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OPTIMAL PATH GENERATION FOR HEALTH SERVICES: A CASE STUDY OF SOLAPUR MUNICIPAL CORPORATION BY USING GIS TECHNIQUES

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Introduction

Good health is no doubt a prerequisite for global livability of man, and it is a critical component of societal needs, hence a need for equitable distribution of health facilities as a factor for sustaining the population in cities. Accessibility to health facilities has a strong influence on people's earning capacity and it is fundamental to people's ability to enjoy and appreciate other aspects of life.

The basic intent of this research is to assess the role of GIS and Network analysis for defining hospital, Blood bank and Ambulance service area and optimal path. To that end, a GIS database was developed where hospitals, Blood Bank, Ambulance and transportation networks were organized within a spatial analytical system that integrated measures of supply, demand, and impedance in the calculation of a normative model of healthcare accessibility.

The research is cast within a healthcare planning context, but the goals of the research are to examine the spatial analytical potentials of GIS and Network analysis for characterizing service areas and generating Optimum path through mapping and simulation procedures respectively. The derived service areas and Optimum path implicitly assume that all patients can be treated at all hospitals and that patient travel

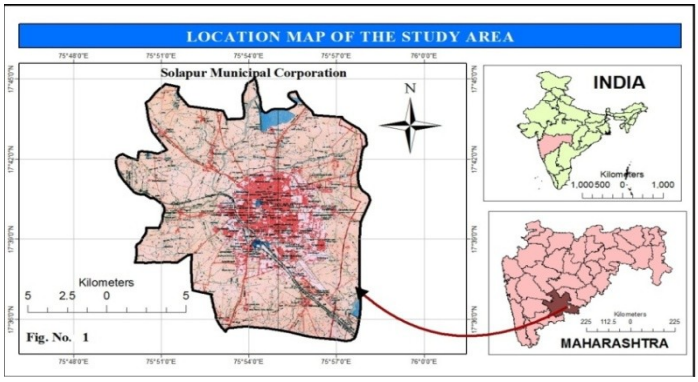
time is the primary decision factor in the selection or allocation of patients to hospitals for healthcare. We are keenly aware, however, that other factors in addition to travel time are involved in the selection of healthcare locations: such factors could also be modeled through the methodologies discussed here, but a demonstration of GIS and Network analysis for healthcare planning was the preeminent objective of the research, and therefore the use of a single patient selection factor was deemed sufficient. Also, this research was used to focus on service areas associated with a specific type of healthcare facilities provided within the study area.

Aims and Objectives

1. Identify the locations of Blood Bank, Hospitals, and Ambulance in study region.
2. To find out optimal path between Hospital to Blood bank.
3. To find out optimal path From Ambulance to Civil Hospital via Incident.

Study Area

Solapur is situated on the south-eastern border of Maharashtra State adjoining Karnataka state. The city is located on the East side of Maharashtra between 17^0 10" N Latitude and 76^0 15" E Longitude. It has an average elevation of 458 meters. It is well known for Textiles Productions such as Bed sheets, Blankets, Towels, etc. Solapur is situated on Deccan plateau. The Solapur Municipal Council established in the year 1852 was given the status of Corporation on 1st May 1964. It is governed under "Maharashtra Municipalities Act – 1965". The city specific characteristics which have greater implication on city development process has been identified and on that basis the entire city has been divided into six zones, with total 51electoral Prabhags



Data Collection

Spatial Data

Toposheet and Cadastral maps were available as a hard copy.

Table 1: Spatial Data

Sr.No.	Used Data	Spatial Reference	Data Source
01	Toposheet 47 O/14	1:50000	Survey Of India (SOI)
02	Cadastral Map	1:10000	Solapur MunicipalCorporation

Service Area

Geographical Coordinates for service area locations are collected from Ground survey by using "GPS Receiver".

Non-Spatial Data

Attribute data for different types of service area have been collected from Internet. Fields like Name, Address, Phone etc. for service areas like, Ambulance, Blood Bank, Fire Station, Hospitals, Police Station have been collected in *.html format.

Table 2: Non-Spatial Data

Sr.No.	Data Used	Data Source
01	Prabhag Name of City	Solapur Muncipal Corporation
02	Attribute Data : Service Areas	www.indiacom.com

Methodology

Boundary Feature Class Generation

The available Solapur city map was encompassed in single sheets, these sheets was then georegistered from SOI Toposheet with the same projection system of topographic map. Then we are digitized the geo referenced sheet and we get the Prabhag wise boundary layer of Solapur Municipal Corporation.

