

Geographical Configuration and Accessibility of Tertiary Health Centres in Kasaragod

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ABSTRACT

The geographical configuration of the public and private health institutions is designed to ensure the quality healthcare services and available to all residents in their location, but it partially contributes to the overall wellbeing of the district's population. The possibility to get healthcare services, including those related to illness, disorders, diagnosis, treatment and management of diseases and other situations that affect health is known as healthcare access. The possibility of obtaining health care exists and a population may "have access" to services if services are offered and there is a sufficient supply of them. Perceivable, operable, intelligible, and robust are the four fundamental criteria that guide accessibility. Accessibility of health care medical facilities in Kasaragod district depends on numerous aspects including location, transportation infrastructure, and available resources. In the field of medical geography, population health is greatly impacted by the accessibility of healthcare facilities. Everyone will be able to get equitable access to high-quality healthcare regardless of where they live if geographic obstacles are removed. The Endosulfan pesticide tragedy has affected Kerala's Kasaragod area, with some victims in the district. Individuals who obtain care from subpar medical facilities soon find that they have to go farther to receive it. The accessibility of health care facilities based on cost, travel time, and distance is a crucial factor that affects the general health and well-being of the community in this district, which is located in northern Kerala and has a population of over 1.4 million. The distance, cost, and time to healthcare facilities can all be determined using the Anova test technique. GIS tools such as Kernel Density, Nearest neighbourhood analysis are utilized to measure the spatial distribution of healthcare and population. The area with the fewest public healthcare services is the hilly Vellarikundu Taluk,

which is located southeast of the Kasaragod district. Food quality, cleanliness, standard of living, cultural norms, and knowledge about illnesses, especially in the area of awareness campaigns, are all variables that affect the health of the population. In an emergency, it could be extremely challenging for residents of rural areas to get to medical facilities. Accessing healthcare facilities in rural and isolated places can provide a substantial problem, particularly for vulnerable groups including the elderly, pregnant women, and people with disabilities. Inadequate transportation infrastructure can lead to delays in reaching these centres, which can further affect the quality of service received. It is imperative that the government and local authorities allocate resources towards enhancing the accessibility of healthcare facilities in order to guarantee that all Kasaragod district inhabitants have prompt and efficient access to medical care.

Keywords: GIS, Accessibility, Infrastructure, Inhabitants, Kernal Density Estimation.

I. INTRODUCTION

Kasaragod district, which is the northernmost part of Kerala state in India, has health institutions for public but at the same time, still living many victims of Endosulfan manmade disaster in this area. They are a vital part of the health infrastructure in the region as they handle larger components of the local population needing medical facilities. The district's public health institutions include primary health centres (PHCs), Community health centres (CHCs), Family healthcare centres, taluk hospitals, and district hospital. These facilities are deliberately located throughout the district to ensure easy attainable for the residents. Primary Health Centres (PHCs): PHCs are the backbone of India's rural health system. In order to covenant accessibility for the rural masses, they are typically positioned at key intersections. PHCs in the Kasaragod district are dispersed throughout the district to offer primary healthcare services, such as immunizations, outpatient care, and maternity and child health. The primary health centres, for instance,

are situated in rural areas, while the district hospital is located in the urban region, providing tertiary care services to the entire population. A number of private hospitals boasts in the district include speciality hospitals and specialised clinics, these facilities are concentrated mainly in urban area and cater to the needs of local residents in this entire district. Community Health Centres (CHCs): CHCs offer a better calibre of healthcare services, such as specialist consultations, diagnostic testing, and inpatient care, and they act as PHCs' referral centres. Usually, they are found in the district's most accessible or central areas. Tertiary Hospitals: The Kasaragod district has the hospitals, including taluk hospitals, general and district hospitals. These facilities, which serve patients with more complicated medical requirements, are typically found in the districts. Transportation Infrastructure: The district's transportation infrastructure has an impact on how easily accessible healthcare facilities are. The accessibility of healthcare services to rural communities can be increased with the use of good road networks and public transit options. Distribution

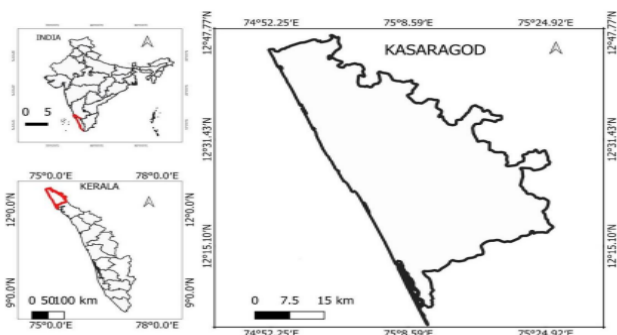
of the Population: There is frequently a correlation between population density and the location of healthcare services. There are typically more healthcare facilities to meet the requirements of the locals in areas with higher population concentrations. By building new facilities, renovating old ones, and launching outreach initiatives to reach outlying communities, the government and non-governmental organisations hope to increase healthcare access. The gaps in healthcare accessibility are being filled in the future by using telemedicine and mobile health units, particularly in the Kasaragod district's underprivileged or isolated areas. Accessibility of health care centres based on distance and time in Kasaragod district is a vital factor that affects the overall health and well-being of the community. The district has a population of over 1.4 million people, and it is essential to have accessible health care facilities to meet the growing healthcare needs of the population. However, the district's geographical location, with its hilly terrain in the eastern portion and scattered population, poses a challenge in terms of accessibility. The distance to health care centres can be a significant barrier for people living in remote areas, especially during emergencies. The lack of proper transportation infrastructure can also lead to delays in reaching these centres, further impacting the quality of care received. It will necessary for the government and local authorities to invest in improving the accessibility of health care centres in Kasaragod district, ensuring that all residents have access to timely and quality healthcare services. The district has a mix of urban and rural areas, with some areas being more remote and difficult to access. In these remote areas, the distance to the nearest health care centre can be quite far, making it challenging for residents to receive timely medical care. Furthermore, the lack of proper transportation infrastructure in these areas adds to the difficulty of accessing health care centres. However, in more urbanised areas, there are multiple health care centres within a reasonable distance, making them

easily accessible. Additionally, in future, with the increasing use of technology, virtual consultations and telemedicine may make it possible for residents to access medical care without having to travel long distances. Overall, while the accessibility of health care centres in Kasaragod district may be limited in some areas, efforts are being made to bridge the gap and ensure that all residents have access to quality healthcare services.

II. STUDY AREA

Kasaragod district, located in the northernmost part of Kerala, is known for its mesmerizing natural beauty and rich cultural heritage. The coordinates of Kasaragod District are latitude 12.49246 N and longitude 74.99062 E. The district is home to some of the most important tourist places in Kerala including the picturesque Bekal Fort, which is considered to be the largest fort in the state. The fort offers stunning views of the Arabian Sea and is a popular spot for picnics and evening walks. Another must-visit attraction in Kasaragod is the Valiyaparamba backwaters, where tourists can enjoy a peaceful boat ride and witness the local village life. The district is also known for its beautiful beaches like Kappil, Kanwatheertha, and Nileshevar. For those interested in spirituality, the Ananthapura Lake Temple, which is believed to be the original seat of Lord Vishnu, is a must-visit. Other notable places in Kasaragod include the Madhur Temple, Malik Deenar Mosque, and Ranipuram Hill Station. With its diverse range of attractions, Kasaragod district offers a unique blend of nature, culture, and spirituality. Bekal Fort and Beach, a well-known tourist destination worldwide, is one of the district's well-known attractions. Certain locations can be transformed to draw in tourists as well. The name Kasaragod means "Land of Gods," and it encompasses magnificent hills, long sandy beaches, rivers, and forts.

Location Map of the Study Area:



Ranipuram:

In Kerala's northernmost point sits the popular tourist site of Ranipuram. Perched 750 meters above sea level, it is situated in Kasaragod. The Madathumala, it shares borders with Karnataka and is home to some of the region's greatest trekking routes. The adaptable vegetation, which consists of meadows, monsoon forests, and evergreen shola woods.

Cultural Scenario:

1. The tragic Endosulfan incident in Kerala, India, is a heartbreaking story of human suffering and environmental destruction.

An insecticide called endosulfan was created in 1954. In farming, it became widely used in the 1980s and 1990s. It was eventually found to be extremely harmful to the environment and human health, despite the fact that it was once thought to be successful. Endosulfan poisoned huge populations of beneficial insects and sickened both people and animals severely.

Kasaragod District: Endosulfan was used as a pesticide on cashew plantations in Kasargod district, Kerala, for more than 20 years. This insecticide was also used by hand pumps or aerial spraying. Regrettably, the long-range atmospheric transport of endosulfan caused major health problems for the local population. **Impact on Health:** As early as 1976, residents of Padre Village, Kasargod, reported aerial spraying of endosulfan. Many species disappeared, including frogs, fish, bees, fireflies, and jackals. Calves were born with malformed limbs. Due to exposure, a large number of children and young adults in the area experienced serious disorders.

Relief Efforts and the Ban: Although the Kerala government outlawed endosulfan in 2005, its usage was nevertheless permitted in nearby states. 2011 saw the worldwide prohibition of endosulfan production and usage under the Stockholm Convention on Persistent Organic Pollutants. Additionally, the Indian Supreme Court outlawed the product's distribution, usage, and manufacturing. In order to support the victims, a relief and remediation program was started.

2. Women Beedi workers in Kasaragod district:

Many of the beedi workers in Kasaragod district work for private enterprises from Dakshina Kannada district in Karnataka since they may work from home and get a living wage. The well-known cooperative company Kerala Dinesh Beedi, based in Kannur, has production facilities spread over the districts of Kasaragod, Kannur, and Kozhikode. The labourers at a Dinesh Beedi plant work six days a week from 9 am to 5 pm in a hall that is supplied for them. Beedi women employees experience severe allergies as well as problems with their stomachs, eyes, and throats. There are more than 20 health problems among beedi rollers, such as weakness, palpitations, irregular menstruation, and dyspnoea. Then-Labour Minister TP Ramakrishnan gave beedi workers Rs 20 crore in 2018 to launch their own businesses, including shops, stitching shops, chicken farms, and cell phone recharging centres. However, the labourers did not receive any benefits from the schemes; they were merely on paper.

There have been no adequate investigations on the health of these workers carried out by the Kerala government. They ought to receive training for another occupation or support in pursuing it.

