIS Service area analysis is used mainly with the problem, other techniques like proximity analysis and interpolation techniques are also intended to be involved in the study to meet the objective set and the answer the research questions.

1.1. Objectives

The study intended mainly to identify Health institutions in the rural settlements and villages of BWW and DBT to give accessibility-based description and suggest impartial geographic distribution platform comparing the rural population with the population in DBT.

Specifically, it is intended to:

- Assess the demographic data of all the target institutions from relevant health offices at Zonal and Wereda levels.
- Establish GPS coordinates (X, Y and Z) location of each health institution in the entire of the Wereda with the help of GPS equipment.
- Identify and map the population and their localities in both the country sides and the Townships using GIS mapping Application.
- Extract all road network at a variety of levels and types and build a road network dataset.
- Make Service Area and proximity analyses along with comparing and contrast between the Rural Wereda and mainly DBT population using ArcGIS extension module of Network Analyst.
- Recommend corrective measures based on the research findings against the problems to the existing population in relation with healthcare services.

1.2. Backgrounds of the study area

Basona Werana Wereda (being centered by Debre Berhan Town, Home of the North Shewa Zone Administration) is one of the 22 Weredas found in the North Shewa Zone of the southern most part (see Figure 1) in the Amhara Regional State Government. Wereda is the second smallest political administrative unit next to kebele in Ethiopia. Basona Werana Wereda is characterized by geographically all types of terrain properties (i.e., flat, rolling, mountainous and escarpment). According to the Central Statistics Agency (CSA) population projection of Ethiopia for 2017, the total population of the area is 254,079 of which 115,515 peoples live in urbanized area and 138,264 are rural. The Wereda covers a total land area of 1315.44 sq km (131544.40 ha) from which the rural portion accounts for 88.88% 90% (1169.17 sq km) and the remaining 146.27 sq km is for Town of Debre Berhan.

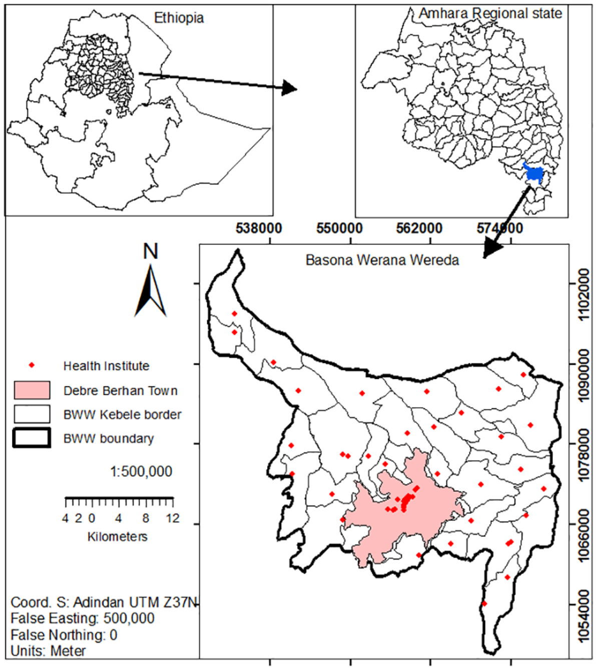

Figure 1. Location map of the study area

2. Data and methodology

2.1. Data

After gathering data in the form of analogue and digital, extraction of input data in digital format was done for ArcGIS as follows:

2.1.1. Road network data

Being as a core data input for the study, different efforts are made to develop full data for building the entire study area road data. The following Tabular Information is the over all areas of road data (see Table 1) and the sources and formats.

Table 1. Profile of road network data source employed

No	Data	Source	Format
1	DBT Road network	Town Municipal	.shp
		Town Orthophoto image	.jpeg
		https://extract.bbbike.org/	.shp
2	Baso wereda Road network	Scanned Topo Map of the area	.jpeg
		Google Earth image	.jpeg
		https://extract.bbbike.org/	.shp

On the basis of their nature, the road network in the study area (both Baso Wereda and Debre Berhan Town) comprises different types (name, class, surface condition and length) as tried to explain in detail in the Table 2.

