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Transport accessibility and efficiency of PHC location in Kanyakumari district, Tamil Nadu

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Abstract

Transportation is an essential feature of modern economics. In general terms, as an economy grows and develops, it becomes more dependent on its transport sector. The efficient location of any PHC center mainly depends on the network pattern. The study area, Kanniyakumari, is the southernmost district of Tamil Nadu. Kanyakumari District lies between 77°15' and 77°36' of eastern longitude and 8°03' and 8°35' of northern longitude. The study area has 83 nodes and 120 edges in the transport network system. The main objectives of the paper are to analyze the variation in the degree of connectivity, accessibility, and nodal efficiency of the network pattern and to assess the relationship between road network structure and the location of the PHC center. (Primary Health Care). The present study depends on secondary data. The secondary sources were collected from various transport offices and institutions. Cartography mapping and buffer analysis are used by GIS software. The quantitative research approaches in network analysis were measures to determine the spatial structure, associate number, route development, nodal efficiency, and accessibility of a given PHC location. The Shimbels shortest path matrix was used to identify the health centrality of a node in the network, and its minimum accessibility was found for each PHC center. The detour index was computed based on knowing the route for existing network systems. The present study aims to understand the characteristics of the road transport network in relation to the structural location of the PHC of connectivity, accessibility, and route efficiency in Kanniyakumari district.

Keywords: PHC; Accessibility; Shimbels; Detour; GIS; Buffer analysis

1. Introduction

The character of transportation as a whole in detail at any particular time and throughout its history is altogether determined by its interrelation with physical and social forces and conditions(1). To understand transportation means simply analyzing these interrelations. Transport is employed to overcome distance. It is one of the basic requirements for each region. The manner in which the places within an area are connected with each other reflects socio-economic well-being, particularly the health location of that area(2,3,4,5). The utilization of resources and the availability of various health facilities and services in an area largely depends on the degree of accessibility of the centers to the surrounding villages (6,7,8). The "node-linkage" association of the transportation network is an important aspect of the location of PHC in the understanding of the spatial organization of an area (9,10,11). An attempt is made in this paper to analyze the structure of accessibility of PHC location efficiency in Kanniyakumari district using matrix algebra, measures of graph theory, and also related accessibility.

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In this study, stress is given to the study of spatial distribution, which is the location of health care centers in the block, the health services that are being provided to the people by these centers, the distance traveled to acquire health facilities in this block, and the infrastructure related to service personnel. The transportation network is viewed as a graph. It becomes useful to develop certain summary indices that can be related to the PHC location structure of the network (12). It has been observed that the most fundamental characteristic of a graph is the relationship between the edges and the vertices (with one PHC). Such a health specification can be made through a simple diagram or, even more compactly, by means of a health matrix (13,14,15).Under normal circumstances, there is a variation in the distribution of various health care facilities and services. This variation in turn affects the utilization pattern of the public, and its location determines the respondent ’ reference (16). In order to understand the utilization pattern of health care facilities by the public, an understanding of the spatial distribution of health care institutions is important (17,18).The spatial distribution of Kanniyakumari Block presents primary health centers and sub centers. The increasing spatial and social imbalance between the distribution of services and consumers results in the fact that consumers in the suburban zones of large cities usually have to travel long distances to gain access to hospitals. (19,20,21).

The primary health centers with sub centers form the nucleus for a minimum scheme of health services for the rural community, primarily as a part of a community development program but with special emphasis on preventive measures and integrated health care. (22,23,24). The primary health centers function as the first anchor against disease and ill health in rural areas. The primary health center complex constitutes the core of the rural health services program in India. The primary health centers are the principle centers providing integrated health services to the rural population(25,26,27). They are the focal points of delivery of health and medical care services in rural areas. It is close to the people and offers adequate medical care services to meet the basic health needs of the rural people.

1.1. Study area

Kanniyakumari is the southernmost district of Tamilnadu. Kanniyakumari District lies between 77°15’ and 77°36’ of eastern longitude and 8°03’ and 8°35’ of northern longitude. (Fig. 1) The district is bounded by Tirunelveli District in the north. The southern-eastern boundary is the Gulf of Mannar. In the south and the south-southwest, the boundaries are the Indian Ocean and the Arabian Sea. In the west and north-west, it is bound by Kerala. The total geographical area of the district is 1684 km2, with a total population of 1,863,174 as per the last census. This four-block has 25 samples sample of primary health centers with sub centers. (Fig 2).