3. Koraga Tribes in Kasaragod district

Different aspects and times of life the Koragas are a tribal community distributed over the Udupi district and Dakshina Kannada of Karnataka South India and Kasaragod District in Kerala. They have been derided as untouchable in history. Their main activity is weaving bamboo articles. They make baskets as their

main job. People use either their own language, which is called Koraga's Language or Tulu. Mainly living in Perdala of Badiadka panchayat, Kasargod district, they have some groups, too, in Enmakaje, Paivalike, Bellur, Puthige Kumbale and other Panchayats. The majority of Koraga people are alcoholics. They have long been skilled with bamboo and creepers, using the grass to craft baskets and other items. Their primary source of income is basketry. However, they don't acquire enough raw materials for it because the trees are disappearing. Even when their customary means of subsistence are insufficient to support them, it is hard for them to find employment outside of their community because of the practice of untouchability. They were guaranteed a colony of forty-five houses with an electricity connection over time by government programs like the Pradhan Mantri Avas Yojna. The central Tribal Affairs Ministry has classified the Koraga group as a PVTG, meaning that they are eligible for several government benefits such as welfare schemes. However, these benefits are either not provided because of poor planning or are not received because of corruption. The government has disbursed a staggering amount of money for the benefit of the tribes, but because they lack literacy and are subject to local authority's corruption, very little of it actually reaches them. Because their poverty, the Koraga typically have poor diets. They worship sun gods, several devas, and mainly the spirits called Bhutas.

4. Theyyam:

The 1500-year-old ritual dance tradition called Theyyam, also called Theyyattam, is mostly practised in northern Kerala Kasaragod district. As is customary during the Kaliyattam ceremony, theyyam workers jump into the fire. Every year, during Kaliyattam celebrations, participants' bodies and legs are burned in the fire as a sign of faith for the welfare of society. In the field of medical geography, accessibility of health care centres is an important factor that influences the health and well-being of a population. Accessibility can be measured in terms of distance and

time, as these factors play a significant role in determining the ease with which individuals can reach medical facilities. Distance is a critical aspect of accessibility, as it determines the physical proximity of a health care centre to a population. Longer distances can create barriers to access, particularly for vulnerable populations such as the elderly, disabled, or those living in remote areas. In such cases, the lack of proximity to health care facilities can lead to delays in receiving necessary medical attention, which may exacerbate existing health conditions or result in preventable complications.

Time is another essential factor in measuring accessibility, as it reflects the time it takes for an individual to travel from their location to a health care centre. Factors such as traffic congestion, public transportation availability, and road conditions can significantly impact travel time, making it more challenging for people to access medical facilities. Longer travel times can also lead to increased stress and anxiety, which can negatively impact a patient's overall health.

To address the issue of accessibility, medical geographers and policymakers must consider various strategies to improve the proximity and travel time to health care centres. These strategies may include the establishment of satellite clinics in remote areas, the expansion of public transportation networks, and the implementation of telemedicine services to provide remote consultations and diagnoses.

In accessibility of health care centres is a vital aspect of medical geography that impacts the health and well-being of a population. By considering factors such as distance and time, medical geographers and policymakers can develop targeted interventions to improve accessibility and ensure that individuals can receive timely and appropriate medical care. This will ultimately contribute to a healthier and more equitable society.

III.OBJECTIVES

1. To analyze the spatial distribution of Private and Public modern healthcare Centre's
2. To analyze using the Anova statistical method, the accessibility of the medical facility in the Kasaragod district is being measured with consideration for travel time, cost, and distance to medical Centre's.
3. To find GIS analysis of the public healthcare accessibility hotspot using kernel density estimation and nearest neighbour techniques.
4. Methodology
 - GIS software is used to construct the maps for the spatial distribution of healthcare centre's based on coordinates.
 - The Nearest Neighbourhood analysis and shortest distance methods are used to quantify healthcare accessibility.
 - In order to determine the location of the healthcare centre and the surrounding radius for accessibility by taluk, Kernel density estimation was measured. These kinds of GIS tools are used to determine how accessible government hospitals are in Kasaragod districts.
 - The cost, travel time, and distance between randomly chosen village patients and tertiary hospitals are determined in statistics using the Anova test.

IV.REVIEW OF LITERATURE

- a. Raju, Shanmathi & Wajid, Shayesta & Radhakrishnan, Nisha & Mathew, Samson. (2017). Accessibility Analysis of Health care facilities using Geospatial Techniques. Transportation Research Procedia. 27. 1163-1170. 10.1016/j.trpro.2017.12.078.

According to SPAI, this study shows the spatial disparity in access to medical facilities in the southern

Thiruverumbur block. PHC is primarily situated in the block's northern region. This study investigated how spatial access is mostly influenced by the proximity to the closest PHCs. By placing additional healthcare facilities in the discrepancy region, equal access is made possible. The multi-criteria decision analysis selected a good location for the new healthcare facility based on SPAI, land use, and accessibility to a road.

- b. The Relationship between Health Care Needs and Accessibility to Health Care Services in Botosani County- Romania. 2016

The geographical distribution of health resources reveals that, in comparison to the urban region, the rural Botosani area is poorly served by health services, which limits the access of the rural population to healthcare. According to the health needs index, people in rural areas are more reliant on health care than people in metropolitan areas. The population's poor health results are a result of the insufficient accessibility of health care services to high deprivation and places with urgent medical requirements. The population of Botosani County is seriously affected by the disparities in access to healthcare that have been highlighted.

V. RESULTS AND DISCUSSIONS

The Four Taluks' Physiographic Structure in Kasaragod

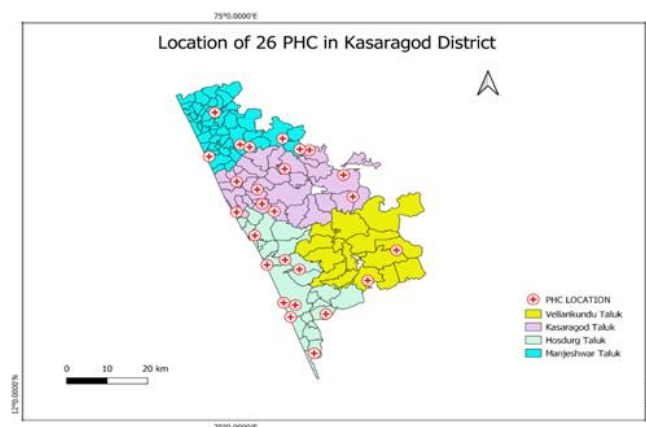
District: Kasaragod district, characterised by its diverse and unique physiographic structure. The district is divided into four taluks: Kasaragod, Hosdurg, Vellarikundu, and Manjeshwaram. Each of these taluks has its own distinct geographical features that contribute to the overall landscape of the region. Kasaragod taluk, the largest of the four, is situated along the Arabian Sea coast and is characterised by its sandy beaches, rocky cliffs, and lush green paddy fields. The taluk is also home to the Chandragiri and Valiyaparamba rivers, which flow through the region, providing fertile land for agriculture. Hosdurg taluk, located to the south of Kasaragod, is known for its

picturesque beaches, such as Bekal and Kappil, and the famous Bekal Fort. The region is also characterised by its dense forests, which are home to a variety of flora and fauna. Vellarikundu taluk, situated in the eastern part of the district, is characterised by its hilly terrain and dense forests. The taluk is home to the majestic Kottancheri Hills and the Kottancheri-Kakkayam forest reserve, which is a popular destination for trekking and wildlife enthusiasts. Manjeshwar taluk, the smallest of the four, is located in the northernmost part of the district and is characterised by its coastal plains and mangrove forests. The region is also home to the historic Ananthapura Lake Temple, which is believed to be the original seat of the Padmanabhaswamy Temple in Thiruvananthapuram. The four taluks of Kasaragod district have a diverse range of physiographic features. This unique landscape contributes to the region's rich biodiversity and cultural heritage, making it a fascinating destination for tourists and researchers alike.

6.1. MAJOR GOVERNMENT HOSPITALS AND ITS LOCATION IN KASARAGOD

6.1.1. Primary healthcare centres in Kasaragod

The distribution of the 26 PHC's x and y coordinates might be displayed on a map using GIS software. It is obvious that the taluks of Manjeshwaram and Vellarikundu have less PHCs installed.

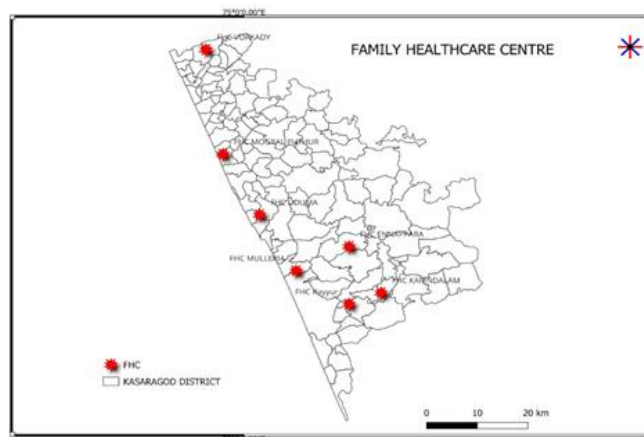


This map shows that there are 9 PHC's in Kasaragod taluk and 9 PHC's in Hosdurg taluk and 6 PHC's in Manjeshwaram taluk and two PHC's in Vellarikundu

taluk. In the Vellarikundu taluk, there are less primary healthcare facilities.

6.1.2. Family Health Care Centre's in Kasaragod district

There are 7 Family Health Care centres in Kasaragod district. By Ardham mission 2017, some PHC's converted into FHC to provide comprehensive care to the patients.

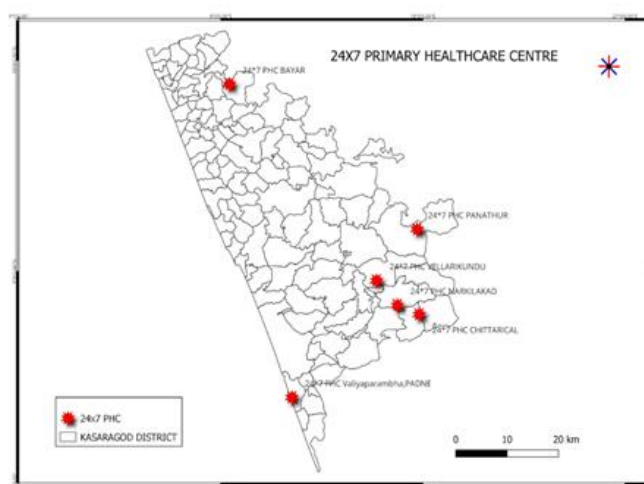


(source: created by author)

6.1.3. 24*7 PHC'S IN KASARAGOD DISTRICT

There are seven 24x7 PHC in Kasaragod district. Out of seven one in Manjeshwaram taluk, one in Hosdurg taluk and five in Vellarikundu taluk.