Table 2. Profile of road network type in the entire study area

No	Road Name & Type	Area	Length (km)	Percentage (%)
1	Asphalt concrete	Debre Berhan	21.818	1.45
		Basona Werana	47.670	3.18
2	Cobble-stone	Debre Berhan	85.111	5.66
		Basona Werana	–	–
3	Gravel	Debre Berhan	126.153	8.41
		Basona Werana	489.119	32.62
4	Stone-Paved	Debre Berhan	0.771	0.05
		Basona Werana	–	–
5	Trail (Footpath)	Debre Berhan	122.341	8.16
		Basona Werana	606.631	40.45
		Total	~1499.614	~100

2.1.2. Location of health institutions

The GPS location data of the target Health Institution are obtained in two main ways. The first and simpler was official contact of pertinent health Offices for previously recorded by experts while the second was through physical collection of missing coordinates. The Health Institutions are categorized into two as Basona Werana Wereda (Country side) and Debre Berhan Town Health Institutions. The institutions are classified as Health Posts, Clinics, Health Centers, Primary Hospitals and Referral Hospitals in order of simple to complex in both areas (Table 3).

Table 3. Statistical data and types of health institutions in the entire study area

No	Type	Address	Number
1	Health Posts	Debre Berhan Town	0
		Basona Werana Wereda	27
2	Clinics	Debre Berhan Town	17
		Basona Werana Wereda	1
3	Health Centers	Debre Berhan Town	3
		Basona Werana Wereda	4
4	Primary Hospitals	Debre Berhan Town	1
		Basona Werana Wereda	0
5	Referral Hospitals	Debre Berhan Town	1
		Basona Werana Wereda	0

2.1.3. Residing population in need of the facilities

Among the toughest procedures during data collection stages was accessing spatial location of the population residence especially those of country side population of Basona Werana Wereda. Different techniques were tried to follow to fill the gap among which the main ones are landuse map of the two districts, some boundary maps of both administration units and also Google earth data as indicated in Table 4.

Table 4. Political boundaries and Landuse data

No	Data type	Administration	Source	Format	C. system
1	Political boundary	DBT	BWW Land Administration Office	.shp	GCS
2	Landuse map of DBT	DBT	DBT Municipal Office	.shp	PCS
3	BWW Kebele Boundaries	BWW Kebeles	BWW Land Administration Office	.shp	GCS
4	Landuse Map of BWW	BWW	https://extract.bbbike.org/	.shp	GCS

Note: DBT (Debre Berhan Town), BWW (Basona Werana Wereda) PCS (Projected Coordinate System), GCS (Geographic Coordinate system).

2.1.4. Equipments, tools and softwares involved

Handheld GPS and its accessories are used mainly to collect primary X and Y coordinates of Health Institutions. Laptop computer is used for data storage, pre-processing (i.e., adjustment, edition, and deletion) and processing (analysis and producing the results). ArcGIS with its full Packages for data input, storage, display, edit, analyze and result output; Garmin software to adjust and upload GPS data; Global Mapper to perform some parametric conversions; Google Earth to view and download imageries; Microsoft Excel to arrange some tabular attribute data for GPS points are softwares involved.

2.2. Methods

2.2.1. Secondary data collection (interaction with organizations)

The beginning stage before taking any physical measurements on the study area was being in connection with organizations. This stage could radically simplify the physical and exhaustive ground surveying data collection because evidences from office highly reduce energy, time and materials. All coordinate data of countryside Basona Werana Wereda, Political boundaries of the Wereda and Kebeles under it with their details were achieved in this stage. That was quit unpredictable task for physical ground surveying because of most dynamic topographical nature and unaffordable transport infrastructure of Basona Werana Wereda for Surveyors. Due to this and other reasons organizational contact stage of data collection was the best alternative under which the researchers were helped a lot.

2.2.2. Primary data (ground surveying)

GPS data of Health Institutions especially in Debre Berhan Town are collected by the researchers physically in exhaustive stage because of difficult topographic nature of the area to them.