Road Feature Class Generation

The minor roads were not mentioned in the Solapur election prabhag wise city map, therefore Google Earth (**GE**) is used to generate the road network. Google Earth imports or exports the feature files only in *.kml (*Keyhole Markup Language*) format.

The major and minor road digitized from the Google Earth and these digitized roads are converted in to geodatabase file using Arc GIS 10 software for further process.

Point Feature Class Generation

GPS receiver is used for collection of points of service area location from ground survey. We are prepared a excel sheet of location of service area. In this way the location for all attribute data for different type of service area is collected for generating a point layer for all service areas

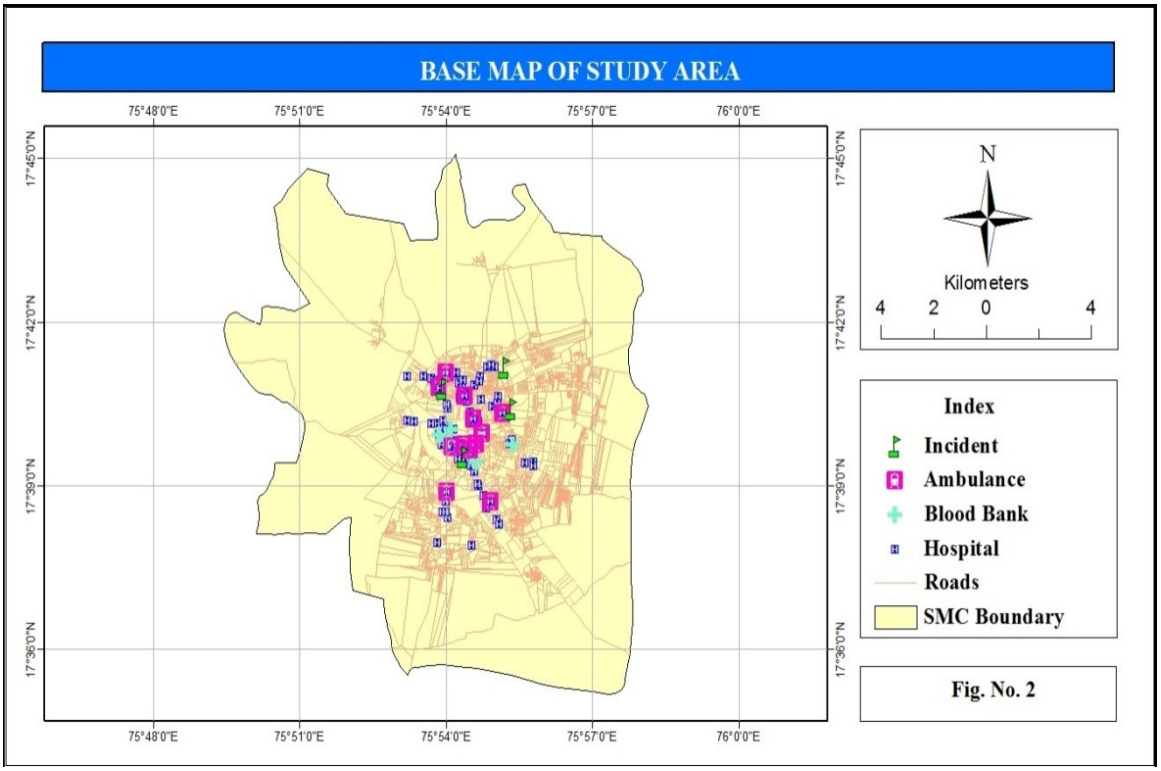
The Excel file created for different service areas with Lat/Long and different fields, have had displayed as a point layer in ArcGIS 9.3. Each point is attached with the attribute data as the excel file is created likewise.

Network Dataset Generation

The road feature class with Distance, Speed and Time field is available for Network Database Generation**.** From the ArcGIS 10 Catlog Network Dataset is created by adding meter and minute fields by setting it's values as Meter and Time fields respectively. The Solapur road network dataset is now build for further analysis purpose.

Data Analysis and Interpretation

For the locating Health facilities (Blood Bank, Ambulance Facility and Hospitals) GPS data used. Total 100 Hospitals, 12 Ambulance Facility and 6 Blood Bank, GPS data was collected on the field as a primary data. In the study area location of Hospitals scattered and the number of Hospitals in study area is also high. The number of Blood Bank and Ambulance are less as consideration of the area of city.