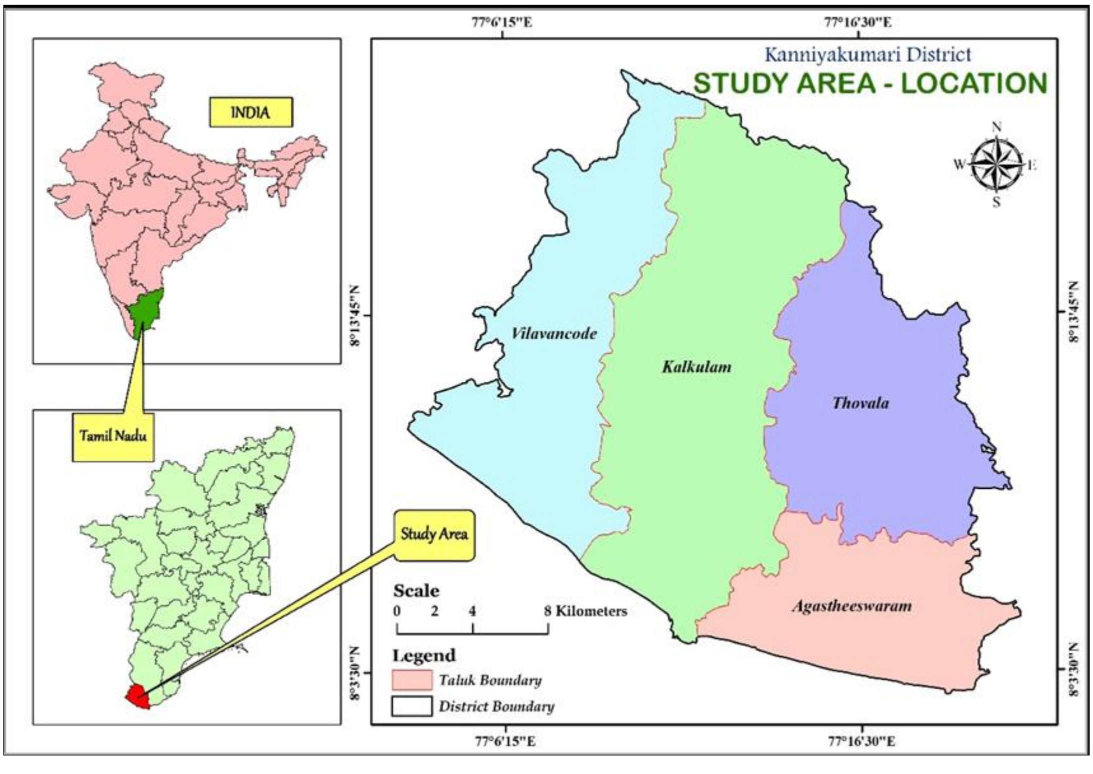

Figure 1 Location of Study area

Aims and Objectives

- The present study aims to understand the characteristics of PHC networks in relation to the structural pattern of connectivity, accessibility, and health care efficiency in Kanniyakumari district.
- To study the association between road transport structural characteristics and other resource bases, the following objectives are framed:.
- To analyze the variation in the degree of connectivity, accessibility, and nodal efficiency.
- To access the relationship between road network structure and selected primary health care (PHC) characteristics.

2. Methodology

The present study mostly depends on secondary data. The secondary sources were collected from various offices and institutions. Road map details were obtained from the survey and land records offices at Nagercoil in Kanniyakumari district. The data related to the location, historical background, and industrial potential of the district has been obtained from the assistant director of the statistics office in Kanniyakumari district. Apart from that, health data and demographic details have been collected from the PHC health center.

2.1. Techniques Applied

In this present study, both descriptive and quantitative analysis have been used for the purpose of road network structural analysis. The connectivity matrix was used to show the nodal hierarchy of the study area. Shimbel's shortest path matrix was used to identify the centrality of a node in the network, and its minimum accessibility was found for each nodal point. The detour index was computed based on knowing the route sinuosity of existing network systems.

Apart from the above-cited indices and matrices, simple statistical and cartographic techniques have been used. To analyze the relationship between road network characters and PHC characteristics, correlation has been used through SPSS software. The preparation of cartography work uses GIS software, like Arc GIS.