24*7 PHC in Kasaragod District

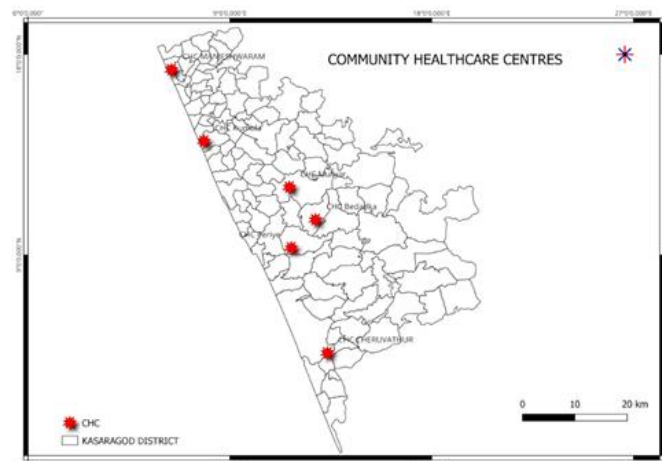


(source: The creation of author using GIS software)

6.1.4. Community Healthcare Centre's in Kasaragod

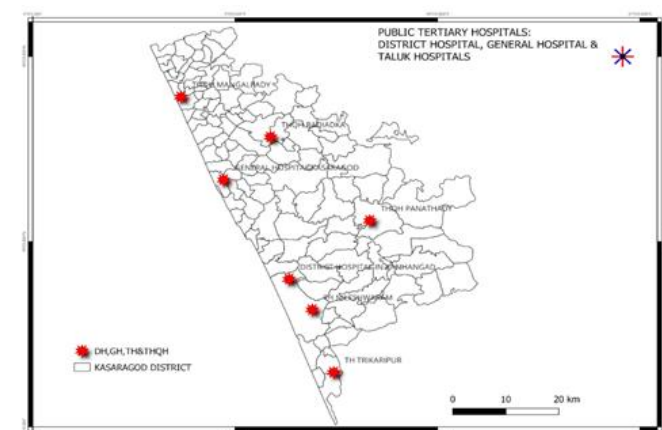
There are six Community Healthcare Centres in Kasaragod district.

Community healthcare centres in Kasaragod:



(source: The creation of author using GIS software)

6.1.5. Advanced Government Tertiary Hospitals

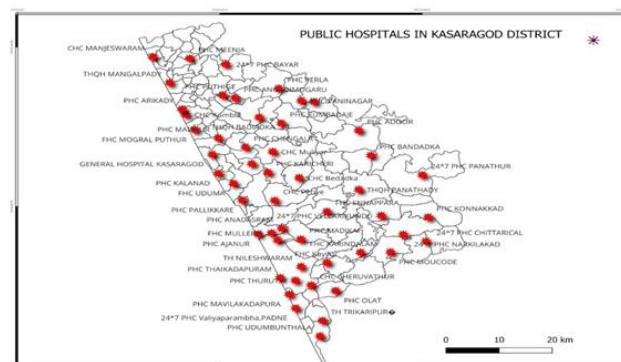


(source: The creation of author using GIS software)

The Kasaragod district has one district hospital, which is situated in Hosdurg taluk's Kanhangad. In Kasaragod Taluk, there is only one general hospital. These advanced hospitals are located in the middle of the western part of the district. Both of the Taluk Hospitals are situated in Hosdurg Taluk. There are three Taluk Head Quarters Hospitals: one in Kasaragod, one in

Vellarikund, and one in Manjeshwaram. The Kasaragod district's public tertiary hospitals are listed below.

6.2. All Government Hospitals:



(source: The creation of author using GIS software)

On this map, every public healthcare facility is displayed. There are very few healthcare facilities in the Kasaragod district that provide higher-level specialty care. There are 47 doctors at the Kanhangad District Hospital and 49 doctors at the General Hospital, representing different specializations. The recommendation from the secondary level of healthcare is to see a specialist for treatment. The District Medical Office employs six physicians. T.B. Centre in the District has two physicians. At the Taluk hospitals, there are 56 doctors. There are forty physicians in six CHCs. FHCs employ 35 physicians. The primary care hospitals are responsible for managing medical concerns and symptoms. In 26 PHCs, there are 52 doctors. Throughout all PHCs, there are 930 Asha workers.

6.2.1. MEDICAL COLLEGES IN KERALA STATE

There are 14 medical colleges in each district but few of them are under construction. The following table describes in detail.

Table 1. Kerala's Medical Colleges

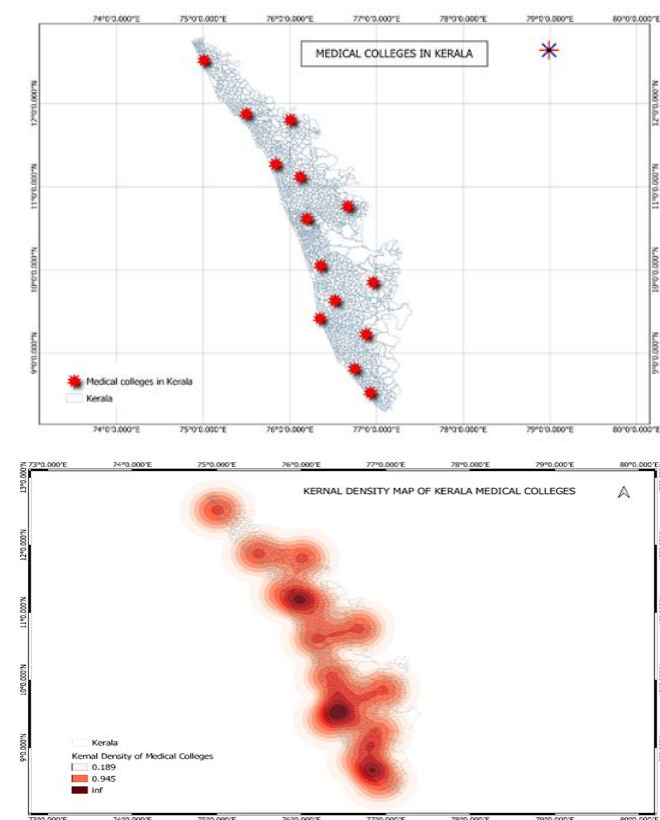
SL. NO.	DISTRICT	MEDICAL COLLEGE	ESTABLISHED YEAR	REMARKS
1.	THIRUVANANTHAPURAM	Govt. medical college Trivandrum	1951	First Medical college in Kerala
2.	KOZHIKODE	Govt. Medical College Kozhikode	1957	
3.	KOTTAYAM	Govt. Medical college Kottayam	1962	
4.	ALAPPUZHA	Govt. T D Medical college Alappuzha	1963	First private medical college in Kerala, later taken over by the Govt. of Kerala in 1972.
5.	THRISSUR	Govt. Medical College Trissur	1981	
6.	KANNUR	Govt. Medical college Kannur.	1995	In April 2018, the Govt. of Kerala took over Pariyaram medical college
7.	ERNAKULAM	Govt. medical college Ernakulam	1999	Previously known as Indira Gandhi Cochin Cooperative Medical College
8.	KOLLAM	Govt. medical college Kollam	2013	It was known as ESI Medical college in 2013 then became Kerala Govt. medical college.
9.	MALAPPURAM	Govt. Medical college, Manjeri, Medical College	2013	MCI approval received on 2019
10	PALAKKAD	Govt. Medical College, Palakkad	2014	Waiting for NMC approval
11	IDUKKI	Govt. medical College Idukki	2014	Granted approval by NMC in 2022 for 100 MBBS seats
12	PATHANAMTHITTA	Govt. medical college	2016	July 24,2020 started

13	KASARAGOD	Govt. medical college	2013	Construction Work is incomplete yet
14	WAYANAD	Govt. medical college	2021	planned

(Source: Wikipedia)

The medical colleges of Kerala state are displayed in this table. The Kasaragod Medical College's foundation was set in 2013 and is continuously being worked on till 2024. due to the Kerala government's disregard for providing financial support.

Location and Kernal Density of Medical colleges in Kerala State



(source: The creation of author using GIS software)

6.3. Importance of Tertiary Health Services in a Society

Public tertiary hospitals play a crucial role in providing accessible and affordable healthcare services to the

general public. These hospitals are the backbone of a society's healthcare system and are especially important for marginalized and low-income individuals who may not have access to private healthcare facilities. These hospitals also serve as training centres for medical students, ensuring a constant supply of well-trained healthcare professionals in the community. Moreover, public tertiary hospitals often offer specialized services and advanced medical treatments that may not be available in smaller healthcare facilities, making them essential for managing complex and critical medical conditions. In addition, these hospitals cater to a large number of patients, reducing the burden on other healthcare facilities and promoting equitable distribution of healthcare resources. The presence of public tertiary hospitals also contributes to the overall economic development of a society by attracting investments and creating employment opportunities. Overall, public tertiary hospitals are vital institutions that play a significant role in improving the health and well-being of individuals and communities, making them an essential asset for any society.

Public tertiary hospitals play an important role in any society, as they provide essential healthcare services to the general public. These hospitals serve as the backbone of the healthcare system, catering to a large portion of the population, including those who cannot afford expensive private healthcare services. They offer specialized medical care, advanced treatment options, and state-of-the-art facilities that are not accessible to everyone. Besides providing affordable healthcare, these hospitals also conduct research and offer training opportunities for medical professionals, contributing to the overall development of the healthcare sector. They

also serve as a safety net for those with chronic or severe illnesses, ensuring that everyone has access to quality medical care regardless of their socioeconomic status. Public tertiary hospitals are also critical in times of emergencies or pandemics, as they have the resources and expertise to handle large numbers of patients and provide life-saving treatments. Therefore, these hospitals are an integral part of any society, promoting health equity, improving overall health outcomes, and contributing to the well-being and progress of the community. Without public tertiary hospitals, many individuals would be left without proper healthcare, leading to increased morbidity rates and a decline in the overall quality of life. Hence, it is crucial to recognize and support the importance of these institutions in society.

Tertiary health services play a crucial role in maintaining the well-being of a society. These services are specialised and advanced medical care provided by highly trained professionals, hospitals, and research institutions. The importance of tertiary health services in a society can be analysed through the following aspects:

1. **Advanced Medical Care:** Tertiary health services offer cutting-edge medical treatments and procedures that are not available at primary or secondary levels. This includes complex surgeries, specialized treatments, and advanced diagnostic techniques.
2. **Research and Innovation:** Tertiary health services are often associated with research institutions and universities, which contribute to the development of new medical technologies, treatments, and medications. This fosters innovation and ensures that a society has access to the latest advancements in healthcare.
3. **Training and Education:** Tertiary health services provide training and education to healthcare professionals, ensuring that they are well-equipped to handle the most complex medical cases. This not only benefits the professionals

themselves but also the society as a whole, as it leads to a more skilled and knowledgeable workforce.

