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Spatial Analysis of Accessibility and Coverage of Healthcare Facilities in YSR District (Kadapa), Andhra Pradesh, India

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ABSTRACT

The study assesses where and how well healthcare facilities are located and the equity of service coverage in YSR District (Kadapa), Andhra Pradesh, given the significant need to address equitable healthcare in line with the WHO and Indian Public Health Standards. India has a hierarchical organization for healthcare facilities, which raises the important research question about whether a similar spatial disparity exists between rural and urban contexts for the district-level location of hospitals and healthcare services. The significance of the study is framed around the geospatial context of healthcare planning; namely, to identify the under-served areas in the health system and support policy and decision-making to advance Sustainable Development Goal 3. The study is based on the hypothesis that the rural and peripheral areas of YSR District face an acute inequities in healthcare access. The purpose of the project is to calculate where hospitals and healthcare facilities are located, and how well they are serving the population in YSR District, using secondary data obtained from the District Medical Health Office (2023). They employed a quantitative analysis methodology and GIS-based mapping in order to evaluate indicators such as: doctor and population ratios, bed availability ratio, and geographic catchment through a 5 km or 10 km buffer. The findings revealed geographic disparities, in terms of availability and access to healthcare; however, overall there is already inequitable access with respect to the doctor and bed to population ratios which fall below the acceptable global norm. Despite 74.5% of villages being located within the catchment of their PHC, this means that almost 7% of villages are beyond the serviceable area. The conclusion notes that urgent spatial interventions, infrastructure upgrades, and strengthening of human resources, are needed. Further, the study recommends multi-dimensional strategies moving forward; along with mobile health units, connectivity improvements, and diverse staffing models that promote equity and resilience in healthcare for all.

Keywords: *Spatial distribution, Healthcare accessibility, Service coverage, Health care indicators, Equity, Public health standards.*

1. INTRODUCTION

Access to quality healthcare constitutes one determining factor of human well-being and sustainable development. Globally, almost half of the world's population still lacks coverage for basic health services, and 100 million persons are pushed into extreme poverty every year by out-of-pocket health care expenses (WHO, 2021). There have been numerous attempts at the Indian government level to increase access to healthcare services through different programs such as the National Health Mission (NHM); however, hardware and healthcare services remain unevenly distributed and accessible, especially between rural and urban areas. The Ministry of Health and Family Welfare (2023) states that most of the rural population in India is largely dependent upon public health infrastructure, yet in many parts of the country, the per capita availability of health facilities is lower than what would be considered acceptable. Such disconnects commonly result in instances where there is unequal access to essential services and poor health outcomes, putting an additional burden on higher-tier hospitals.

The healthcare system in India is organised in a pyramidal manner comprising Sub-Centres, Primary Health Centres (PHCs), Community Health Centres (CHCs), Sub-District Hospitals (SDHs), and District Hospitals (DHs). The physical infrastructure is supposed to ensure equitable health services for any geo-political or population segments based on Indian Public Health Standards (IPHS) and international norms, for example, WHO norms (Ministry of Health and Family Welfare, 2021). However, historically, the spatial distribution and service coverage in most instances have not adhered to the planning norms. In localities such as YSR (Kadapa) district in the state of Andhra Pradesh, where a large chunk of the population resides in an agglomeration of villages, such geographic and functional accessibility to health services poses a bitter reality. Even though several hierarchies of public health infrastructure exist at different levels, rarely has the equitable reach and functionality of these services been subjected to spatial analyses.