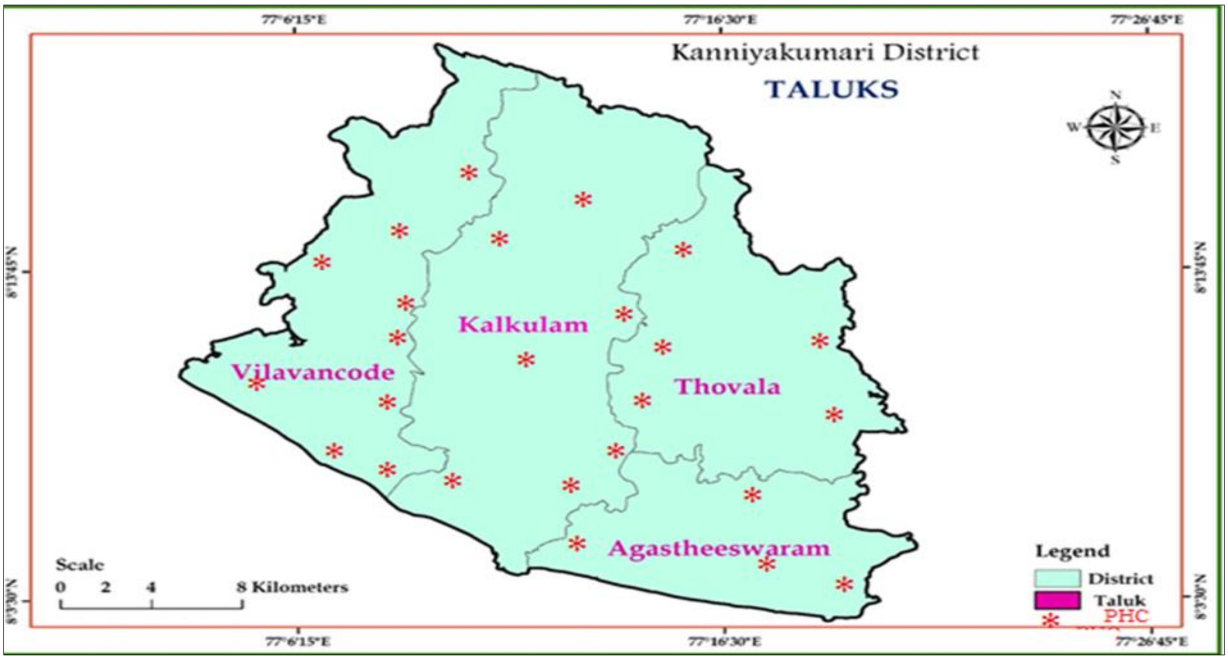

Figure 2 Taluk wise Spatial distribution of Sample PHC

3. Results and Discussion

3.1. The concept of flow

This refers simply to the movement of patients, commodities, messages, and flows, which form the most important aspect of the study of transportation(28,29,30). As a result of this work, geographers and allied researchers have postulated a relationship between the networks. The flow pattern indicates the intensity of traffic, which emphasizes the traffic efficiency of the network system. (Fig 3) The volume of traffic that flows between different nodes (PHC) denotes the internal flow.

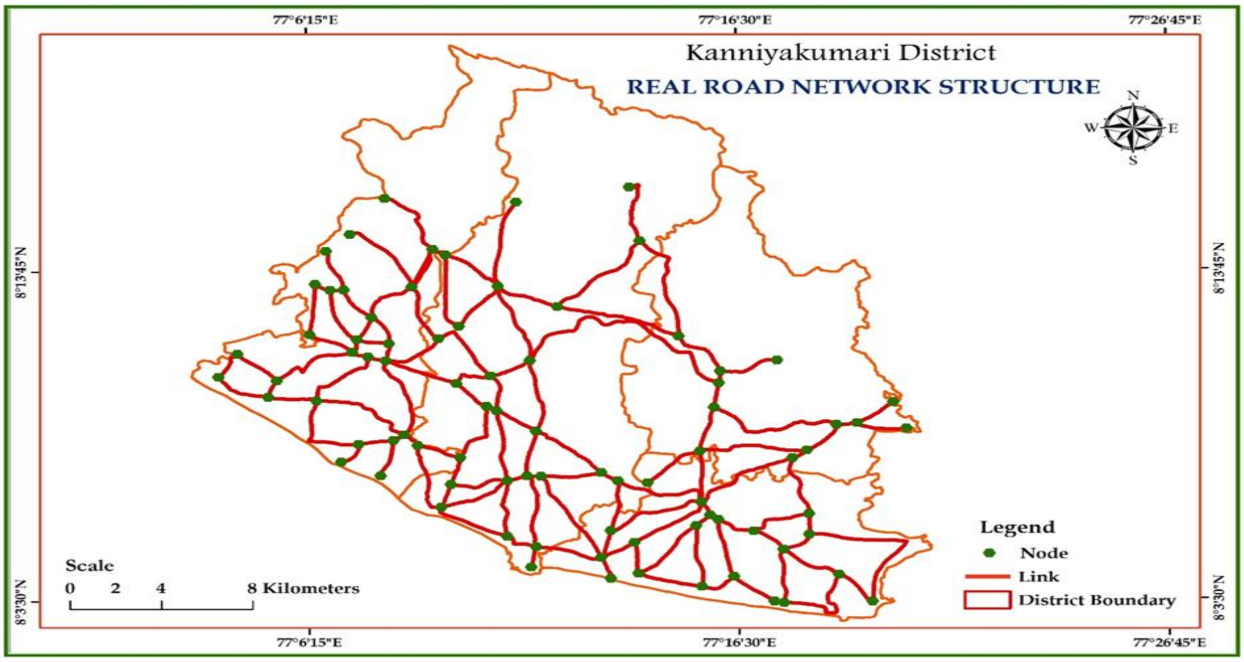

Figure 3 Road network Structure in Kanniyakumari district

3.2. Network as a Matrix

Any network or an obstruction of a network, such as a graph, may be represented as a matrix. By convention, the horizontal rows of the vertical columns of the matrix are defined as a set of destination nodes (31,32). The number of rows and columns in the matrix will each correspond to the total number of primary health care centers in the network. Each cell in an entry in the matrix may be used to record some information on the relationship between the pains of nodes. Depending on the information recorded in the cells, the matrices may represent network structure or network flows. It is possible to derive from this matrix the measure of centrality and accessibility.

3.3. Degree of Node (Nodal Accessibility)

The most primitive measurement of accessibility is obtained directly from the connectivity matrix. If a linkage exists between any given pair of PHC, a value for it is entered in the appropriate cell. If no direct linkage exists between pairs of primary health care centers, then a value of zero is recorded. This is known as the connectivity matrix, or binary matrix. A sum of the individual rows of the matrix produces a column or vector of values. Each row sum equals the total number of direct linkages from a given center to the set of all other centers in the network and is defined as the degree of node. The higher the value of an individual node, the greater its health accessibility to all other centers.