Optimal Path from Hospital to Blood Bank

The optimal path has been analyzed between Blood Bank and hospitals. The hospitals selection based on the services they provides and there locations, i.e. distributed well throughout the map.

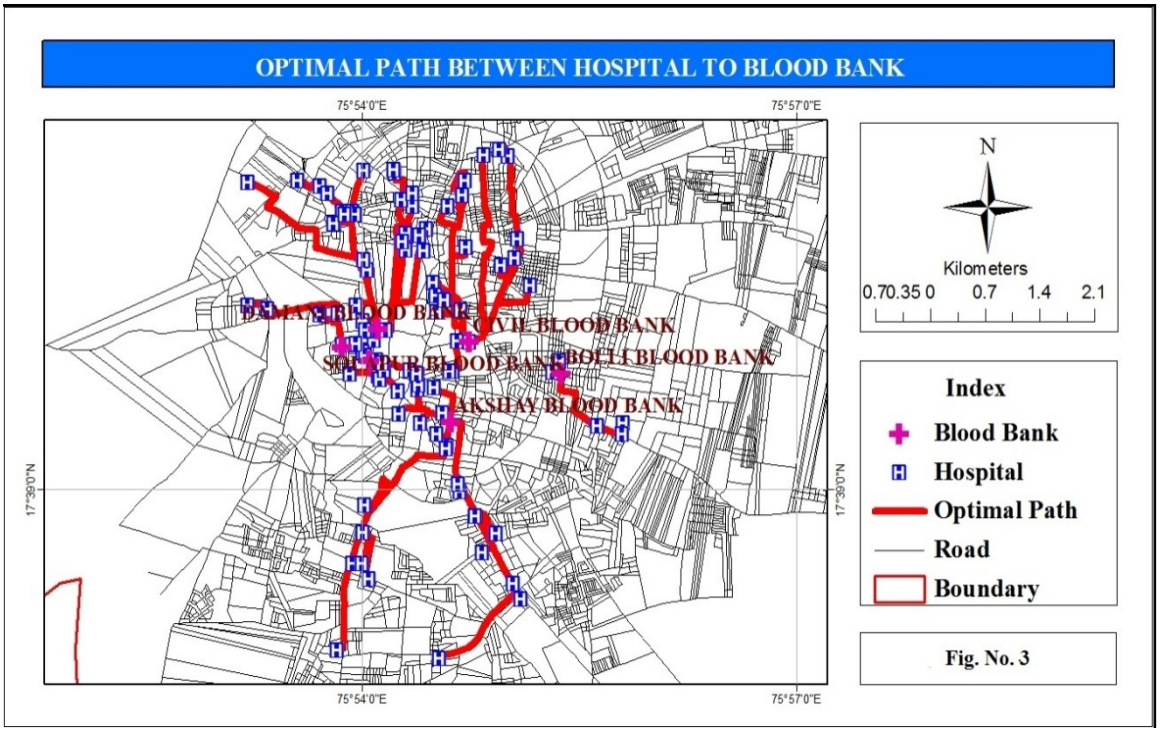


Table 3: Optimal path from Hospital to Blood Bank

Sr. No.	Hospital To Blood Bank	Time (Minute)	Distance (Meter)
1	Aadhar Hospital - Akshay Blood Bank	3.77	1885.47
2	Adarsh Eye Hospital - Hegdevar Blood Bank	1.13	567.17
3	Ahilyabai Holkar Hospital - Damani Blood Bank	0.19	95.91
4	Ajit Upase Hospital - Damani Blood Bank	3.52	1759.33
5	Alfaij Hospital - Civil Blood Bank	1.97	983.88
6	Ambika Hospital - Damani Blood Bank	3.11	1557.24
7	Amlae Klinik - Hegdevar Blood Bank	0.39	193.22
8	Anand Hospital - Civil Blood Bank	5.37	2682.93
9	Aparna Hospital - Damani Blood Bank	2.79	1394.74
10	Ashwini Hospital - Akshay Blood Bank	1.17	585.29
11	Ayyer Aorthopedik - Solapur Blood Bank	0.07	32.89
12	Bakale Clinik - Hegdevar Blood Bank	0.55	275.43
13	Baldawa Hospital - Damani Blood Bank	4.53	2263.84
14	Banshankari Devi Hospital - Damani Blood Bank	0.60	302.34
15	Basweswar Hospital - Civil Blood Bank	2.92	1461.31
16	Bhandari Hospital - Hegdevar Blood Bank	0.26	129.89
17	Bhavana Rushi Hospital - Bolli Blood Bank	0.35	175.09
18	Bhavani Hospital - Civil Blood Bank	5.03	2515.54
19	Birajdar Hospital - Damani Blood Bank	3.16	1579.10
20	Chaitanya Hospital - Akshay Blood Bank	5.29	2643.02
21	Chandak Munot Hospital - Civil Blood Bank	3.89	1942.81
22	Chatrapati Shivaji Maharaj Hospital - Civil Blood Bank	0.00	0.68
23	Chidgupkar Hospital - Damani Blood Bank	4.06	2030.59