This research focuses on filling a significant gap in research, Beyond descriptive spatial inequities, this study investigates how the geographic position of settlements—relative to transport corridors, urban centers, and terrain—directly affects healthcare accessibility. how has a spatial analysis been disregarded in assessing imbalances in the geographic distribution, accessibility, and service coverage of health-care facilities in YSR District? Most of the literature has concentrated on some demographic aspect or on the service quality dimension of healthcare, but few studies have integrated geospatial tools to map disparities in access to services across the urban-rural continuum (Patil & Paul, 2020; Rao et al., 2019). Serving the spatial disparities is

required from district hospitals, at one extreme, to HWC-SCs, at the other. Such understanding also helps to identify areas that are underserved and consequently can be used in optimizing health facility allocation and in promoting greater equity in public health. Hence, it needs to be considered in planning and policy-making toward improving the accessibility and service delivery of public health infrastructure under the framework of Sustainable Development Goal 3 is to "Ensure healthy lives and promote well-being for all at all ages" (United Nations, 2015).

2. LITERATURE REVIEW

Healthcare accessibility and service coverage have traditionally been a subject of research in the field of public health and regional planning. According to WHO, healthcare accessibility refers to the degree of ease with which people can avail of medical services that are needed promptly and at affordable prices (World Health Organization, 2020). In various global studies, factors such as geographic location, availability of transport, distribution of facilities, and socioeconomic status emerged as some of the key factors influencing healthcare access (Gulliford et al., 2002). In the Indian context, the healthcare infrastructure is often skewed towards certain areas, with rural regions suffering from acute shortages of facilities, medical personnel, and material resources (Ministry of Health and Family Welfare [MoHFW], 2023). A nationwide review conducted by Singh and Chauhan (2015) revealed that even though the Indian health-care system is hierarchically structured to offer coverage, accessibility is skewed due to poor planning and lack of geospatial assessment. This calls for area-specific studies incorporating spatial tools to assess coverage and disparities at a finer scale.

In seminal contributions to health geography, Joseph and Phillips (1984) considered spatial accessibility as a determinant of health utilization, therefore laying the foundation for spatial analysis in the planning of health services. Pioneering Indian health infrastructure studies by Sundararaman and Muraleedharan (2010) and Bhandari and Dutta (2007) considered the rural-urban divide in assessing healthcare, indicating that population-based plans for facilities often cannot reflect the ground realities. The use of GIS has more recently developed to map spatial accessibility and service catchment areas: in one application, Tiwari and Sushma (2019) attempted to use GIS to assess the coverage of PHCs in Madhya Pradesh and found gross service inequities in tribal areas, and Srivastava et al. (2021) conducted spatial modeling for assessing the accessibility of CHCs in Uttar Pradesh, noting incongruities between population densities and facility locations. Despite progress in this direction, investigations are scarce when analyzing at the district level in Andhra Pradesh, a state whose geographical variation and administrative fragmentation construct a set of peculiar challenges for health equity.