3.4. Associated Number

The associated number is the highest value in a row of the shortest path matrix. The associated number provides an understanding of the maximum number of PHC centers from a given vertex to each of the other vertices. The lower the associated number, the higher the degree of accessibility, and vice versa. It refers to the maximum number of PHC from a given set of vertices required to reach another vertex in the network.

The nodes with high accessibility and a high associate number, less than 550 are in Kadayal, Palappalam, Thricannamcode,Colachel,Athivila,Ammandivila,Manavalakurichi,Eraniel,Vallukuri,Parvathipuram,Thuckala,Azhakia mandapam,Mulakumoodu,Kattathurai,Mekode,andAttoor.The nodes with medium accessibility are seen in Kuzhithura,Nagercoil,andKulasekaram,with a value ranging from 550 to 650. Mangode, Azhanchola, ArumanaMelpuramMaruthancode, Pacode, Kuzhithurai, Pudukode, and Perunchani.

The nodes with low accessibility and an associate number of more than 700 are seen in Palukal, Kaliyikavila, Chuzhal Karingal,Kollencode,Chenbagarammaputhur,Vellamadamputhrri,Chenbagaraman,Puthur,Manakudithurai,Marungoor, Marthandapuram, Agastheeswaram, and Kanyakumarai.

3.5. Shimbel Index

This index from the sum of the values in a row of the shortest path matrix indicates the number of edges needed to connect any vertex with all the other vertices in the network by the shortest path, and it is considered to be the best measure of PHC accessibility.

3.6. Accessibility

This indicates the actual length required to reach all other vertices in the network from that vertex. A low value indicates higher health accessibility, and vice versa. (Fig4) One of the most important attributes of a transportation network relates to accessibility, and the geographer is particularly concerned with accessibility as a PHC location feature(33, 34,35). Previously, we focused on various techniques for measuring the degree of completeness of links between nodes in a network(36). Any node that is well- connected to other nodes in a network is said to be accessible. In more complex networks involving many nodes and, where possible. Alternative routes between nodes make it less easy to make conjectures with respect to accessibility, and one has to approach the problem in a more systematic way by compiling a matrix.

3.7. Accessibility can be measured topologically in three different ways

By the shortest-path matrix, the number of arcs used in the shortest path between all possible pairs of nodes.By the associated number, the number of arcs needed to connect a node to the most distant node from it .The Shimbel index is derived from the shortest path matrix, which indicates the number of arcs needed to connect any node with all the other nodes in the network by the shortest path.

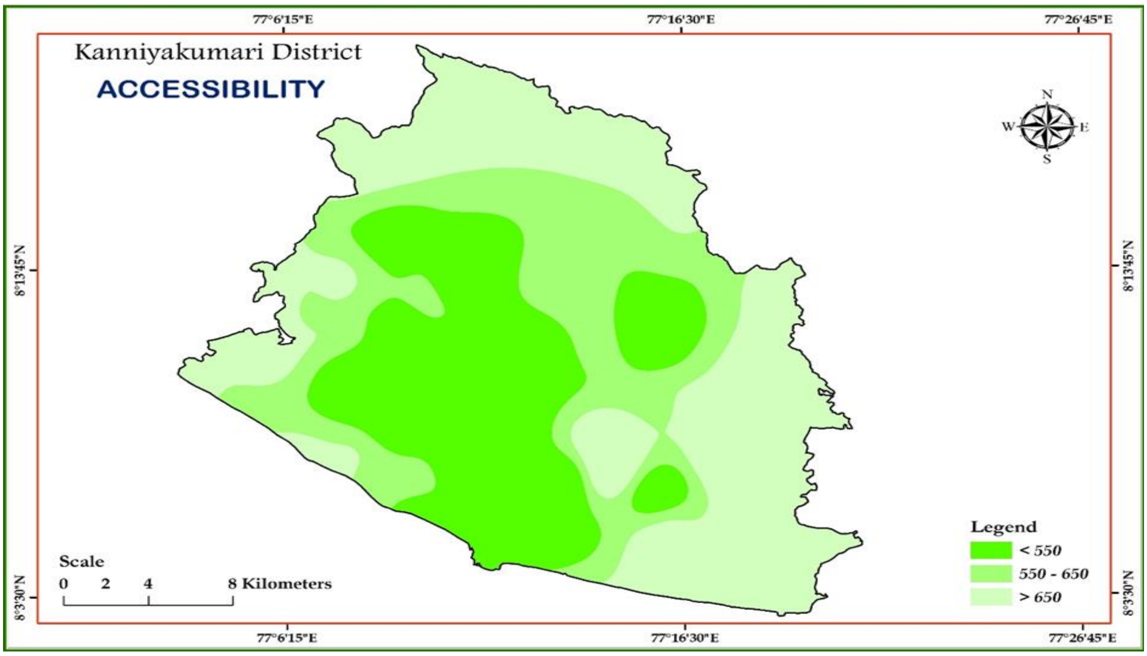

Figure 4 Accessibility of Health care Utilization in Kanniyakumari district..