4. **Economic Impact:** The presence of tertiary health services in a society can have a significant economic impact. It attracts medical tourists, generates employment opportunities, and contributes to the overall growth of the healthcare sector.
5. **Public Health:** Tertiary health services contribute to public health by addressing complex medical issues and providing specialized care for patients with rare or difficult-to-treat conditions. This helps to improve the overall health and well-being of a society.

The tertiary health services are essential for the growth and development of a society. They provide advanced medical care, foster innovation, train healthcare professionals, contribute to the economy, and improve public health. Ensuring access to these services is vital for the well-being and progress of any society.

6.4. Relation between Vector Analysis of Shortest Line between Features and Euclidean Distance Theory:

Vector analysis is a branch of mathematics that deals with the study of quantities that have both magnitude and direction, such as forces, velocities, and accelerations. It plays a crucial role in determining the shortest line between features in a given space. The Euclidean distance theory, on the other hand, is a mathematical concept that defines the shortest distance between two points in a Euclidean space.

The relationship between vector analysis and the shortest line between features can be understood by considering the concept of the dot product, which is a scalar quantity obtained by multiplying the corresponding components of two vectors. The dot product can be used to determine the angle between two vectors, which in turn helps in finding the shortest line between two features.

The Euclidean distance theory comes into play when calculating the distance between two points in a Euclidean space. This distance is the shortest possible path between the two points and can be calculated using the Pythagorean theorem. By combining vector analysis and the Euclidean distance theory, we can effectively determine the shortest line between features in a given space. The relationship between vector analysis and the shortest line between features is established through the use of the dot product, which helps in determining the angle between two vectors.

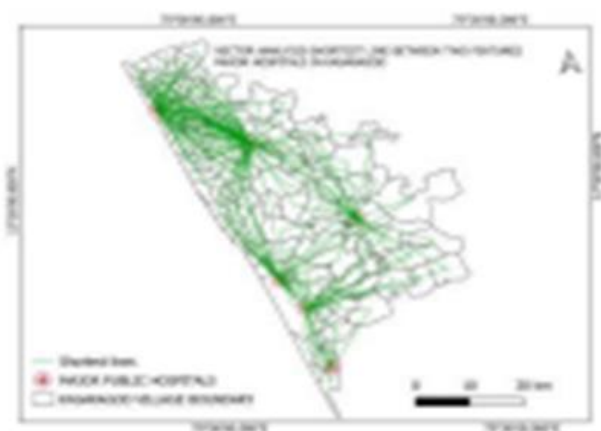
6.4.1. Euclidean Distance

The Euclidean distance is a mathematical concept that measures the distance between two points in a Euclidean space. It is widely used in various fields, including mathematics, physics, and computer science. The formula for calculating the Euclidean distance between two points

(x_1, y_1) and (x_2, y_2) is as follows:

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

Despite the advent of non-Euclidean geometries in the 19th century, Euclidean geometry remains a cornerstone of modern mathematics. Its timeless principles continue to provide a solid foundation for understanding the properties of space and shape, making it an essential tool for mathematicians, scientists, and engineers alike.



In conclusion, Euclidean geometry is a mathematical system that has stood the test of time, providing a

framework for understanding the properties of points, lines, and shapes. Its enduring influence on various disciplines highlights the importance of this foundational system in the world of mathematics.

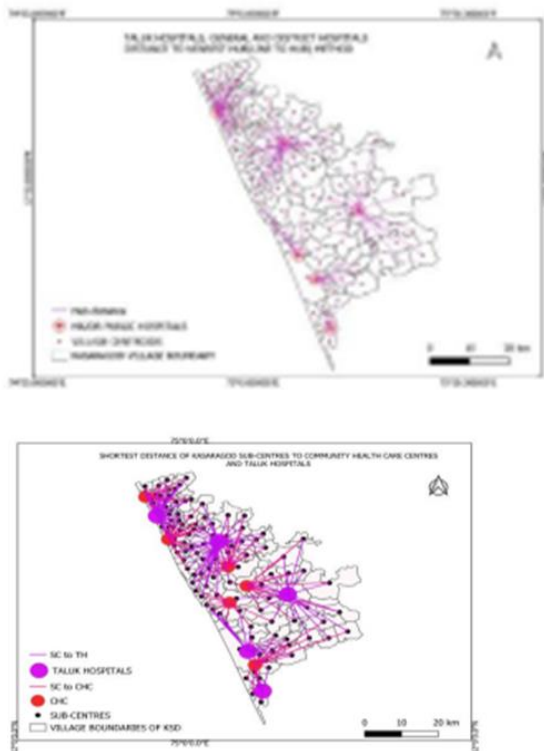
6.4.2. Euclidean Distance in Kasaragod Public Healthcare Centre's Accessibility

In the realm of public healthcare, accessibility plays a role in ensuring that citizens receive the necessary medical attention. Kasaragod has been making strides in improving the accessibility of its public healthcare centres. One such measure is the implementation of the Euclidean distance algorithm to optimize the distribution of healthcare facilities. The Euclidean distance algorithm is a mathematical concept that calculates the shortest distance between two points in a Euclidean space. In the context of healthcare accessibility, this algorithm can be used to determine the most efficient locations for healthcare centres, minimizing the distance between these facilities and the population they serve.

By implementing this algorithm, Kasaragod has been able to strategically place its public healthcare centres, ensuring that the majority of the population can access these facilities within a reasonable distance. This has resulted in improved healthcare outcomes, as patients are more likely to seek medical attention when the facilities are easily accessible.

The use of the Euclidean distance algorithm in determining the optimal locations for public healthcare centres in Kasaragod has significantly improved accessibility to these facilities. This, in turn, has contributed to better healthcare outcomes for the district's residents. As the district continues to grow and evolve, it is essential to maintain and improve upon these efforts to ensure that all citizens have access to quality healthcare services.

The closest hub line for secondary and tertiary public hospitals:



(source: The creation of author using GIS software)

The distance between 129 village centroids and the closest hub line for secondary and tertiary public hospitals is displayed on this map. In the 48 villages that make up Manjeshwaram Taluk, there aren't many public healthcare facilities. Public hospitals are located far away, so people must travel there. The lack of public healthcare in the Manjeshwaram taluk is due to the city of Mangalore in Karnataka, it has a greater number of Mult speciality hospitals, which is situated to the north of the taluk. Nonetheless, a taluk requires an adequate quantity of medical facilities. Individuals shouldn't be compelled to go to other states in order to receive healthcare.

6.4.3. Vector Analysis and the Shortest Line Between Features

Vector analysis is a powerful mathematical tool that allows us to analyse and manipulate geometric objects in a coordinate system. In the context of finding the shortest line between two features, vector analysis provides a straightforward and elegant solution.

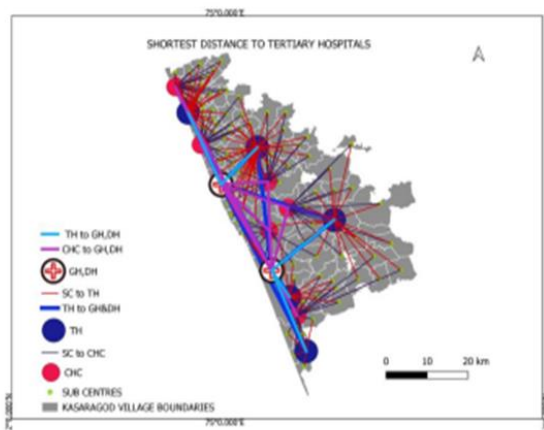
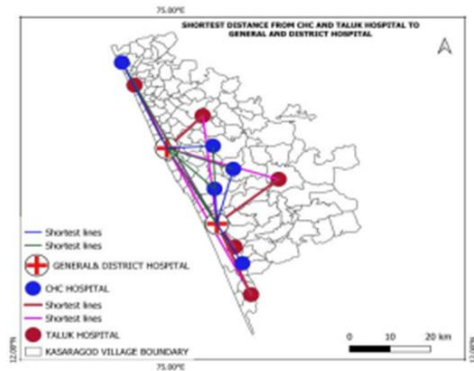
To determine the shortest line between two points in a two-dimensional plane, we can use the concept of the Euclidean distance. The Euclidean distance between two points, represented by their respective position vectors, is the length of the straight line connecting these points. Mathematically, this can be expressed as:

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

where (x_1, y_1) and (x_2, y_2) are the coordinates of the two points, and d is the distance between them. To find the shortest line between two features, we can calculate the Euclidean distance between their respective position vectors. This will give us the length of the straight line connecting the features. By connecting the two points with a line segment of this length, we obtain the shortest line between the features. Vector analysis provides a concise and efficient method for determining the shortest line between features in a coordinate system. By leveraging the power of mathematical concepts, we can solve complex geometric problems with ease and precision.

This map shows the shortest path from the CHC and Taluk hospitals to the District and General hospitals. When it comes to tertiary care, medical officers from CHC and Taluk hospitals favour General Hospital and District Hospital.

Shortest path from the CHC and Taluk hospitals to the District and General hospitals



(source: created by author)

This map indicates the shortest path between each subcentre or the village centroids to each of the district's higher level public hospitals, which include CHC, Taluk Hospitals, General Hospital Kasaragod, and District Hospital Kanhangad.

6.4.4. Distance, Time, and Cost: Impacts on Health Care Accessibility

Accessibility to healthcare is a crucial factor in maintaining public health. However, several factors, including distance, time, and cost, can significantly impact an individual's ability to access healthcare services.

Distance plays a vital role in determining the accessibility of healthcare facilities. For individuals living in remote or rural areas, the distance to the nearest healthcare facility can be a significant barrier. This can lead to delays in seeking medical attention, resulting in worsening health conditions and increased healthcare costs.

Time is another critical factor that affects healthcare accessibility. Long waiting times at healthcare facilities can discourage patients from seeking timely medical attention. This can lead to increased healthcare costs and poorer health outcomes. Cost is also a significant barrier to healthcare accessibility. High out-of-pocket expenses can deter individuals from seeking medical care, particularly those with lower incomes. This can result in the exacerbation of existing health conditions and increased healthcare costs in the long run.

In conclusion, distance, time, and cost are critical factors that can significantly impact healthcare accessibility. Addressing these barriers is essential to ensure that all individuals have equal access to quality healthcare services.

6.4.5. Distance from Tertiary Hospital and Critical Issues for Major Disease Patients

Living far from a tertiary hospital can pose significant challenges for patients suffering from major diseases. The distance can lead to delays in receiving critical care, which may exacerbate the patient's condition and negatively impact their prognosis. Therefore, it is crucial for individuals with major diseases to consider proximity to specialized healthcare facilities when making decisions about where to live or seek treatment.