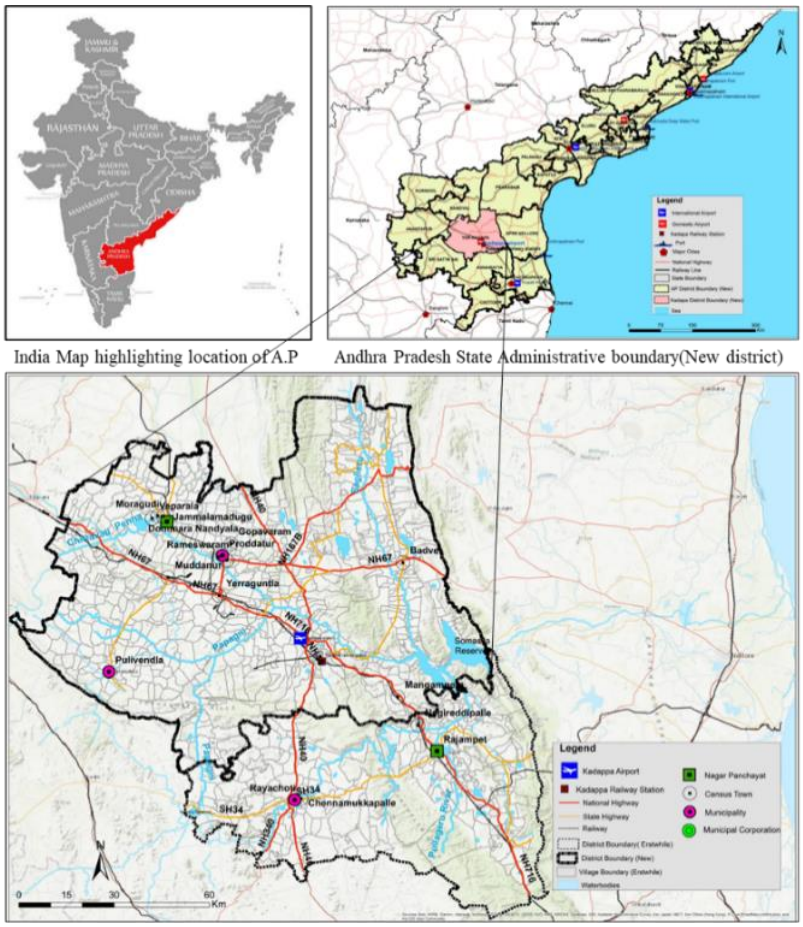
In recent times, contemporary literature has begun to engage with and explore the other side of spatial aspects: the functional dimensions of healthcare accessibility. The indicators of performance measured in Tamil Nadu by Rao et al. (2022) suggest that even well-positioned facilities performed inadequately concerning the provision of human resources and equipment. Conversely, Verma and Saxena (2020) discouraged the overreliance of location-based measures on spatial proximity to determine access, thereby ignoring cultural and socio-economic barriers. Such discussions show that there is a true complexity in finding adequate definitions and measurements of accessibility. Additionally, national-level reports like the Rural Health Statistics (MoHFW, 2023) provide excellent information on the number of facilities and staff. There is a lack of spatial visualization or contextual interpretation at the district level. A crucial limitation of earlier studies is their poor integration of WHO norms and IPHS standards into spatial assessments, thus undermining the ability to assess performance and coverage against global and national standards. The gap remains especially glaring in district-specific scenarios like YSR (Kadapa), where the co-existence of intensive processes of urbanization and rural poverty calls for a much more nuanced, spatially informed healthcare planning approach. With the application of Geographic Information System (GIS) tools, this study attempts to present a detailed spatial view in healthcare infrastructure.

3. DATABASE AND METHODOLOGY

3.1 Study Area

Andhra Pradesh, located on the southeastern coast of India, draws its varied geography from coastal plains, fertile river deltas, and rugged hilly terrains. The state, consisting of 26 districts (Figure 1), faces demographic and infrastructural problems peculiar to each district. According to the 2011 Census, the population of Andhra Pradesh was about 49.6 million of which approximately 70 percent live in rural areas (Government of India, 2011). The HDI value for the state is 0.642, which portrays moderate development; however, disparities occur between urban and rural areas (Government of India, 2022). Urban towns like Visakhapatnam, Vijayawada, and Guntur are placed much better in terms of healthcare facilities while enjoying the advantages of good infrastructure and easy availability of medical professionals. However, the rural areas and the tribal pockets, especially in the areas of the Eastern Ghats and the Rayalaseema region, experience healthcare access deficits due to several reasons, such as geographic isolation, poor transportation networks, and socio-economic constraints.

Figure 1: Study Area: YSR District (Erstwhile and New Boundaries)



Source: Author (2023)

Andhra Pradesh has a healthcare infrastructure built on a tier system providing comprehensive care to its population. On the frontlines are the Primary Health Centres (PHCs) and Community Health Centres (CHCs), established to serve primary healthcare needs. There is, however, considerable concern about their functionality and adequacy. A survey conducted by Jan Swasthya Abhiyan and People's Monitoring Committee revealed that only about half of the existing PHCs and not a single CHC satisfied the Indian Public Health Standards (IPHS), with each PHC serving an average of 38,740 persons, far more than the stipulated norm (Vadlamudi, 2016). The situation is worsened in tribal and hilly regions, where each CHC in plains caters to 120,000 people, and in tribal areas, about 80,000 (Government of India, 2022). To tackle these concerns, a few measures have been initiated at the state level. Dr. YSR Aarogyasri Health Care Trust was initiated in 2007 and rejuvenated in 2020 to provide financial assistance for medical treatment to families with an annual income of less than ₹5 lakh diagnosed with various health conditions (Government of Andhra Pradesh, 2020). Andhra Pradesh Medtech Zone (AMTZ) at Visakhapatnam is also India's first medical device park, aimed at curbing import dependence and promoting innovation in medical technologies (Government of Andhra Pradesh, 2016).