2.2.3. Data preparation methods

Preconditions for the core data analysis where correction of booboos, anomalies and absence of data are undertaken through modifications, deletions, substitutions etc. were made deeply during this groundwork. Collected spatial data from different offices and ground surveying were having different formats and coordinate reference systems and thus coordinate projections and transformations, digitization and attribute entry are also done to all in order to bunch the reference frames of the whole spatial data. A file geodatabase is created under which different datasets are further categorized to their geometrical nature (feature datasets and raster datasets).

2.2.4. Building a network

This is where two distinct but interdependent activities were developed towards building this road network datum. The first was road network topology whereas the descending one was network dataset of the road in the entire study area under the formerly built geodatabase.

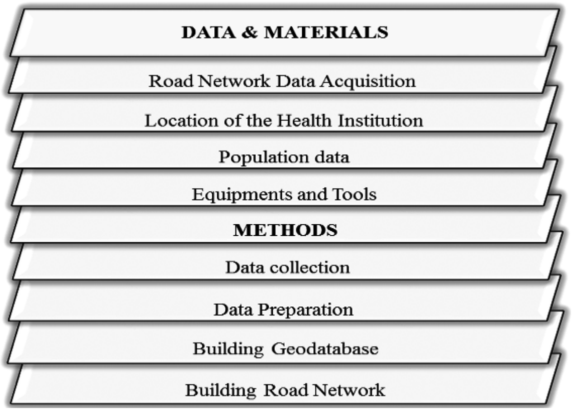

Figure 2. Structural design (approach) of the research

2.2.5. Proximity analysis

It is another vital technique used in the study as a determining approximation of proximity (accessibility). A number of toolsets are provided in proximity analysis of the analysis tools in ArcToolbox window among which Create Thiessen polygons option is to be used specifically. Figure 2 shows generalization of data investigation.

2.2.6. Data analysis

Service area analysis

The central portion of analysis truly begins here where network analyst sub-module of ArcGIS Software is undertaken as soon as the built-up road network is prompted to the ArcMap window. The built network, service facilities (i.e., Health Institutions) and population requiring the service are the main requirements to be considered. Analysis result forms confines of irregularly shaped polygons considering each health facility as a centroid of each polygon. The Polygons are generated on basis of the built road network, impedance values (distance or time) and the spatial location of the health facilities the analysis procedure is followed workflow shown in Figure 3.

3. Data analysis, results and discussion

3.1. Data analysis and results

Statistical and pictorial results achieved in different scenarios are exhibited and discussed in the following subtopics.

3.1.1. Service area network analysis

Two rating elements from which data analysis results generated are distance and time. According to the 2017 population projection by Ethiopian Central Statistical Agency (CSA), the sum total of BWW population including both rural and urban is 254079. Worldometer (https://www.worldometers.info/world-population/ethiopia-population/) estimation evidence of the 2020 indicates, Ethiopia's

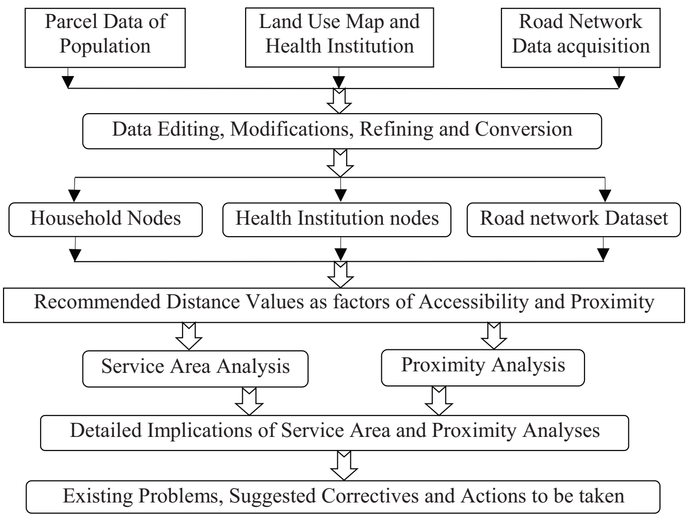

Figure 3. Schematic diagram of data pre-processing and processing method

yearly population growth rate and average family (household) size are 2.57% and 4.6 respectively.