3.8. Detour Index

The ideal path between two places is a straight line joining them, or, in other words, the direct distance. This path is seldom achieved, and the shortest path between two places is usually longer than the direct distance. The efficiency of a route in terms of directness is lower if the detour index is smaller. There are three types of detour indicators, which can be distinguished as follows:.

- The route detour index, which measures the directness of a single route between two places.
- The vertex detour index, which measures the directness of routes from all the vertices to all the other vertices.

3.9. The network detour index, which measures the directness of routes from all the vertices to all other vertices

The detour index measure indicates the efficiency of healthcare in the network system (37,38,39). A high-efficiency network system with a range of more than 110 is found in Azhanchola, Kadayal, Mangode, Devikulam, Paluka, Melpura, Kaliyikavila Maruthancode., Thottoor, Chuzhal, Karingal, Paloor, Thripparapu. Medium-efficiency network system with a range of 110 to 130 It is seen in Edaicode, Kaliyikavila, Mangode, Marthandam, Unnamalakanda, Vara,Kollencode,Keezhkula,Enayamthurai,Palappura,Trikannamcode,Neyyoor,Colachel, Athivila, and Manavalakurichi. A low-efficiency network pattern is found in Pacode, Nullivila, and Vallukuri, with a range of more than 130(Fig 5).

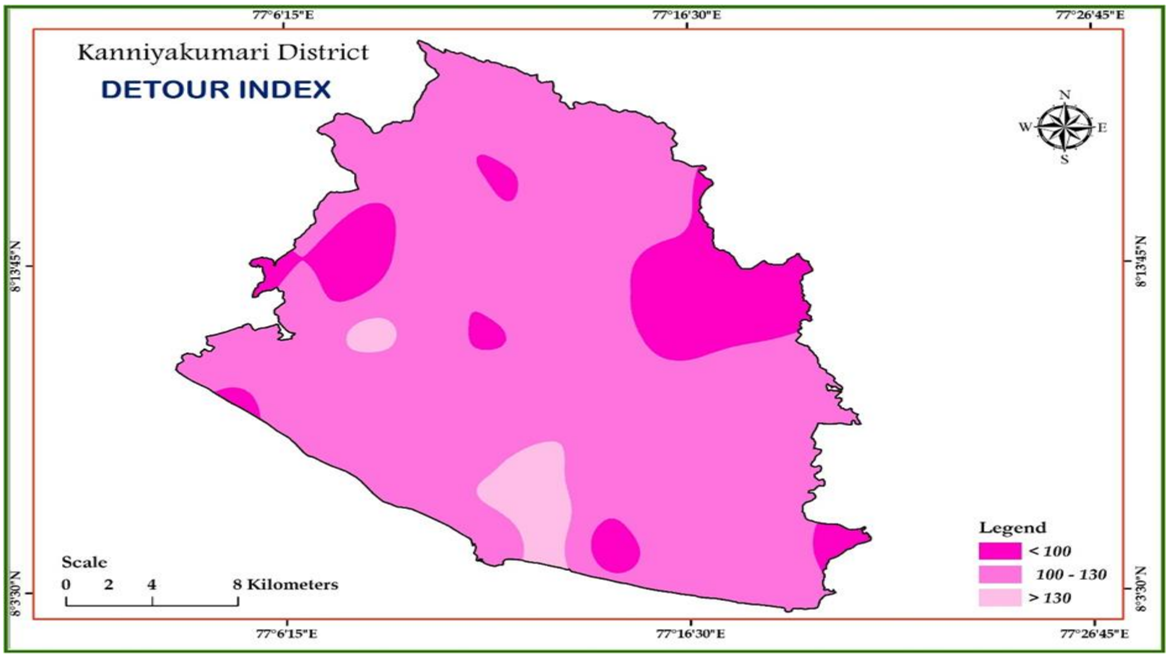

Figure 5 Access of Health care in the Detour Index value

3.10. Degree of Connectivity/Degree of a Node

The study area has 83 nodes and 120 edges in the transport network system. The degree of connectivity value (degree of anode) ranged from 1 to 6. The higher value (6) represents a very high degree of PHC connectivity. It denotes that Nagerkovil ranked first in the order of connectivity and was maximally connected with other parts of the PHC. Low degree of PHC connectivity is seen in Azhanchola, Mangode, Devikode, Enayamthurai,Melmidam,Pechipara,Balanore, Putheri, and Dharmapuram, with a value of less than 2 moderate degree for PHC connectivity seen in Main 2. Moderate degree of PHC connectivity is seenmainly mainly in Kadayal, Muzhukode, Kaliyikavila, Chuzhal, Maruthancode, Edaicode, Kollencode, Aruvikkara, Agastheeswaram, Arumana, Melpuram, and Kanyakumari, with a value between 2 and 4. A higher degree of connectivity is seen in Kuzhithura, Nagerkovil, and Kulasekaram,with a value ranging from more than 4.