YSR District has an area of 15,359 sq. km, it comprises 51 mandals, 5 revenue divisions, and 919 villages. The data record shows that there are 28.8 lakh persons in the district, constituting 6% of the total of Andhra Pradesh. The urban population forms 33.4%, with a population density of 188 per sq. km. The sex ratio is 985, and the literacy rate is 67%. Moderate Population Growth Rate (2000-2011) at 10.79%. Factors such as the administrative setup and demographic parameters indicate a mixed existence of rural and semi-urban facets.

YSR District has a strong economic contribution to Andhra Pradesh with a 5% contribution to the state's Gross State Domestic Product (GSDP). Per capita income is ₹1,47,213. The economy is spread across three big sectors: services (41%), agriculture and related services (34%), and industries and manufacturing (25%). The district, in spite of this equilibrium, still has issues regarding poverty, skills of the workforce, and unbalanced economic growth. The region also stands at position 8 in the state Multidimensional Poverty Index, highlighting the continuity of socio-economic vulnerabilities. The district has a road density of 34 kilometers for 100 square kilometers and 177 kilometers per lakh population. This makes it the fifth-best in the state to connect by road, rail, and air. A notable 69% of the mandal headquarters in the district connect to both state and federal highways. With a power capacity of 2886 MW, the YSR District makes up 16% of the total installed power in the state. When it comes to land use, 34.6% is wasteland, 20% is net sown area, and 33% is forest cover. Farming plays a key role in rural life here. 85% of farmers own less than two acres and earn ₹2.61 lakhs per hectare.

Environmental issues are a big deal in the YSR District. This area often faces droughts and water shortages, along with problems like heat waves, floods, and dropping groundwater levels. To make things worse, the district has poor infrastructure, many people living in poverty, and not much crop variety. It's ranked 2nd among Aspirational Districts and 10th in meeting Sustainable Development Goals. To fix these problems and help everyone in the area, the district needs a smart plan. This includes turning Kadapa into a place for industry and boosting farming-related businesses like raising livestock. These steps could help balance out the differences in development across the region and boost the economy for everyone.

3.2 Aim

This study intends to critically examine the spatial setting of health facilities, access to these facilities, and service coverage in YSR District (Kadapa), Andhra Pradesh.

3.2 Objectives:

1. To examine the performance of health indicators recommended by the WHO.
2. To examine the spatial distribution and categorization of health facilities existing in the district.
3. To Assess the accessibility of these services, considering geographic and population variances.
4. To locate underserved and underperforming areas and to suggest spatial strategies for equitable healthcare access.

3.3 Hypothesis:

With respect to rural and urban areas in YSR District, an acute imbalance exists regarding spatial distribution and access to healthcare facilities, thus leading to inequitable service coverage and outcomes for healthcare.