3.1.1.1. Distance

Linear amounts in intervals are assigned in meters or kilometers from each health institution to population nodes relative to network built in the study area around each locality. According to this, a 1 km, 2 km, 3 km, 4 km and 5 km impedance values are set and a result is achieved as can be seen in Figure 4a.

Table 5. Statistical data as result of Service area data analysis

	Scenarios	Number of household nodes and their respective area covered in need of services within specified cost value of service area analysis			
		Population nodes coverage		Land area Coverage	
		Nodes' quantity	% age of total	In Square kilometers	% age of total
Travel distance (cost in kms)	1	22 009	33.73	101.35	7.70
	2	37 883	58.06	323.66	24.60
	3	46 547	71.34	596.20	45.32
	4	53 609	82.16	840.41	63.89
	5	59 985	91.94	1100.40	83.65
Travel time (cost in minutes)	5	44 778	68.63	466.81	35.49
	10	54 595	83.68	794.27	60.38
	15	59 015	90.45	962.73	73.19
	20	61 273	93.91	1055.14	80.21
	25	62 194	95.32	1096.82	83.38

3.1.1.2. Time

Time parameter is also considered in the same way done for distance impedance cost. It is duration taken from a point representing a population node to its closest Healthcare service following the road network. Based on this, a 5, 10, 15, 20 and 25-minutes impedance values are set in 5 minutes interval and cumulative result map is generated as seen in Figure 4b.

3.1.2. Proximity analysis

ArcToolbox of ArcGIS contains a powerful set of tools that perform the most fundamental GIS operations among which proximity analysis option is one. Proximity determines how a particular population node is closer to or farther from a healthcare institute than other institute or facility. Therefore, each and every particular health institute encompasses household nodes around its vicinity. In the Figure 5, there have been 55 total number of health institutions delivering service in both BWW and DBT in the entire area. Thiessen polygon technique is preferred in this case among the different set of techniques in the proximity analysis. This is used because the result generated in this technique could give best and accurately bounded space around each service center without missing even a single population node. The number of polygons following the analysis output are therefore as per the number of 55 separate non-overlapping health institutions (33 in BWW and 22 in DBT).

3.2. Discussion

The process of the research is started with collection of secondary data and other information of all spatial and socioeconomic backgrounds related to study area and