3.11. Buffering

Buffer analysis is one of the cartography methods for efficient primary health care delivery systems in the population of each PHC.(40,41,42) Two buffer zones are created to represent the travel pattern of each PHC in the Kanniyakumari district. The first buffer zone represents an area up to 500 people in the PHC. This is a highly accessible area and shows maximum health utilization. The second buffer represents the area up to the average distance of 1000 people from the area of PHC(Fig 6). The second buffer zone is less accessible compared to the first zone of maximum utilization. The remaining buffer zone extends from the second buffer zone up to 1000 people; this is a zone of very low accessibility. The patients coming from this region are usually more male patients. Females who prefer very short-distance travel (>64-year) also travel very short distances to reach the PHC.

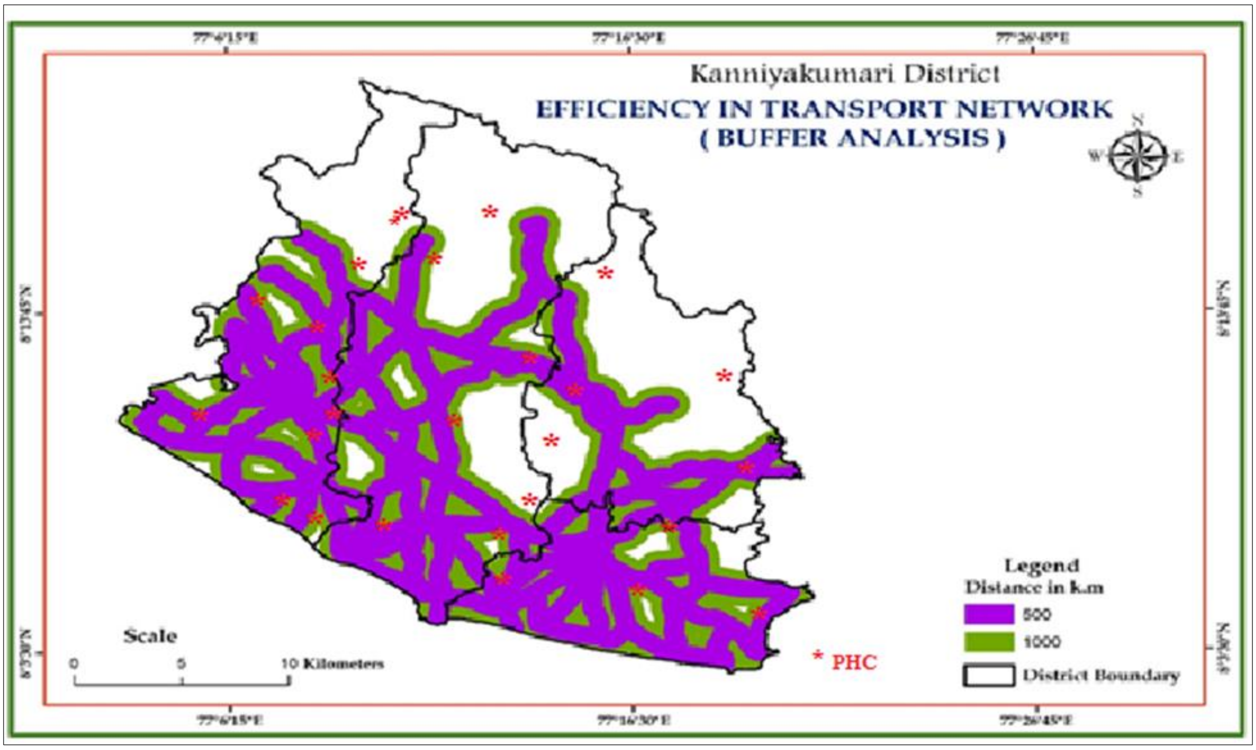

Figure 6 Efficiency of PHC accessibility

4. Conclusion

The transport network in Kanniyakumari district is mainly characterized by density or efficiency in a large way. There are certain regions that show a density pattern in an elaborative manner, particularly in the southern region of the district, where the efficiency of PHC service is seen in a certain way. The study area has been mainly classified by two types of density patterns: high and medium. A higher flow of density patterns is mainly seen in the southern region, particularly in the PHC in Nagercoil, Kulasekaram, and Kuzhithura, where we can see an overflow of networks.

A medium degree of PHC service is mainly seen in Kadayal, Muzhukode, and Kaliyakavila. Chuzhal, Maruthancode, Edaicode,Kollencode, Aruvikkara, Arumana, Melpuram, and Kanniyakumari, where the density pattern is not that high. The remaining PHC efficiency density pattern of the network is mainly seen in areas like Azhanhola, Mangode, Devicode, Enayamthuri, Melmidam, Pechipari, Balanore, Putheri, and Dharmapuri that have low access to PHC.

Compliance with ethical standards

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Disclosure of conflict of interest

Corresponding author states that there is no conflict of interest.

References

[1] Yıldırım, M., & Arslan, G. (2022). Exploring the associations between resilience, dispositional hope, preventive behaviours, subjective well-being, and psychological health among adults during early stage of COVID-19. Current psychology, 41(8), 5712-5722.

[2] Kumar, K. (2023, April). Location Analysis of Primary Health Care Centers: A Case Study of Mohalla Clinics in Delhi. In Operations Research Forum (Vol. 4, No. 2, p. 33). Cham: Springer International Publishing.