24	Chitale Clinik - Akshay Blood Bank	1.42	709.80
25	Chitnis Narsing Home - Solapur Blood Bank	0.82	411.24
26	City Hospital - Hegdevar Blood Bank	0.71	355.70
27	Devini Hospital - Civil Blood Bank	1.86	927.82
28	Dhanrajgiri Charitible Trust Hospital - Damani Blood Bank	1.08	542.12
29	Dhandore Hospital - Akshay Blood Bank	6.91	3454.29
30	Dr. Katikar Hospital - Akshay Blood Bank	1.55	774.71
31	Dr.Gayakwad Kala Klinik - Bolli Blood Bank	0.42	208.02
32	E.S.I[Vima Davakhana]Hospital - Akshay Blood Bank	1.90	949.95
33	Gandinatha Hospital - Damani Blood Bank	3.67	1834.40
34	Gullapalli Narsing Home - Bolli Blood Bank	2.86	1432.03
35	Hogade Hospital - Civil Blood Bank	4.79	2395.61
36	I.B Tangsal Hospital - Akshay Blood Bank	4.47	2235.54
37	Indian Kancer Socity - Hegdevar Blood Bank	0.66	331.30
38	Jaine Ayurvedic Rugnalaya - Damani Blood Bank	3.28	1637.94
39	Jaine Hospital - Damani Blood Bank	3.03	1515.91
40	Joshi Clinik - Hegdevar Blood Bank	0.21	107.30
41	Joshi Hospital - Akshay Blood Bank	4.72	2360.76
42	Kadadi Hospital - Damani Blood Bank	3.89	1946.38
43	Karvekar Hospital - Akshay Blood Bank	4.88	2438.42
44	Karwa Narsing Home - Damani Blood Bank	3.19	1595.34
45	Kasliwal Hospital - Damani Blood Bank	4.58	2291.69
46	Kasturi Hospital - Civil Blood Bank	5.41	2703.27
47	Kelkar Narsing Home - Damani Blood Bank	2.39	1193.30
48	Khairnar Hospital - Damani Blood Bank	0.30	147.50
49	Kore Hospital - Civil Blood Bank	4.00	1999.14

50	Kothadiya Hospital - Civil Blood Bank	1.49	747.21
51	Kotnis Smarak Relway Hospital - Solapur Blood Bank	1.31	652.84
52	Krishnamai Narsing Hime - Damani Blood Bank	1.51	756.22
53	Kumthekar Hospital - Akshay Blood Bank	7.31	3654.07
54	Lotas Hospital - Solapur Blood Bank	2.94	1470.33
55	M.V.C.M Dental Hospital - Civil Blood Bank	2.87	1436.93
56	Madar Teresa Hospital - Damani Blood Bank	2.81	1403.85
57	Maher Hospital - Civil Blood Bank	2.36	1178.49
58	Mahila Hospital - Akshay Blood Bank	2.60	1300.84
59	Mangoli Hospital - Damani Blood Bank	2.59	1293.02
60	Markandeya Solapur Rugnalaya - Civil Blood Bank	2.34	1171.70
61	Mitanshu Hospital - Bolli Blood Bank	1.92	960.54
62	Nannajkar Hospital - Solapur Blood Bank	3.55	1774.01
63	Navneet Hospital - Akshay Blood Bank	1.54	767.77
64	Navnit Hospital - Civil Blood Bank	1.14	571.85
65	Nirikshana Memoriyal Hospital - Damani Blood Bank	4.64	2321.28
66	Onkar Klinik - Damani Blood Bank	0.30	149.74
67	Preezam Medikal Dainastik Hospital - Hegdevar Blood Bank	1.17	587.33
68	Raghoji Hospital - Civil Blood Bank	2.48	1240.27
69	Raghoji Kidni Hospital - Hegdevar Blood Bank	0.37	185.66
70	Raghvendra Hospital - Akshay Blood Bank	3.96	1980.36
71	Rama Clinik - Hegdevar Blood Bank	0.38	191.64
72	Ramkrishna Hospital - Hegdevar Blood Bank	0.38	191.64
73	S.L.Hospital - Akshay Blood Bank	3.74	1870.13
74	Sai Suman Hospital - Damani Blood Bank	5.81	2904.27