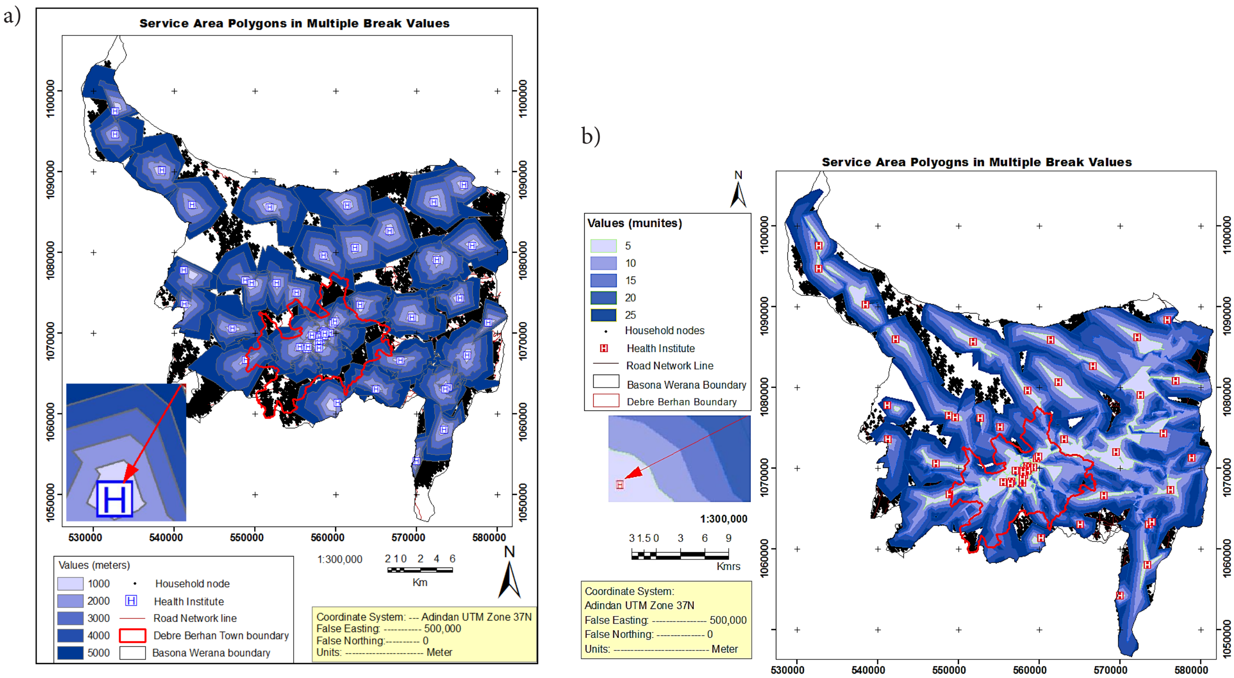

Figure 4. Result map of distance impedance cost (a) and Result map of time impedance cost (b)

health care institutions of all kinds and level from DBT Municipal, Health office and zonal Bureau of land use and management, BWW Health Office and Land use and Management office. In the consecutive stepwise service area distance and time costs of travelling along the built-up road network infrastructures (Figure 4a, 4b and Table 5) which includes all available means of transportation including traditional on foot, scenarios of various values were generated showing accessibility statuses of health care services in both BWW and DBT. According

a) b)

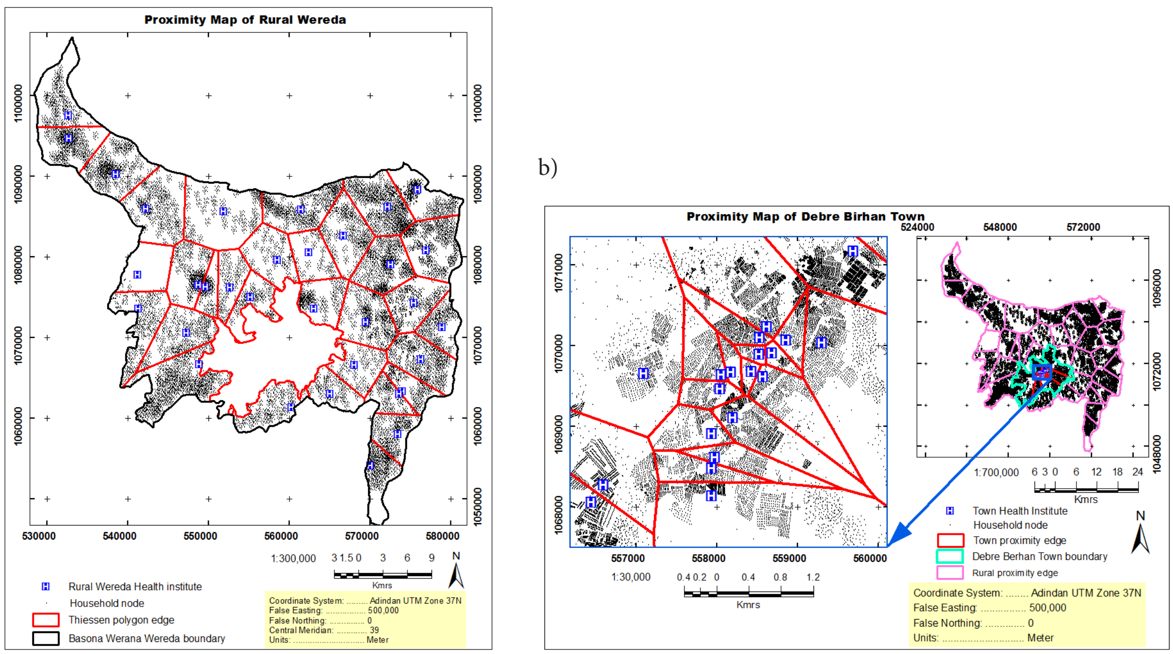

Figure 5. Thiessen Polygon Map of BWW (a) and DBT (b)

a)

b)