[3] Saravanabavan, V., Reshma, C. U., & Preethi, S. (2021). Determinants of reproductive health in working women in Thrissur district, Kerala. GeoJournal, 86, 239-253.

[4] Saravanabavan, V., Balaji, D., & Preethi, S. (2019). Identification of dengue risk zone: A geo-medical study on Madurai city. GeoJournal, 84(4), 1073-1087.

[5] Saravanabavan, V., Balaji, D., & Sudharsan, R. (2014). A Geo-Medical Analysis of Chikungunya and Patients Environmental Perception in Madurai City. Joural of JAC Journal of Science, Humanities, and Management, 1(2), 111-120.

[6] Vinothini, C., & Saravanabavan, V. (2022). Spatial Distribution of Emerging Diseases in Madurai District: A Geo Medical Study. International Journal of Innovative Science and Research Technology, 7(6), 2456-2165.

[7] Vinothini, C., Saravanabavan, V., & Balaji, D. (2021). Travel pattern of health utilization to primary health care centres in Madurai district. International Journal of Geography, Geology and Environment, 3(2), 144-151.

[8] Vinothini, C., Neethidevi, A., & Saravanabavan, V. (2019). Health impact and nine fold classification of land use change in Nilakottai Taluk, Dindigul District, Tamil Nadu. International Journal of Geography, Geology and Environment, 1(1), 80-86.

[9] Eswari, S., Saravanabavan, V., & Balaji, D. (2021). Structural Equation Modelling Approach to Determine the mother and Child Health Care in Madurai District, Tamil Nadu. International Journal of Scientific Research in Science and Technology, 8(2), 335-344.

[10] Eswari, S., Saravanabavan, V., & Balaji, D. (2020). Infant neonatal and post neonatal mortality in Madurai district, Tamil Nadu, India: A Geomedical Study. International Journal of Geography, Geology and Environment, 2(2), 102-112.

[11] Sudharsan, R., & Saravanabavan, V. (2019). Availability and Utilization of Primary Healthcare Centre in Thanjavur District, Tamilnadu. International Journal of Scientific Research in Science and Technology, 6(4), 288-297.

[12] Vinothini, C., & Saravanabavan, V. (2023). Determinants of health care facilities and patients' accessibility to PHC in Madurai district. International Journal of Geography, Geology, and Environment, 5(2), 17-22.

[13] RahamathNisha, R., & Saravanabavan, V. (2020). Occupational health: a special reference to lung disease in petrochemical, metal and building material industrial workers in Melur taluk Madurai district. *International journal of Contemporary medical Research*, *7*(7), G1-G6.

[14] Zhou, X., Yuan, L., Wu, C., Yu, Z., & Lei, W. (2023). Measuring spatiotemporal accessibility to healthcare with multimodal transport modes in the dynamic traffic environment. *Open Geosciences*, *15*(1), 20220461.

[15] Radhakrishnan, R., & Vaithialingam, S. (2023). Exploring the Suitability of Groundwater for Domestic Water Quality and Irrigation Purpose in Dindigul District, Tamil Nadu. InChaitanyaB.Pande, Manish Kumar, N. L. Kushwaha (ed) In Surface and Groundwater Resources Development and Management in Semi-arid Region: Strategies and Solutions for Sustainable Water Management (pp. 253-277). Cham: Springer International Publishing.

[16] Suja Rose, R. S., & Krishnan, N. (2009). Spatial analysis of groundwater potential using remote sensing and GIS in the Kanyakumari and Nambiyar basins, India. Journal of the Indian Society of Remote Sensing, 37, 681-692.

[17] Balaji, D., &,V Saravanabavan, V. (2021). Geo spatial variation of dengue risk zone in Madurai city using autocorrelation techniques. GeoJournal, 86(3), 1481-1501.https://doi.org/10.1186/1476-072X-8-5.

[18] Balaji, D., & Saravanabavan, V. (2020). A geo medical analysis of dengue cases in Madurai city-Tamilnadu India. GeoJournal, 85(4), 979-994.https://doi.org/10.1007/s10708-019-10006-4

[19] Saravanabavan, V. (2000). An analysis of pattern of leprosy and regional classification of Health Care service in Tamilnadu. Geography Review of India, 62(4), 379-386.

[20] Saravanabavan, V. (1997). Geo-Medical analysis of Multibacillary Leprosy in Tamil Nadu. The Deccan Geographer, 35(2), 179-189.

[21] Saravanabavan, V. (1997). Impact of Micro climate elements to built environment in selected urban centers of Tamilnadu. The Deccan Geographer, Vol 35 (1) , Pp 91-100. ISSN.NO 0011-7269.

[22] Saravanabavan, V. (1996). Bicycles and health-a geo medical study of Madurai city. In *Velo Australis and Velo-City'96, International Bicycle Conference, 1996, Fremantle, Western Australia*.

[23] Saravanabavan, V. (2011). GIS analysis of pedestrian problem and spatial risk areas for each buffer zone in uraban cities a case study of Madurai city in Tamlnadu, India.

[24] Saravanabavan, V. (2013). Patients perception and travel behavior pattern in primary health care center in Haripad block-A micro Geo-medical study. Journal of Language in India, 13(4), 194-207.