As shown in the table 3 and Fig 3, the network of 100 optimal path has been

75	Saifi Hospital - Civil Blood Bank	0.94	468.54
76	Sathe Narsing Home - Damani Blood Bank	1.77	885.14
77	Savaskar Hospital - Akshay Blood Bank	2.60	1300.84
78	Sharadha Narsing Home - Akshay Blood Bank	0.63	314.23
79	Shivsantoshi Hospital - Damani Blood Bank	3.93	1962.86
80	Shree Balaji Hospital - Bolli Blood Bank	2.59	1295.46
81	Shree Hospital - Civil Blood Bank	1.23	614.95
82	Shree Sidheshwar Kancer Hospital - Akshay Blood Bank	3.31	1653.95
83	Shree Sidhivinayak Clinik - Solapur Blood Bank	0.28	142.24
84	Sidheshwar Hospital - Damani Blood Bank	3.67	1835.27
85	Solapur Klinik - Damani Blood Bank	0.30	150.26
86	Span Hospital - Hegdevar Blood Bank	1.46	730.93
87	Sudatt Nersing Home - Akshay Blood Bank	0.69	346.77
88	Suman Speshality Hospital - Civil Blood Bank	0.29	143.40
89	Sunrise Hospital - Hegdevar Blood Bank	0.26	129.89
90	Sushrut Hospital - Solapur Blood Bank	0.37	184.63
91	Suyash Narsing Home - Akshay Blood Bank	1.73	863.06
92	Unique Hospital - Damani Blood Bank	2.95	1475.20
93	Utkarsh Hospital - Akshay Blood Bank	1.06	530.15
94	Vinayak Narsing Home - Akshay Blood Bank	0.43	214.28
95	Vinit Hospital - Damani Blood Bank	2.96	1480.98
96	Wadiya Hospital - Hegdevar Blood Bank	0.74	370.51
97	Walwekar Hospital - Akshay Blood Bank	0.67	336.89
98	Yajurvedi Hospital - Akshay Blood Bank	4.80	2399.26
99	Yashodhara Hospital - Civil Blood Bank	1.57	782.75
100	Zahmbre Nersing Home - Damani Blood Bank	3.10	1552.38

created for 6 Blood Bank and 100 Hospitals. The table shows the total travel time in minutes for the distance to be complete which is in meter.

Optimal Path for Ambulance to Hospital Via Incidence

Here Ambulance service is consider as a facility and from four major places is considered as an incident places i.e. Dayanand College Chowk, Akkalkot Naka, ST Stand and Sat Rasta.

Table 4: Optimal path for Ambulance to Hospital via Incidence

Sr. No.	Ambulance To Govt. Hospital Via Incident			Time (Minute)	Distance (Meter)
1	Markandeya Solapur Rugnalaya	Dayanand College Chowk	Civil Hospital	8.27	4136.31
2	Markandeya Solapur Rugnalaya	Akkalkot Naka	Civil Hospital	4.13	2065.83
3	Ambika Hospital	ST Stand	Civil Hospital	5.46	2728.58
4	Span Hospital	Sat Rasta	Civil Hospital	3.42	1712.29