In such cases, telemedicine and mobile healthcare units can help bridge the gap, ensuring that patients receive timely care and support, regardless of their geographical location. However, it is essential to recognize that these solutions may not always be sufficient or appropriate for every patient's needs.

Ultimately, the distance from a tertiary hospital can have a profound impact on the health outcomes of major disease patients. It is crucial for healthcare providers, policymakers, and patients themselves to be aware of this issue and work together to address it effectively.

Distance from tertiary hospitals can pose significant challenges for individuals with major diseases. Tertiary

hospitals are specialized facilities that offer advanced medical care, making them the go-to option for critical and complex health issues. However, these hospitals are often located in urban areas, making it difficult for people living in rural or remote areas to access them. This geographical distance can result in delayed diagnosis and treatment, which can be life-threatening for individuals with major diseases. Moreover, the lack of access to specialized medical equipment and highly trained healthcare professionals can also compromise the quality of treatment received by these patients. This creates a significant disparity in healthcare services, as those living in remote areas are at a disadvantage compared to their urban counterparts. As a result, there is a pressing need for improved healthcare infrastructure and transportation systems to ensure that individuals with major diseases have timely access to tertiary hospitals and receive the best possible care.

6.4.6. In Kasaragod district, critical issues for individuals with major diseases:

1. **Access to Healthcare:** Limited availability of specialized healthcare facilities and medical professionals could pose challenges for timely diagnosis and treatment.
2. **Financial Burden:** High medical costs, especially for long-term treatments and medications, may strain the finances of individuals and their families.
3. **Stigma and Discrimination:** Societal stigma surrounding certain diseases may lead to discrimination, isolation, and mental health issues among affected individuals.
4. **Lack of Awareness:** Insufficient awareness about symptoms, preventive measures, and available support services may result in delayed diagnosis and exacerbation of health conditions.
5. **Environmental Factors:** Pollution, inadequate sanitation, and other environmental factors could aggravate health conditions or contribute to the spread of diseases.
6. **Accessibility Challenges:**

Physical disabilities or mobility issues may hinder access to healthcare facilities, transportation, and other essential services.

Addressing these issues would require concerted efforts from healthcare providers, government agencies, community organizations, and society as a whole to ensure equitable access to healthcare and support for individuals with major diseases in Kasaragod district.

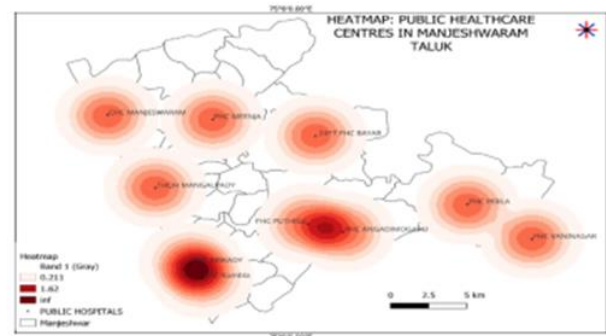
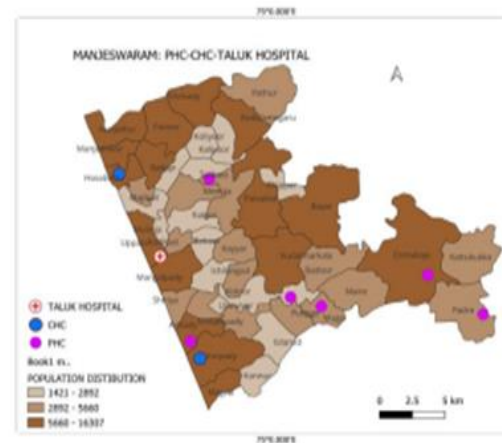
6.5. Importance of Kernel Density Estimation Maps in Accessibility of Health Care Centre's:

Access to healthcare is a fundamental right, and ensuring that healthcare facilities are easily accessible to the population is crucial. Kernel density estimation (KDE) maps play a significant role in improving the accessibility of health care centres. These maps use statistical methods to estimate the density of a population within a specific area, allowing for better planning and distribution of healthcare resources. The importance of KDE maps lies in their ability to provide a visual representation of the population distribution, enabling healthcare providers to identify areas with high demand for healthcare services. By analyzing these maps, decision makers can allocate resources more efficiently, ensuring that healthcare facilities are strategically located to serve the population effectively. Furthermore, KDE maps can help identify areas with limited access to healthcare, allowing policymakers to prioritize the development of new facilities or the expansion of existing ones in these regions. This, in turn, can help reduce disparities in healthcare access and improve overall population health. In the use of kernel density estimation maps is essential in improving the accessibility of health care centres. By providing valuable insights into population distribution and healthcare demand, these maps empower decision-makers to make informed choices that ultimately benefit the entire population.

6.5.1. Accessibility of Public Healthcare: A Taluk-wise Analysis -Manjeshwaram taluk:

The Taluk of Manjeshwaram does not have an FHC. The district and general hospitals are absent from the Manjeshwaram taluk as well. There are public hospitals there, including one Taluk hospital, two CHCs, and six PHCs. CHC, a secondary public hospital, and taluk hospital, a tertiary public hospital, are situated northwest, west, and southwest of Manjeshwaram Taluk. The villages known as Koipady (CHC), Mangalpady (Taluk Hospital), and Hosabattu (CHC), in that order. However, secondary and tertiary public healthcare centres are absent from the central regions of Taluk, including the northeast, east, and southeast. PHC is situated in Manjeshwaram Taluk's southeast and centre. In many of the villages in this Taluk, there are no CHC, or Taluk Hospitals.

A Taluk-wise Analysis -Manjeshwaram taluk: *The Heatmap of public health centres in Manjeshwaram*



(source: created by author)

In each location, the measurement unit for the Kernel Density Estimation of public health care centres in this heat map is around 4.5 km in radius. The residents of the villages named Pavor, Vorkady, Pathur, Kodalamogaru, Koliyoor, Chippar, Bayar, and so on must travel a great distance to receive care at a tertiary hospital.

Table 2. Random selected village to Tertiary level of public health care centres in Manjeshwaram Taluk

Distance to health care in kilometres	No. of villages	Distance of random selected village to Tertiary level of public health care centres (Mangalpady taluk hospital)	Time for travel to healthcare	Cost (Autorikshaw)
0-8	10	Shiriya (6 km)	10 minutes	150
8-16	20	Kodalamogaru(16km)	40 minutes	400
16-24	18	Bayar(24km)	60 minutes	600

(Source: Calculated by author)

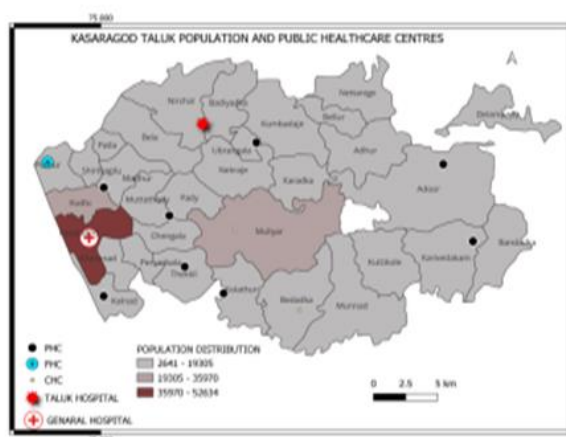
Ten of the 48 villages in Manjeshwaram Taluk must travel the approximate 8 kilometres to the Taluk

Hospital. Residents of 20 villages must travel approximately 16 km to get to Taluk Hospital, whereas residents of 18 villages must travel approximately 24 km to get to Taluk Hospital Mangalpady. Patients from the villages that are least accessible to healthcare facilities, such as Puthur, Kodalamogaru, Vorkady, etc. Ten villages fall into the same group based on a distance of 0 to 8 kilometres far from the taluk hospital. Here, we've chosen Bayar village as an example. It's 24 km away from the Taluk Hospital Mangalpady, and getting there by autorickshaw requires 600 rupees and takes 60 minutes. We consider Kodalamogaru village as an example, which is 16 kilometers away from the taluk hospital Mangalpady. The autorickshaw requires 400 rupees to drive 40 minutes to the hospital. With Shiriya village as an example, we can see that the taluk hospital in Mangalpady is 6 km away. It takes 12 minutes to drive there by autorickshaw, costing 150 rupees.

6.5.2. Accessibility of Public Healthcare- Kasaragod Taluk:

1. Kasaragod Taluk Public Healthcare Centres-The

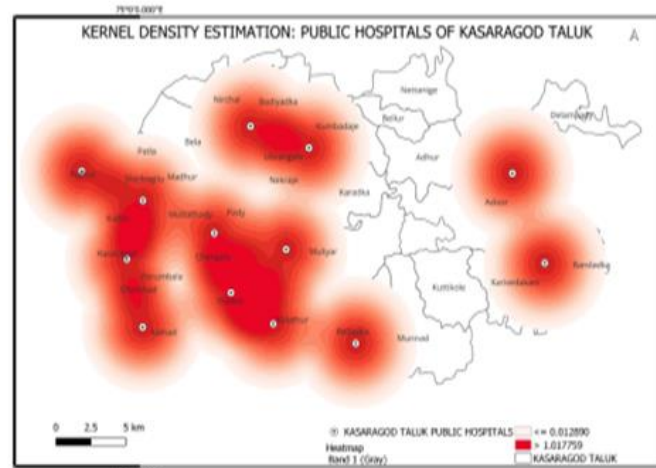
Heatmap of public health centres in Kasaragod Taluk:



KASARAGOD TALUK ACCESSIBILITY

Table 3. Random selected village to Tertiary level of public health care centres in Kasaragod Taluk

Distance from Public health centre	Distance to Tertiary level of public health care centres	Time for travel to healthcare	Cost by Autorickshaw	No. of Same category villages
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(source: created by author)

On the western part of Kasaragod taluk, there's a tertiary level general hospital. In the Kasaragod area, it is the second-largest public healthcare facility. The Endosulfan- affected area is located near the Badiyadka Taluk headquarters hospital. The population distribution 19305 to 35970 distribute to Kudlu and Muliya villages.

This Kernel density map shows that the 'Kasaragod taluk and its public hospitals', the densities are represented PHC, FHC, CHC, Taluk Hospital Badiyadka and General hospital. The villages of Delampady, Nattanige, Adhur, Kuttikol, Munnad, and other adjacent areas are among the most underserved in the western part of the Kasaragod taluk. The residents have a considerable distance to go in order to get to tertiary hospitals like District Hospital Kanhangad (Hosdurg taluk), General Hospital Kasaragod and Badiyadka Taluk hospitals.