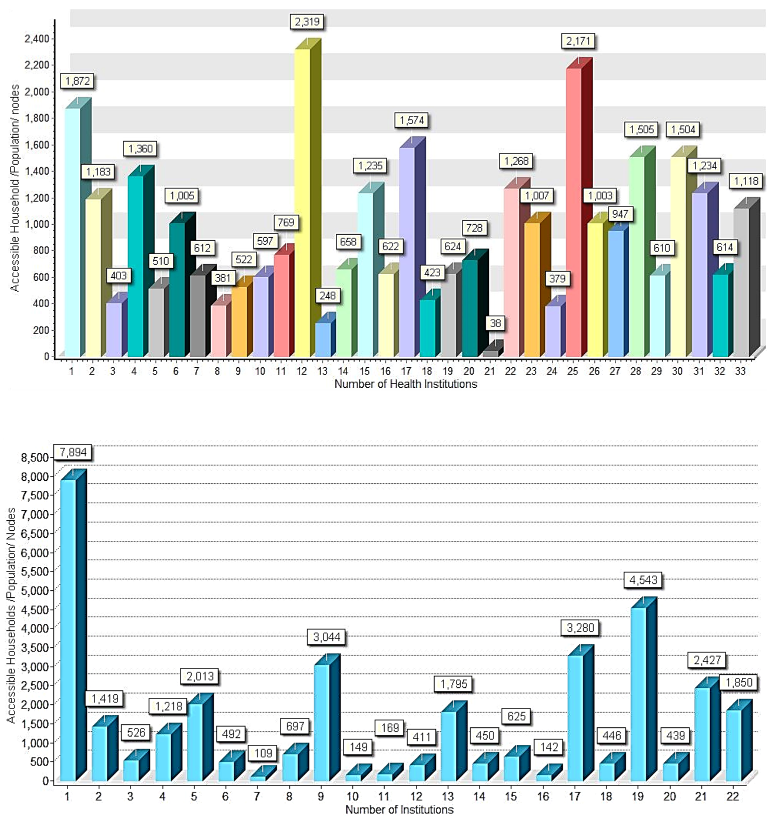

Figure 6. Graphical view of proximity levels of each Thiessen Polygon in BWW (a) and DBT (b)

to this, the study has found from the common ground and technical analysis that the socioeconomic position and lifestyles of the residing community could influence distribution of the health institutions in the entire study area. The health posts, Health Centers, Clinics of all grade and type, Primary hospital and Referral hospital owned by both government and private are all considered and judged similarly. Thus, there has been a total number of 55 institutions in BWW and DBT out of which 15 (1 primary hospital and 14 clinics) are private ownership and the remaining 40 are government owned. Studying the depth, complexity, intensity level and quality service delivery of each institute is beyond this study whose main focus is investigation of the geographical location of service demanding population and coverage assessment of the institutions. Of the total household population (i.e., 59673 house hold nodes), coverage sizes in successive travelling distances and time taken to reach at service destinations are inspected and results achieved (Table 5) at each level (i.e., 19041, 32340, 37883, 40542, and 54129 consecutively for 1 km, 2 km, 3 km, 4 km and 5 km distances while 38522, 48557, 53237, 55622, 56537 for 5 minutes, 10 minutes, 15 minutes, 20 minutes, and 25 minutes of time durations respectively). According to this, among the minima of cost values (1 km and 1 minutes) the minimum coverage of 31.91% (19041) of households are included whereas among the maxima (5 kmrs and 25 minutes) the maximum amount reaches 94.74% (56537) households. The average 61.65% (36787) households are accessible in the distance and 84.62% (50495) households in the time scenarios. On the other hand, the corresponding land area coverage in Table 5 also indicates the minimum of only 7.70% (101.35 sq km) in 1 km distance cost and the maximum of 83.65% (1100.40 sq km) in 5 km distance from the total of 1315.44 sq km area could be covered with the average of 45.03% (592.40 sq km) in distance scenario and 66.53% (1100.40 sq km).