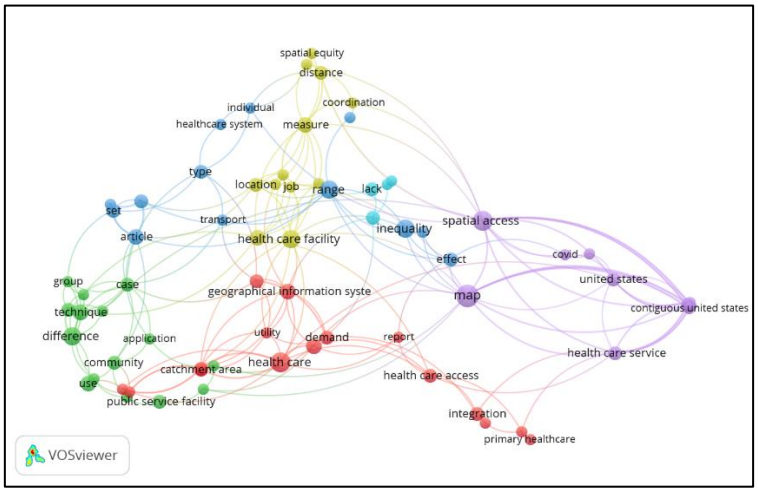
3.4 Methodology Summary and Data Collection

The methodology includes quantitative data analysis and geospatial mapping of the healthcare accessibility assessment. The study employs secondary data, mostly from the District Medical Health Office (DMHO), 2023; such data include:

1. The number and types of healthcare facilities (DH, SDH, CHC, PHC, HWC-SC).
2. Health indicators: institutional birth rate, death rate, maternal and infant mortality rates.
3. Facility-to-population ratios: doctors, beds per 1,000 population.
4. Distance buffers of 5 km and 10 km and catchment from the PHC.

Additionally, gaps were identified related to the facility placement (especially in the remotest northern mandals), unavailability of staff, infrastructure like laboratories and blood banks, and distance barriers for populations in the rural areas. The study proceeds using a mixed-method approach consisting of descriptive spatial analysis-normative comparison (against IPHS/WHO standards) to justify planning recommendations for the development of infrastructure and policy adjustments. The results would help local governments and planners in making decisions.

Figure 2: Network Visualisation of co-occurrence of words from Research papers in VOS viewer



Source: Author

the network visualization map in Figure 2, created by VOSviewer, shows the conceptual structure of literature related to health access and spatial analysis. it uses the term co-occurrence analysis to find out which terms frequently appear together and their relationships/associations into color-coded clusters, each clustering indicating a thematic focus area in the research field. in producing the network visualization map in vosviewer, one had to extract bibliographic information from a respective database (say, scopus, web of science) using relevant search terms such as "healthcare accessibility," "spatial analysis," and "health facilities." the dataset was then imported into vosviewer, and terms were selected for co-occurrence analysis from titles and abstracts. a threshold was set to select frequently occurring terms, and the software grouped terms related to one another into color-coded clusters. thus, we have the symbolism of a conceptual co-occurrence network.

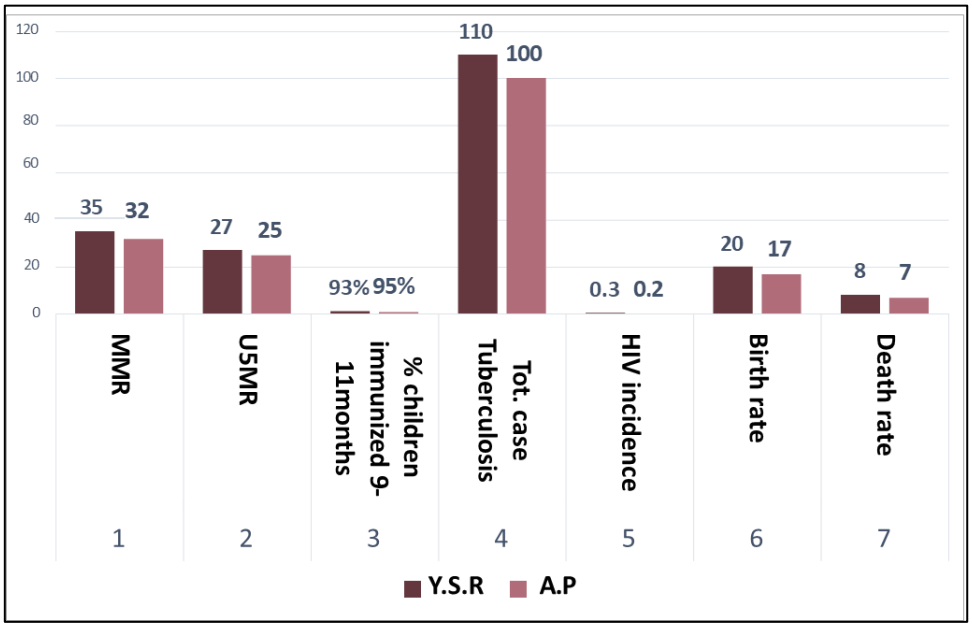
In the middle of the VOSviewer-made network map, core terms, such as “health care facility,” “health care,” “geographical information system,” and “map,” become highly interconnected nodes. Being at the center means the term has a foundational bearing on the studies in question and gets cited often by research articles on healthcare accessibility. These terms serve as conceptual connectors among different research fields and, thus, underscore the significance of GIS and spatial mapping tools in analyzing and improving healthcare infrastructure. The red cluster points to research in spatial planning and service area optimization, with keywords like “catchment area,” “public service facility,” “integration,” and “primary healthcare” geared toward facility allocation and coverage modeling.