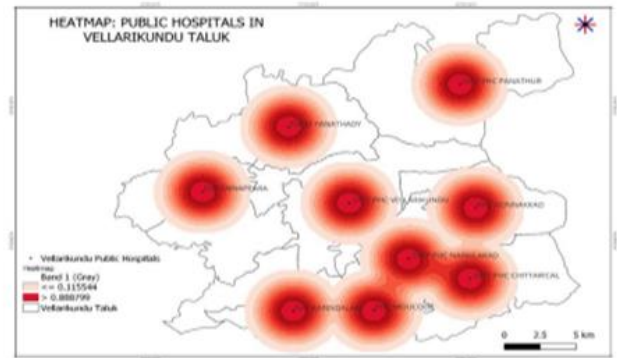
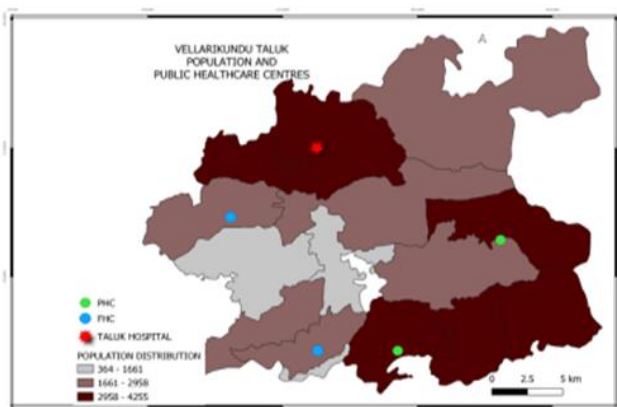
0-8	Madhur(8km)	20 minutes	200	6
8-16	Pady(12km)	22 minutes	400	8
16-24above	Delampady(44km)	1.30 hours	1600	20

(source: measured by author)

There are six villages in the range of 0 to 8 km. For instance, if we recently transported a patient from Madhur Village, which is 8 km away, to General Hospital, which is 20 minutes away. The autorickshaw ride costed Rs. 200. There are eight communities based on a range of eight to sixteen kilometres. For instance, we had carried a patient from Pady Village, which is 12 kilometres away, to General Hospital, which is 22 minutes away. The autorickshaw ride costed 400 rupees. There are 20 villages in the span of 16 to 24 kilometres. For instance, if transported a patient from Delampady village, which is 44 km away, to General Hospital, which is 90 minutes away by autorickshaw and requires 1600 rupees.

6.5.3. Accessibility of Public Healthcare- Vellarikundu Taluk:

Vellarikund taluk public healthcare -The Heatmap of public health centres in Vellarikundu Taluk



(source: created by author)

Compared to other villages in the Vellarikundu Taluk, Maloth, Palavayal, Chittarikkal, and Kallar have higher population densities. However, there are just two PHCs in Palavayal, Chittarikkal, and Maloth. The government should start working to build a tertiary healthcare facility in these areas since there is a need for a public Taluk Hospital. The Panathady Government Homoeo Dispensary is situated in the village of Panathady. The CHC Panathady, which was situated in Kallar village next to Panathady village, was transformed into the Taluk headquarters hospital. The Ranipuram Hill Station is situated in the area known as 'Panathur' in Maloth Village. There are more widows in Panathur because some residents drink too much when they're young and some young people in this area pass away from alcohol addiction at an early age. Due to its location near the Karnataka border, it is quite easy for them to buy or sell harmful alcohol. Residents of these locations must therefore receive health awareness training from the government healthcare system. Higher education institutions should be required to run healthcare awareness campaigns for their student body. In this community, awareness classes of this kind will bring about societal transformation. The residents of Vellarikundu Taluk,

particularly those living in the villages of Palavayal, Chittarikkal, Bheemanady, West Eleri, Maloth, and Parappa, face challenges in accessing healthcare due to insufficient facilities. In the event that an individual suffers from heart issues, residing in those remote

communities may pose a significant risk to their health due to limited access to tertiary hospital facilities and lengthy travel times.

Vellarikund taluk Accessibility to taluk hospital

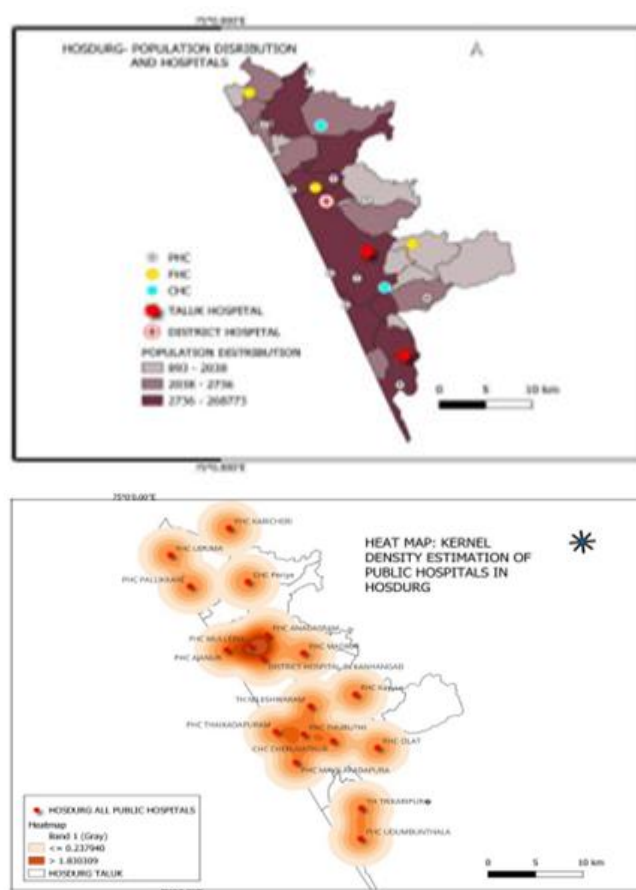
Table 4. Random selected village to Tertiary level of public health care centres in Vellarikundu Taluk

Distance from Public health care centre	Distance to Tertiary level of Public health care centres	Time (in minutes) for travel to healthcare	Cost by Autorickshaw	No villages
0-8	Kodom(7km)	15 m	400	4
8-16	Parappa(14km)	30m	800	5
16-24	Palavayal(33km)	60m	1500	6

This data indicates that Kodom village is located 7 km from Taluk hospital Panathady. The patient needs to pay 400 rupees for transportation, which takes 15 minutes by autorickshaw. similar to this group there are 4 further communities. The selection was made according to a range of 0 to 8 kilometres. The Taluk Hospital Panathady is 14 km away from the village of Parappa. The patient needs to pay 800 rupees for travel expenses, as the autorickshaw ride takes 30 minutes. similar to this group 6, there are further communities. It made its selection between 8 and 16 kilometres away. The distance of the village Palavayal from Taluk Hospital Panathady is 33km. It takes 60 minutes for the patient to travel by autorickshaw, and the cost of the trip is 800 rupees. There are more villages in the same category 7, for example. It made its selections between 16 and more than 24 kilometers away.

6.5.4. Accessibility of Public Healthcare- Hosdurg Taluk:

Hosdurg taluk- Kernal Density map of Public Hospitals in Hosdurg Taluk:



(source: created by author)

The Kasaragod district is divided into four taluks: Manjeshwaram, Kasaragod, Hosdurg, and Vellarikundu. Of these, only the inhabitants of Hosdurg Taluk have easy access to healthcare facilities

due to the presence of tertiary public hospitals there, including District Hospital Kanhangad and Trikkaripur Taluk hospitals. In comparison to other taluks, it has a lower land area and a higher population density. Every village name is displayed on this map of Hosdurg Taluk. This taluk's urban centre is called Kanhangad. According to this Kernel Density estimation, the villages in the taluk's centre and south have more easily accessible health services, while the village in the

southeast has fewer than other villages in the taluk. Every public hospital is measured as 3.5 km in radius on this heat map. The biggest hospital in Kasaragod district, situated in the Hosdurg taluk, is called "the district hospital Kanhangad." It has a larger workforce, more beds, and better infrastructure than comparable public hospitals.

HOSDURG TALUK ACCESSIBILITY

Table 5. Random selected village to Tertiary level of public health care centres in Hosdurg Taluk

Distance from Public health care centre	Distance to Tertiary level of public health care centres	Time for travel to healthcare	Cost by Autorickshaw	No villages same category
0-8	Ajanur(8km)	10	300	17
8-16	Periya(13km)	20m	500	12
16-24	Cheemeni(20km)	30m	800	3

In this Hosdurg taluk, the majority of the inhabitants have easy access to the Trikkaripur taluk hospital and the district hospital Kanhangad. It contains 32 villages. In Hosdurg Taluk, there are 17 villages that are close to tertiary hospitals compared to 3 that are far away. The Kasaragod district is divided into four taluks: Manjeshwaram, Kasaragod, Hosdurg, and Vellarikundu. Of these, only the inhabitants of Hosdurg Taluk have easy access to healthcare facilities due to the presence of tertiary public hospitals there, including District Hospital Kanhangad and Trikkaripur Taluk hospitals. In comparison to other taluks, it has a lower land area and a higher population density. The tertiary hospital is 8 km away from the village of Ajanur. The patient needs to pay 300 rupees for the 13-minute autorickshaw ride. There are seventeen more settlements in the same category. It was chosen according to a range of 0 to 8 kilometres. So, the most accessible taluk is this Hosdurg Taluk. Periya, the

village 13 km from the hospital that is tertiary level. The patient needs 500 rupees for travel expenses, and the autorickshaw ride takes 20 minutes. Twelve other settlements fall into the same category. It was chosen according to the 8–16 km distance. The Cheemeni community is 20 kilometre's away from the Tertiary Hospital. The patient needs to budget 800 rupees for their 30-minute autorickshaw ride. similar to this group 4, there are further communities. It was chosen according to the 16–24 kilometre distance.