Proximity describes the closeness within a bounded space or time. In this study, it is used to identify how closer a health institution to a service requiring household is than other health institution in the study area and vice versa. A GIS proximity analysis using Thiessen polygon generation technique has been implemented considering the 55 institutions of all types and levels under study in similar manner to the service area analysis. Based on the results shown in Figures 5 and 6, varieties are apparently seen across the whole area and household population coverage where minimum of 38 household nodes per institute and maximum of 5644 household nodes per institute are recorded with average (mean) of 1085 households per each single institute. In addition to the whole variation among institutions in the entire area, it is also elucidated in terms of rural and urban population. The bar graphs shown in Figure 6a and 6b respectively describe the rural and urban variation. Taller bars of the rural wereda in Figure 6a show scarcity of institutions apart from each other enclosed with huge amounts of household numbers around while small height graphs of DBT institutions (Figure 6b) with smaller number of households to serve are indications of availability of more institutions closer to each other in smaller area of the Town.

Result in terms of accessibility and coverage varies highly in both land area and cut off parameters (i.e., distance and time values). On the other hand, better health service accessibility of rural Wereda population extremely differs from urban population. All health posts of the Wereda are situated only in the rural BWW whereas all clinics of all kind, health centres are available in the urbanized areas of the Wereda in addition to those two (primary and referral) hospitals located only in DBT. From the Total fraction, 40% or 22 of the institutions are available only in DBT. The land area to health service coverage ratio of rural to urban on the other hand is 6.65: 35.43. Service area generated for the referral hospital shows patients in need of better hospitalization shall travel in average for 20 km or 1hr while the maximum distance and time taken for remote patients exceeds 40 km or 2 hrs respectively. Similar situations happen in proximity analysis to the service area regardless of complexity, quality and land area coverage and accessibility (proximity) between urban and rural. Patients shall move for several kilometres of distance from around even from outside of the study area to get the only single referral hospital found in the central Town, Debre Berhan.

A great deal of researches has been conducted using GPS and Spatial technologies on health infrastructures as a means of decision support systems with varieties of approaches like for example "Spatial accessibility of primary care" and "Hospitals accessibility" in Ireland and US by Koutelekos et al. (2007) in their issue 3 where spatial data of hospital location, road network and attribute data of population were integrated in a database of GIS. Issues like travel time, hospital size, and population weighting are raised undergoing a spatial weighted accessibility formula in former whereas distribution of hospital, specialty services and service in rural in comparison to urban in terms of distance, affordability of care and measures of accessibility in the later one. Even though location and accessibility matters are addressed here, the livelihood and access of population in these areas are quite different from our subject of study (i.e., BWW including DBT). Ejiagha et al. (2012), employing GIS network analysis tools to measure accessibility have used closest facility, single and multi-criteria queries (to show location and ownership of healthcare facility and attribute) and buffering (to show proximity to the facilities) techniques through which two locations were identified whose people have to travel more than 10km to access healthcare facilities. Here in this study, the techniques used are service area analysis and Thiessen polygon generation because these can perfectly measure both access and coverage of primarily the institutions of health (health posts in particular to rural population) nearer to residents whereas service area analysis enables to determine maximum km and hours to be taken for more intensive care to get hospitals of DBT.