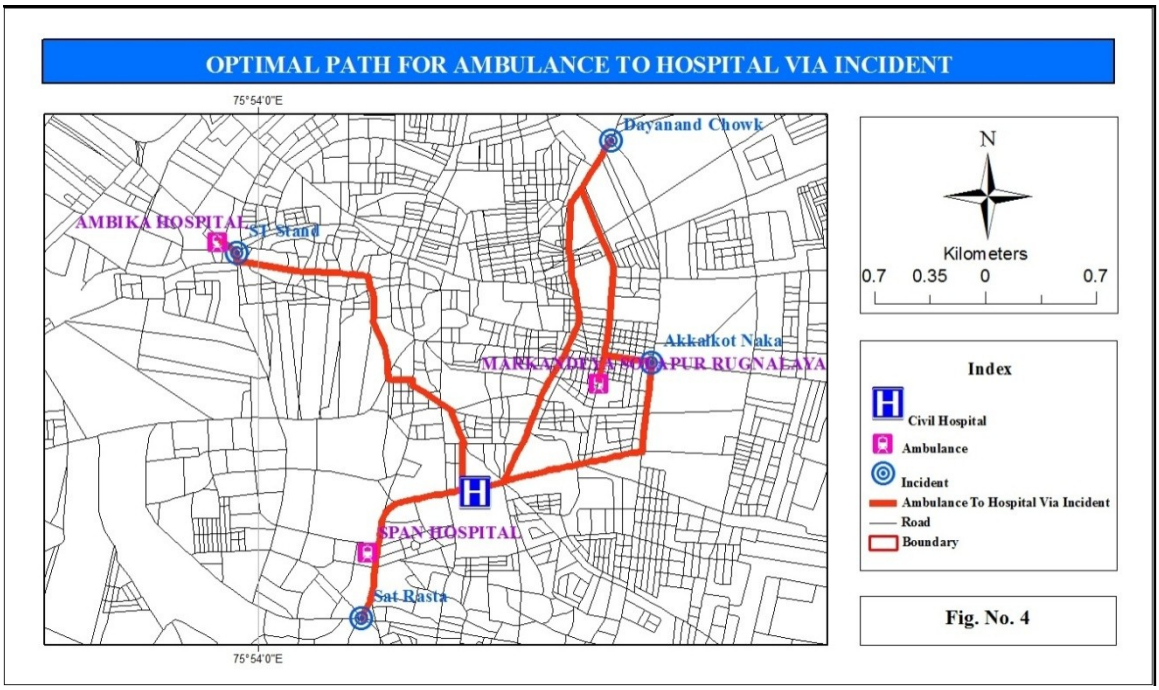
Dayanand College Chowk:

Ambulance service is consider as a facility and from Education feature "Dayanand College Chowk" is considered as an incident place, however by closest facility analysis it is derived that "Markandeya Solapur Rugnalaya" is closest among all 12 ambulance services. Therefore an optimal path is derived from "Markandeya Solapur Rugnalaya" to incidence and from incidence to government hospital "Civil" from hospital feature, to complete the medical facility for individuals suffering from incidence occurrence. As shown in table 4 Ambulance took 8.27 Minutes to complete the path of 4.14 Km at the given speed for providing medical facility.

Akkalkot Naka:

Ambulance service is consider as a facility and from Crowd Place "Akkalkot Naka" is considered as an incident place, however by closest facility analysis it is derived that "Markandeya Solapur Rugnalaya" is closest among all 12 ambulance services. Therefore an optimal path is derived from "Markandeya Solapur Rugnalaya" to

incidence and from incidence to government hospital "Civil" from hospital feature, to complete the medical facility for individuals suffering from incidence occurrence. As shown in table 4 Ambulance took 4.13 Minutes to complete the path of 2.06 Km at the given speed for providing medical facility.



ST Stand:

Ambulance service is consider as a facility and from Crowd Place "ST Stand" is considered as an incident place, however by closest facility analysis it is derived that "Ambika Hospital" is closest among all 12 ambulance services. Therefore an optimal path is derived from "Ambika Hospital" to incidence and from incidence to government hospital "Civil" from hospital feature, to complete the medical facility for individuals suffering from incidence occurrence. As shown in table 4 Ambulance took 5.46 Minutes to complete the path of 2.73 Km at the given speed for providing medical facility.

Sat Rasta:

Ambulance service is consider as a facility and from Crowd Place "Sat Rasta" is considered as an incident place, however by closest facility analysis it is derived that "Span Hospital" is closest among all 12 ambulance services. Therefore an optimal path

is derived from "Span Hospital" to incidence and from incidence to government hospital "Civil" from hospital feature, to complete the medical facility for individuals suffering from incidence occurrence. As shown in table 4 Ambulance took 3.42 Minutes to complete the path of 1.71 Km at the given speed for providing medical facility.