6.6. Nearest Neighbour Analysis in GIS:

Understanding Accessibility of Health Care Centres in a District: Access to healthcare is a fundamental right, and ensuring its availability to all citizens is a priority for governments worldwide. In this context, Geographic Information Systems (GIS) have emerged as powerful tools for analysing and optimizing healthcare infrastructure. One such technique is the

Nearest Neighbour (NN) analysis, which helps to understand the accessibility of Primary Health Centres (PHCs) to Tertiary Hospitals in a district. NN analysis is a spatial statistical method that measures the spatial distribution and accessibility of healthcare facilities. It calculates the average distance between a given facility (e.g., a PHC) and its nearest neighbour (e.g., a Tertiary Hospital). This information can be used to identify gaps in healthcare coverage, optimize resource allocation, and improve overall accessibility. In the context of a district, NN analysis can help policymakers and healthcare planners to identify areas with inadequate healthcare coverage. By analysing the distribution of PHCs and Tertiary Hospitals, they can determine whether the existing facilities are evenly distributed or if there are areas with a higher concentration of facilities, potentially leading to overcrowding and inefficient resource utilization. Moreover, NN analysis can also help identify areas with a higher demand for healthcare services. By analysing the distance between PHCs and Tertiary Hospitals, planners can identify areas where the population may be underserved or where the existing healthcare infrastructure may be insufficient to meet the needs of the population. In Nearest Neighbour analysis in GIS is a valuable tool for understanding the accessibility of health care centres in a district. By providing insights into the spatial distribution and accessibility of PHCs and Tertiary Hospitals, it can help policymakers and healthcare planners to optimize resource allocation, identify gaps in healthcare coverage, and ultimately improve access to healthcare services for all citizens. Nearest neighbour analysis, also known as proximity analysis, is a useful tool in GIS for planning and managing health care services. By using this analysis, healthcare providers can determine the closest facilities to certain populations, identify areas with inadequate access to services, and plan for the most efficient distribution of resources. This method takes into account the geographic location of patients and health care facilities, as well as the

distance and travel time between them. By understanding the spatial relationships between patients and facilities, healthcare providers can make informed decisions about resource allocation, improve accessibility to care, and ultimately, enhance the overall health outcomes of the community. Nearest neighbour analysis can also be used to identify areas with high disease prevalence, allowing for targeted interventions and resource allocation. Overall, this analysis plays a crucial role in the efficient and effective delivery of health care services.

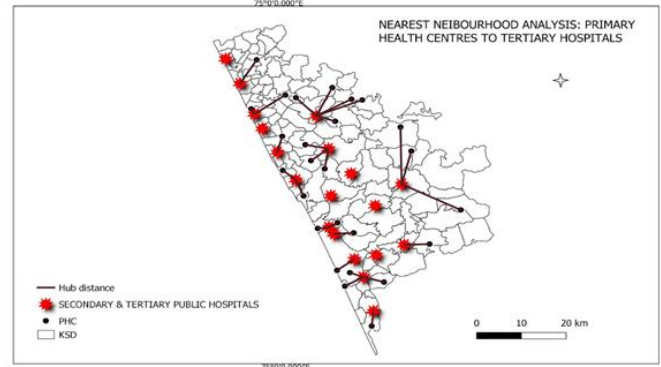
Using $R_n = 2d - n/A$, one may perform a nearest neighbour analysis. The formula in question involves the following variables: n is the total number of phenomena being studied, A is the area of the phenomena in square kilometres, d is the observed average neighbour distance, and R_n is the nearest neighbour value capturing the point pattern. When the observed average distance is divided by the expected average distance, the average nearest neighbour ratio is expressed. Nearest neighbour analysis is a fundamental technique in Geographic Information Systems (GIS) that is used to examine the spatial distribution of point features. This method is employed to determine whether a given set of point features exhibits a clustered, random, or dispersed pattern. The nearest neighbour analysis is based on the principle that the distance between each point and its nearest neighbour can be used to infer the spatial distribution of the points. The average nearest neighbour distance is compared to the expected distance under a random distribution to determine whether the points are clustered or dispersed. To perform a nearest neighbour analysis in GIS, the following steps are typically followed:

1. Data preparation: The point features must be properly formatted and loaded into the GIS software.
2. Calculation of nearest neighbour distances: The software calculates the distance between each point and its nearest neighbour.

3. Comparison to expected values: The average nearest neighbour distance is compared to the expected distance under a random distribution.
4. Interpretation: Based on the comparison, the spatial distribution of the points is determined to be clustered, random, or dispersed.

Nearest neighbour analysis is a valuable tool in GIS for understanding the spatial distribution of point features, which can inform decision-making in various fields, such as urban planning, environmental management, and public health. By providing insights into the spatial patterns of point features, this analysis can help identify areas that require further investigation or targeted interventions.

Nearest Neighbourhood Analysis of PHC to Tertiary Hospitals:



(source: created by author)

In a nearest neighbour analysis, this map displays the proximity of PHC to secondary and tertiary public hospitals. Patients are referred by PHC medical officers to the closest secondary or tertiary public hospitals. People from low-income backgrounds primarily rely on government healthcare facilities.

6.7. Anova Test of Major Patients Travel Distance, Time and Cost to Advanced Government Hospitals in Kasaragod:

Table 6. The patient travels the distance to reach the closest public tertiary hospital in the Kasaragod district:

TALUK	SELECTED VILLAGES	DISTANCE in KM	TIME in minutes	TRANSPORT EXPENCE BY Autorickshaw	TRANSPORT BY BUS
MANJESHWARAM	KUNCHATHUR	13	24	350	15
MANJESHWARAM	PATHOOR	24	43	830	25
MANJESHWARAM	BAYAR	20	40	750	22
KASARAGOD	DELAMPADY	45	75	1100	52
KASARAGOD	BANDADKA	43	60	1000	52
KASARAGOD	ADHUR	30	47	900	35
HOSDURG	UDUMA	16	27	400	20
HOSDURG	PERIYA	12	20	320	15
HOSDURG	CHEEMENI	28	40	800	30
VELLARIKUND	PALAVAYAL	49	70	1050	55
VELLARIKUND	KODOM	20	30	750	25
VELLARIKUND	CHITTARIKKAL	42	60	1000	50

Here, three villages from each taluk are chosen, and the patient's travel time, distance, and costs by bus and

autorickshaw are all listed. When seeking critical emergency medical care, the residents of Delampady,

Bandhadukka, Palavayal, Chittarikkal, and the District Hospital Kanhangad and General Hospital Kodalamogaru must travel more than an hour to get to Kasaragod, two tertiary public hospitals.

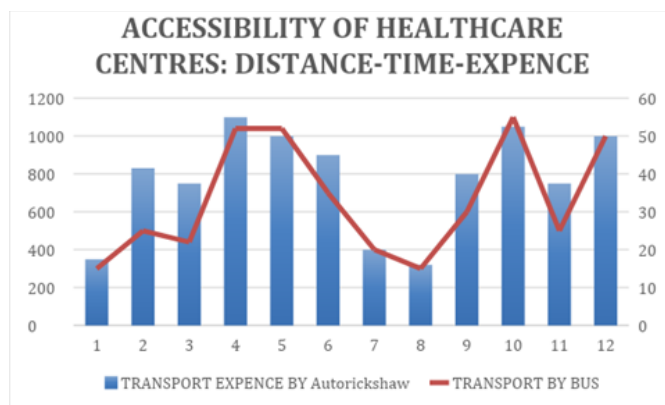
Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
DISTANCE in KM	12	342	28.5	1746364
TIME in minutes	12	536	44.66667	331.5152
TRANSPORT EXPENCE BY Autorickshaw	12	9250	770.8333	75553.79
TRANSPORT BY BUS	12	396	33	234

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	4869578	3	1623193	85.10204	2.4E-18	2.816466
Within Groups	839233.3	44	19073.48			
Total	5708811	47				



The distance, time, and cost by bus and autorickshaw are displayed in this graph. Due to their remote location and limited bus service during certain hours and there is no bus service at night, the residents of many remote villages rely on autorickshaws for emergency situations.

1. Mode of Transport chosen by patients to reach Tertiary Hospital

Taluk	Bus	Autorikshaw	Own Car	walk	Total
Manjeshwaram	38	18	10	16	82
Kasaragod	40	20	12	18	90
Hosdurg	45	18	14	15	92
Vellarikundu	49	15	8	10	82

Anova:

Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
Bus	4	72	43	24.66667
Autorikshaw	4	71	17.5	4.25
Own Car	4	44	11	6.66667

walk	4	59	14.75	11.58333
Total	4	346	86.5	27.66667

ANOVA

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	15996.3	4	3999.075	267.1988	9.61E-14	3.055568
Within Groups	224.5	15	14.96667			
Total	16220.8	19				

show that although the patients travel in various ways to get to the public tertiary health centres in the Kasaragod district.

P value is = 0.000000000000961, that means less than 0.05. the significance level accepts the null hypothesis. So, it is statistically significant. The ANOVA results

2. Travel Cost of Patient to reach Tertiary Hospital

Taluk	0	Rs:<50	Rs:50-100	Rs:>100	Total
Manjeshwaram	13	20	29	20	82
Kasaragod	15	25	26	24	90
Hosdurg	10	42	22	18	92
Vellarikundu	2	30	25	25	82

Anova: Single Factor

SUMMARY

<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
0	4	0	10	32.6667
<50	4	117	29.5	88.91667
50-100	4	102	25.5	8.333333
>100	4	87	21.5	10.91667
Total	4	346	86.5	27.66667

ANOVA

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	14301.3	4	3575.325	106.0927	8.23E-11	3.055568
Within Groups	505.5	15	33.7			
Total	14806.8	19				

So, it is statistically significant. The ANOVA results show that although patient transportation costs to the

P value is = 0.0000000000823, that means less than 0.05. the significance level accepts the null hypothesis.

public tertiary health centre vary throughout Manjeshwaram 16 38 28 82
Kasaragod district's each taluk. Kasaragod 15 45 30 90

3. Travel Time of Patient to reach Tertiary

Hospital

Hosdurg 49 41 2 92
Vellarikundu 18 32 32 82

30 to
60

Taluk <30min min >60min Total

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
<30min	4	98	24.5	268.3333
30 to 60 min	4	156	39	30
>60min	4	92	23	198.6667
Total	4	346	86.5	27.66667

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	10601	3	3533.667	26.94028	1.29E-05	3.490295
Within Groups	1574	12	131.1667			
Total	12175	15				

P value is = 0.0000129, that means less than 0.05. the significance level accepts the null hypothesis. So, it is statistically significant. According to the ANOVA results, patients in the Kasaragod district do not all have equal access to the public health centre; the time it takes differs depending on the taluk.

4. Travel Distance of Patient to reach

Tertiary Hospital

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
<10km	4	52	13	33.33333
10-50 km	4	191	47.75	94.91667
50km>	4	103	25.75	110.9167
Total	4	346	86.5	27.66667

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	12448.5	3	4149.5	62.20362	1.39E07	3.490295
Within Groups	800.5	12	66.7083			
Total	13249	15				

10-50
Taluk <10km km 50km> Total
Manjeshwaram 12 40 30 82
Kasaragod 14 45 31 90
Hosdurg 20 62 10 92
Vellarikundu 6 44 32 82

P value is = 0.000000139, that means less than 0.05. the significance level accepts the null hypothesis. So, it is statistically significant. There are variations in the distances to the closest Tertiary Health Centre in Kasaragod district, according to the ANOVA results. The test verifies that even if there is a variation in the groups' distances from one another.