The WHO in its health statistics report of 2018 assumes that for a particular country to achieve the goals set in the UHC, all the citizens shall receive the essential services they are satisfied in with the absence of financial sufferings. Among the SDG target 3.8 (World Health Organization [WHO], 2018) indicators set towards monitoring countries progress, one was coverage of essential services that BWW shall still work for the fulfilment because it is obligatory for the Wereda population until now to make journeys for several kilometres of distance to have access of DBT Referral Hospital from around. On the other hand, WHO in its UHC report, premature deaths can be averted (WHO, 2019a, 2019b) upon improvements of strong health workforce and increased provision of health facilities which implies these peoples shall have access to hospitals through avoidance of financial obstacles to services. According to WHO directives, portion of population to which those resilient health facilities should be nearer to them are marginalized, stigmatized and geographically isolated people of all ages and genders without financial, time and distance problems.

Conclusions

Along with efforts and advancements made by the government and private sectors of health in the rural and urban areas of BWW and DBT, involvements of GPS and GIS technologies in integration greatly helps in spatial distribution of effective health institutions. In measurements as a checking mechanism of how accessible the health institutions to nearby population and the extent of the health coverage, these technologies are of great significance. GPS is of its crucial role for three-dimensional space time locations of the existing and forthcoming health infrastructures while GIS has huge capability to store, edit, analyse and display or map the spatial and non-spatial existing data and future locations of health institutions in the study area. Road network infrastructure-based service area network analysis and spatial location-based Thiessen polygon proximity analysis are best fit problem identification and decision-making techniques for the area of study. Apparent variation can be seen from the study that accessibility and coverage level of health institutions in rural population of BWW approximately 90% land area coverage is highly deteriorated when compared to those of the DBT population that occupies only 10% area coverage with essential service provision.

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Author contributions

Except for some analysis and text editing activities assisted by co-authors, Natnael Agegnehu and Andnet Nigussie, all research work, data collection and organisation, Road network building, core analysis and written works and manuscript preparation are accomplished by Mr Wondwossen Mindahun.

Disclosure statement

Conflict of interest: the researchers indicated in this research article document declares that there is no conflict of interest and they have not received research grants either in national or foreign currency from any company including the affiliated Ethiopian Space Science and Technology Institute and Debre Berhan University. The study does not also contain any violating narration against ethics of either human rights or research.

References

Bekele, A., & Lakew, Y. (2014). *Projecting Ethiopian demographics from 2012–2050 using the spectrum suite of models.* Health Policy Project. Addis Ababa.

Ejiagha, R. I., Ojiako, C. J., & Eze, G. C. (2012). Accessibility analysis of healthcare delivery system within Enugu urban area using geographic information system. *Journal of Geographic Information System*, *4*(4), 317–319. https://doi.org/10.4236/jgis.2012.44036

Koutelekos, J., Photis, N. Y., & Manetos, P. N. (2007). Geographic information analysis and health infrastructure. *Health Science Journal*, *1*(3), 55–67.

Ministry of Finance and Economic Development. (2014). *Growth and transformation plan: Annual progress report for F.Y. 2012/13.* Addis Ababa, Federal Democratic Republic of Ethiopia.

Mushonga, T. H., Banda, F., & Mulolwa, A. (2017). Development of a web based GIS for health facilities mapping, monitoring and reporting: A case study of the Zambian Ministry of health. *South African Journal of Geomatics*, *6*(3), 321–332. https://doi.org/10.4314/sajg.v6i3.4

National Planning Commission. (2018). *The second growth and transformation plan (GTP II): Midterm review report.* Addis Ababa, Federal Democratic Republic of Ethiopia.

PHE Ethiopia Consortium. (n.d.). *Meeting the GTP targets: The contribution of the population, health and environment integration approach.* USAID, Addis Ababa.

Wamai, R. G. (2004). Reviewing Ethiopia's Health System Development. *JMAJ*, *52*(4), 279–286.

World Health Organization. (2018). *World health statistics 2018: Monitoring health for SDGs.* Geneva.

World Health Organization. (2019a). *Primary health care on the road to universal health coverage 2019 monitoring report conference edition.* Geneva.

World Health Organization. (2019b). *World health statistics 2019: Monitoring health for SDGs.* Geneva.

World Health Report. (2008). *The challenges of a changing world; Primary health care – now more than ever.*