[25] Saravanabavan, V., Vinothini, C., & R.S Suja Rose (2023) Spatial distribution of primary health care centre and socio economic conditions of patients in Madurai district. International Journal of Geography, Geology and Environment 2023; 5(2): 192-198 DOI: https://doi.org/10.22271/27067483.2023.v5.i2b.192.

[26] Saravanabavan, V., Aneesh, P., Babu, H. M., & D Harieswari, M. (2021). Patient's perception and level of primary health care utilization in east block of Madurai North taluk: A geo-health study. International Journal of Geography, Geology and Environment, 3(1), 34-41.

[27] Saravanabavan, V., Keerthi, S. P., Anupama, A., & Vinothini, C. (2019). Psycho-social characteristics of mental disorder patients in Thiruvananthapuram District: A geo medical study. International Journal of Geography, Geology and Environment, 1(2), 08-16.

[28] Luo, W., Yao, J., Mitchell, R., Zhang, X., & Li, W. (2022). Locating emergency medical services to reduce urban-rural inequalities. *Socio-Economic Planning Sciences*, *84*, 101416.

[29] Rahamath Nisha, R., Saravanabavan, V., & Sureshkumar, R. (2020). Emerging COVID-19 epidemiology in Tamil Nadu India using GIS. International Journal of Contemporary Medical Research, 7(8), H10-H17.

[30] ReshmaCU, SK Sheheersha, Saravanabavan,V (2015)An Investigation on Reproductive Health Problem and Socio-Economic Predictors of Gynecological Morbidities Among Women in Thrissur District: Levels and Determinants.International Journal of Applied Management Research (IJAMR) 7 (1), 205-207

[31] Nandy, S., Adhikari, M., Balasubramanian, V., Menon, V. G., Li, X., & Zakarya, M. (2023). An intelligent heart disease prediction system based on swarm-artificial neural network. *Neural Computing and Applications*, *35*(20), 14723-14737..

[32] Sheheersha, S. K., & Saravanabavan, V. (2020). Geo-Medical Analysis of the Detection of Cervical Pre-Cancer Cases Using Telemedicine System in Kerala State, India. IOSR Journal of Dental and Medical Sciences, 10(11), 12.

[33] Saravanabavan, V., Emayavaramban, V., Thangamani, V., Manonmani, I. K., Rose, R. S., Balaji, D., ... & Vinothini, C. (2023). Spatial variation of covid-19 morbidity status and identification of risk zone in Tamil Nadu (India) during first wave. GeoJournal, 88(2), 1341-1354.

[34] Saravanabavan, V., Balaji, D., Reshma, C. U., Sheheersha, S. K., Sudharsan, R., Vimala Vinnarasi, J., ... & Balasubramani, K. (2021). Urban disease ecology and its spatial variation of Chikungunya in Madurai City, Tamilnadu, India: a geo-medical study. GeoJournal, 86, 2335-2350.

[35] Saravanabavan, V., Balaji, D., Rahamath, N. R., Preethi, S., & Vadivel, S. (2020). Geo-ecological association of dengue disease in Madurai city-using multivariate analysis.International Journal of Mosquito Research 2020; 7(2): 37-45

[36] Saravanabavan, V., Sudharsan, R., Balaji, D., & Rahamath Nisha, R. (2014). Patient's perception and epidemiological characteristics of dengue in Madurai city-using factor analysis. International Journal of Mosquito Research, 1(2), 18-24.

[37] Saravanabavan, V., Lekha, C. A., Aparna, T., Nisha, R. R., Balaji, D., Kannadasan, K., & Kanna, S. V. (2021). Spatio-temporal variation of dengue in Kozhikode district, Kerala: a medico geographical study. International Journal of Mosquito Research 8 (1), 130-140

[38] Saravanabavan, V., Vinothini, C., Balaji, D., Alok, M., Arya, M., & Athira, R. (2022). Geo-spatial approach on COVID-19 mortality in Tamil Nadu. International Journal of Geography, Geology and Environment, 4(1), 123-131.

[39] Vinothini, C., Saravanabavan, V., &Emayavaramban, V. (2022). Location Accessibility of PHC and Health care travel performance in Madurai District. International Journal of Innovative Science and Res3earch Technology. ISSN, (2456-2165), 7(12)

[40] Vinothini C and V. Saravanabavan, (2023)Patients Perception and Travel Behaviorpattern of Primary Health Care Centres in Madurai DistricBook Volum.In Edited by V. Emayavarambaned Advanced Techniques in

Geography".Jayalakshmi Publications, T.P.K Main Road, Vasantha Nagar, Madurai -3,2022 .ISBN: 978-93-91987-37-4, Page No 81-87

[41] Saravanabavan, V., Reejo, R. J., Neethidevi, A., & Jayashree, R. (2006). Travel and health care utilization pattern of patients in Vadippati panchayat union: A micro level study using GIS. Journal of Deccan Geographer, 44(2), 97-108.

[42] Nodari, C., Crispino, M., & Toraldo, E. (2022). From Traditional to Electrified Urban Road Networks: The Integration of Fuzzy Analytic Hierarchy Process and GIS as a Tool to Define a Feasibility Index—An Italian Case Study. *World Electric Vehicle Journal*, *13*(7), 116.