6.8. Advantages of Heatmaps in GIS for Accessibility Studies in Healthcare:

In the realm of health care, accessibility is a critical factor that determines the quality of care provided to patients. Geographic Information Systems (GIS) have emerged as a powerful tool to analyze and visualize spatial data, enabling researchers to study health care accessibility more effectively. One of the most valuable features of GIS is the heatmap, which offers numerous benefits in the context of health care accessibility studies.

Firstly, heatmaps provide an intuitive and visually appealing representation of spatial data, allowing researchers to identify patterns and trends in health care accessibility. By overlaying multiple layers of data, such as population density, the location of healthcare facilities, and transportation networks, heatmaps can reveal areas with limited access to healthcare services. Secondly, heatmaps facilitate the identification of underserved communities and areas with high demand for healthcare services. This information is crucial for policymakers and healthcare providers to make informed decisions about resource allocation and the establishment of new healthcare facilities.

Moreover, heatmaps can be used to evaluate the impact of interventions aimed at improving healthcare accessibility. By comparing heatmaps before and after the implementation of these interventions, researchers can assess their effectiveness and make data-driven recommendations for further improvements.

The use of heatmaps in GIS offers numerous benefits for health care accessibility studies. By providing a powerful visualization tool, heatmaps enable

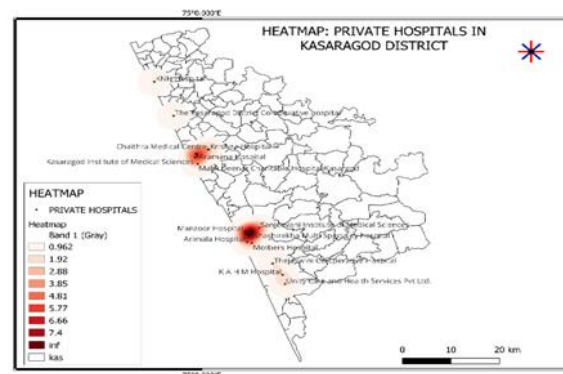
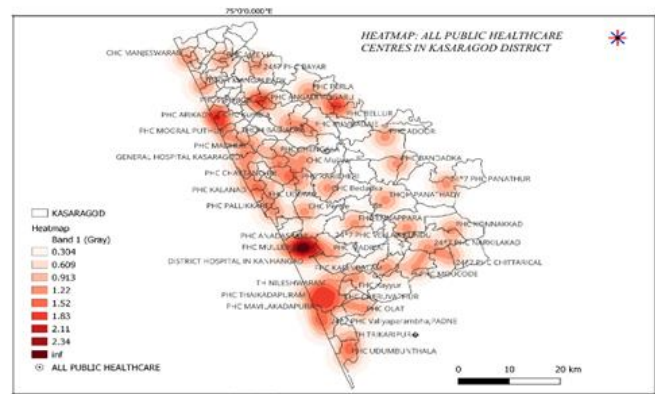
researchers to identify patterns, underserved areas, and evaluate the impact of interventions, ultimately contributing to the improvement of healthcare accessibility for all.

6.9. Kernal Density Map Of Public and Private Hospitals

Heat Map: Public Healthcare

Heat

Map: Private Healthcare



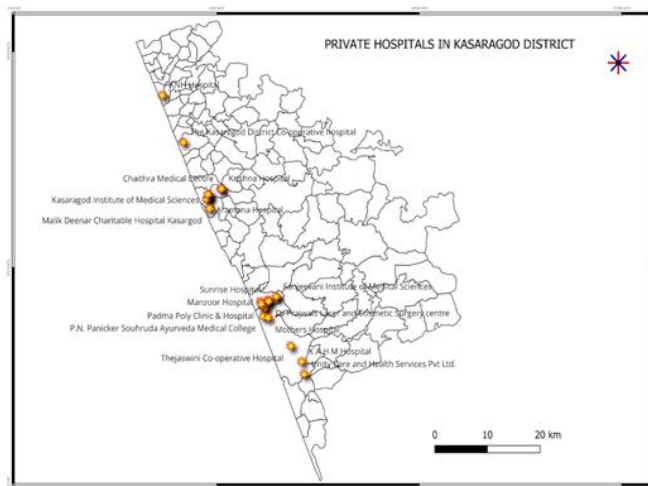
All public healthcare facilities, whether large and small, are included in this heat map. The western part of the Kasaragod district is located to the tertiary hospitals known as General Hospital Kasaragod and District Hospital Kanhangad. Heat Map of Private Healthcare: Here, only the largest private hospitals are highlighted. Due of the huge population density in the western region, these are located in Kasaragod's western part. The cost of healthcare is a significant concern for patients seeking medical attention. In this regard, the expenses incurred by patients in public healthcare centres and private healthcare centres vary significantly. Public healthcare centres, being government-funded, offer relatively affordable

services, with minimal out-of-pocket expenses for patients. In contrast, private healthcare centres, driven by profit motives, charge exorbitant fees for their services, making them inaccessible to many.

The disparity in expenses is largely attributed to the difference in operational costs, infrastructure, and staffing. Public healthcare centres are subsidized by the government, allowing them to maintain lower costs. Private healthcare centres, on the other hand, invest heavily in state-of-the-art infrastructure and attract top medical talent, resulting in higher costs.

Furthermore, the cost of treatment in private healthcare centres is often inflated by the inclusion of luxury amenities and services, which are not essential to the medical treatment itself. In contrast, public healthcare centres focus solely on providing essential medical services, keeping costs low.

Ultimately, the choice between public and private healthcare centres depends on individual financial circumstances and priorities. While public healthcare centres offer affordable services, private healthcare centres provide premium services at a higher cost.



(source: created by author)

In the district, there are 25 private hospitals. The majority of these are found in the taluks of Kasaragod and Kanhangad. Since private hospitals have financial incentives to profit from medical services, residents pay much more at private hospitals than at public ones.

- The cities of Kasaragod and Kanhangad are home to the majority of private hospitals. The bare minimum for physician fees is around 500. If a person works as a coolie and makes Rs:1,000 a day, they must pay 50% of the doctor fee if he visits a private hospital. However, a patient in a private facility need not suffer from medical personnel ignorance.
- When compared to the government hospital, they receive better treatment. People prefer receiving their medical care from private providers for this reason. Not every member of the government medical staff treats patients harshly, but some do. It will have more complex effects on the patient's health.
- The patient would rather receive care in private hospitals in order to prevent this neglect. There is a pay and park area in tertiary general government hospitals, however there is no security for helmets or vehicles.
- The physicians who work for the government receive additional compensation from their private clinics or consultations. If they require money from a private clinic or private consultation, the government should force them to quit. Many physicians who work for the government provide private consultations in order to supplement their income, so they place greater value on private clinics.
- Patients receive better treatment from some staffs if they tip them. One kind of corruption is this. Because there are more patients in tertiary hospitals, staff members occasionally act rudely. There will be fewer workers in these areas if the tertiary level healthcare centres' capacities grow.

6.10. Inadequate Public Healthcare Services in Eastern portion of Kasaragod District:

The eastern part of Kasaragod district in India faces several challenges, including inadequate public healthcare services, hilly terrain, and moderate

population density compared to the western side of the district. This aims to explore these issues and their impact on the local population.

Inadequate Public Healthcare Services:

One of the most pressing concerns in the eastern part of Kasaragod district is the lack of adequate public healthcare services. This region is home to a significant number of people, many of whom live in remote areas with limited access to healthcare facilities. As a result, they often have to travel long distances to receive medical care, which can be a significant burden, particularly for those who are ill or injured.

Furthermore, the existing healthcare facilities in the region are often understaffed and under-resourced, leading to long wait times and suboptimal care. This situation is exacerbated by the fact that many healthcare professionals are reluctant to work in rural areas due to the lack of amenities and the challenging terrain.

Hilly Terrain

The hilly terrain in the eastern part of Kasaragod district presents another significant challenge. The rugged landscape makes it difficult to build and maintain healthcare facilities, as well as to provide transportation for patients and medical professionals. This can result in further delays in accessing medical care, as well as increased costs for both patients and the healthcare system.

Moderate Population Density

While the population density in the eastern part of Kasaragod district is lower than in the western part, it is still significant enough to strain the existing healthcare resources. The region's population is diverse, with a mix of ethnicities and socioeconomic backgrounds, which can further complicate the provision of healthcare services.

Impact on the Local Population

The combination of inadequate public healthcare services, hilly terrain, and moderate population density has a significant impact on the health and well-being of the local population. Residents in the eastern part of

Kasaragod district often face limited access to healthcare, leading to delayed diagnoses and treatments, as well as increased morbidity and mortality rates.

The eastern part of Kasaragod district faces several challenges related to public healthcare services, hilly terrain, and moderate population density. Addressing these issues is crucial to improving the health and well-being of the local population. This can be achieved through increased investment in healthcare infrastructure, targeted recruitment of healthcare professionals, and the development of innovative solutions to overcome the challenges posed by the region's terrain.

VI.CONCLUSION

An Inadequate public healthcare system in Kasaragod district, Kerala, is grappling with inadequate accessibility, which has a significant impact on the quality of healthcare services provided to the residents. Despite the government's efforts to improve the situation, several factors contribute to this issue. The geographical location of the district, with its vast expanse of land and scattered population, makes it challenging for people to access healthcare facilities easily. This is further exacerbated by the lack of transportation infrastructure, which makes it difficult for people to travel to the nearest healthcare centre. The shortage of healthcare professionals and resources in the district adds to the problem. With limited staff and equipment, the healthcare centres are unable to cater to the growing needs of the population, leading to long waiting times and inadequate care. To address these challenges, the government needs to invest in improving transportation infrastructure, increasing the number of healthcare professionals, and providing better resources to the existing healthcare centres. By doing so, the accessibility of public healthcare in Kasaragod district can be significantly improved, ensuring that the residents receive the quality care

they deserve. Access to healthcare is a fundamental human right, yet millions of people worldwide struggle to access essential medical services due to geographical barriers. In rural and remote areas, the distance to healthcare facilities can be a significant challenge. To improve accessibility, governments and healthcare providers must invest in infrastructure development, such as constructing new healthcare facilities in underserved areas and upgrading existing ones. Additionally, telemedicine services can help bridge the gap by providing remote consultations and monitoring, reducing the need for patients to travel long distances for medical care IN DEVELOPED COUNTRIES. By addressing the geographical barriers to healthcare access, we can ensure that everyone, regardless of their location, has equal opportunities to receive quality medical care.

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