Summary and Conclusion

The GIS approach to assessing healthcare accessibility places hospitals, patient origin locations, transportation arteries, and intervening opportunities within a spatial context where trajectories in the healthcare system and community characteristics can be simulated. The spatial database and the automated analytical system afforded through the ARC/INFO software can incorporate actual planning of healthcare accessibility as well as alternative scenarios in which the redistribution of supply and demand are simulated through Network analysis. The GIS-Network system was demonstrated in this research to be an important tool for assessing the spatial linkages between healthcare users and providers and for examining possible healthcare planning scenarios where the interaction of population, facility characteristics, and transportation networks is spatially mediated. The GIS-Network approach may be even better suited to analyzing and allocating lower-level care services, such as primary care or rural health clinics where geographic distance is clearly a constraining factor in healthcare accessibility.

The study is covered Solapur Municipal Corporation, Maharashtra. The study is based on the health facilities in Solapur Municipal Corporation and location of available health facilities. In that study we are consider health services as a Blood Bank, Ambulance and Hospital. On that the optimal path were marked.

The service area of blood bank and ambulance facilities are covered less than 50% of the study area. Therefore above services are useful to only 70% population in study area. Because such services has identified in central part of the study area. Hence Municipal Corporation not provided above facilities beyond central part of the study area.

As per the result, in study area, the distance of every hospital is nearly 5 minutes from blood bank. But in extended area hospital facility are not available. Hence it is conclude

that, none of the health facilities are found in villages included in Solapur Municipal Corporation. It is strongly recommended that health facilities should be provide in extended area.

References

Aday, L. And Anderson, R. (1981). Equity of Access To Medical Care: A Conceptual And Empirical Overview. Medical Care, 19(Suppl.), 4-27

Albert D.P., Gesler W.M., Wittie P.S. (1995), Geographic Information Systems and Health: An Educational Resource. Journal of Geography, 1995, 94, 2. Pp. 350-356

Baru R. (1998), Private Healthcare In India. Social Characteristics and Trends, Delhi: Sage Publications.

Blackwell TH, Kaufman JS: Response time effectiveness: comparison of response time and survival in an urban emergency medical services system. Acad Emerg Med 2002, 9:288-295.

Cohen, M. A., and H. L. Lee. (1985). "The Determinants of Spatial Distribution of Hospital Utilization in a Region." Medical Care 23 (1): 27-38.

Cromley, E. K. And S. L. Mclafferty (2002), Gis and Public Health. New York, Guilford Press.

Curtis, S. E. (1989). "The Development of Geographical Information Systems for Locality Planning in Health Care." Area 21 (4): 391-99.

Dunn, E. D. 1992. "Optimal Routes in GIS and Emergency Planning Applications." Area 24 (3): 259-67.

Environmental Systems Research Institute. 1992. "Network Analysis: Modeling Network Systems." In ARC/INFO User's Guide. Redlands, CA: ESRI.

Gesler, W. M. 1986. "The Uses of Spatial Analysis in Medical Geography: A Review." Social Science and Medicine 23 (10): 963-73.

Gould, P. R., and T. R. Leinbach. 1966. "An Approach to the Geographic Assignmentof Hospital Services." Tydschrift voorEconomische en Sociale Geografie 57: 203-206.

Guagliardo M.F. (2004), Spatial Accessibility of Primary Care: Concepts Methods and Challenges. International Journal Of Health Geographic's 3(3): 13pages.

Hulsure C.L. and More R.N. (2009) : Utility Information System of Aurangabad Municipal Corporation by using GIS and Remote Sensing Technology.

Phibbs, C. S., and H. S. Luft. 1995. "Correlation of Travel Time on Roads Versus Straight Line Distance." Medical Care Research and Review, 52 (4): 532-42.

Richards Jr, Ferrall Sj: Inappropriate Use of Emergency Medical Services Transport: Comparison Of Provider And Patient Perspectives. Acad Emerg Med 1999, 6:14-20.

Walsh, S. J., P. H. Page, W M. Gesler, and T. W Crawford. 1995b. "Health Care Accessibility: Comparison of Network Analysis and Hospital Use Indices." Proceedings ofthe LIS/GIS '95 Conference, Nashville, TN 2: 994-1005.

Wofford JL, Moran WP, Heuser MD, Schwartz E, Velez R, Mittelmark MB: Emergency medical transport of the elderly: a population-based study. Am J Emerg Med 1995, 13:297-300

WEBSITES

www.glcf.com

www.indiacom.com

www.yellowpages.com

http://bbs.keyhole.com/ubb/ubbthreads.php/Cat/0

http://www.zonums.com/kml2shp.html

http://opensourcegis.org/