The surrounding clusters contextualize the theme explored in the chart. The blue and cyan clusters discuss the challenges of equity and policy issues and contain terms such as “inequality,” “lack,” and “coordination,” signifying that these studies look at systemic gaps in healthcare, particularly those of underserved populations. The yellow cluster is oriented toward determinants of accessibility, with key terms like “distance,” “location,” and “transport” to describe issues of spatial equity and the effect of physical geography in service delivery. Conversely, the green cluster pertains to methodological research, implying a focus on innovations in GIS techniques and data-based modeling in the context of public health analysis. The purple cluster, hinging upon terms like “spatial access,” “United States,” and “COVID,” apprehends pandemic-era studies that illustrate how global crises stimulate intense exploration into healthcare access.

3.5 RESULTS AND DISCUSSION

Figure 3 presents an interesting glance at the health status and distribution of healthcare facilities in YSR District (Kadapa), Andhra Pradesh. The major indicators of health show that the district is barely behind the average of the state on a few critical health indicators. For instance, the infant mortality rate and mortality rate of children are higher in YSR at 35 and 32, respectively, in comparison to 32 and 27 in the state. Immunization of children below the age of 1 year is good, viz., 93%, yet it lags slightly behind the 95% state average. The incidence of tuberculosis is slightly higher in YSR (110 cases) compared to Andhra Pradesh as a whole (100 cases), thereby requiring stronger control efforts.

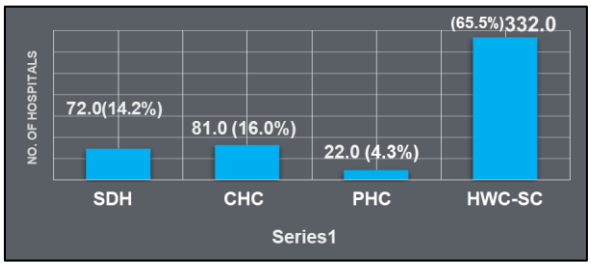
Figure 3: Major Key Health Indicators performance comparison between the YSR District and Andhra pradesh.



Source: Author (2023)

Figure 4 shows the spatial distribution of health facilities within a 10-kilometer buffer of the national highway, which is heavily laden with primary healthcare facilities. A large proportion of the health centres identified fall into the primary healthcare area, with the value of 65.5% representing 332 health centres all categorized as the Health and Wellness Centre-Sub Centre (HWC-SC). There are not as few health facilities higher in the health system. The Sub-District Hospitals (S.D.H.) comprised about 14.2%, Community Health Centres (C.H.C.) comprised about 16.0%, and Primary Health Centres (P.H.C.) comprised about 4.3%. Though arrangements supporting basic healthcare access exist, there are low levels of mid- and higher-level medical services, which is ultimately significant to provide more care.

Figure 4: Hospitals based on Facility type within a buffer of 10 km from the National Highway



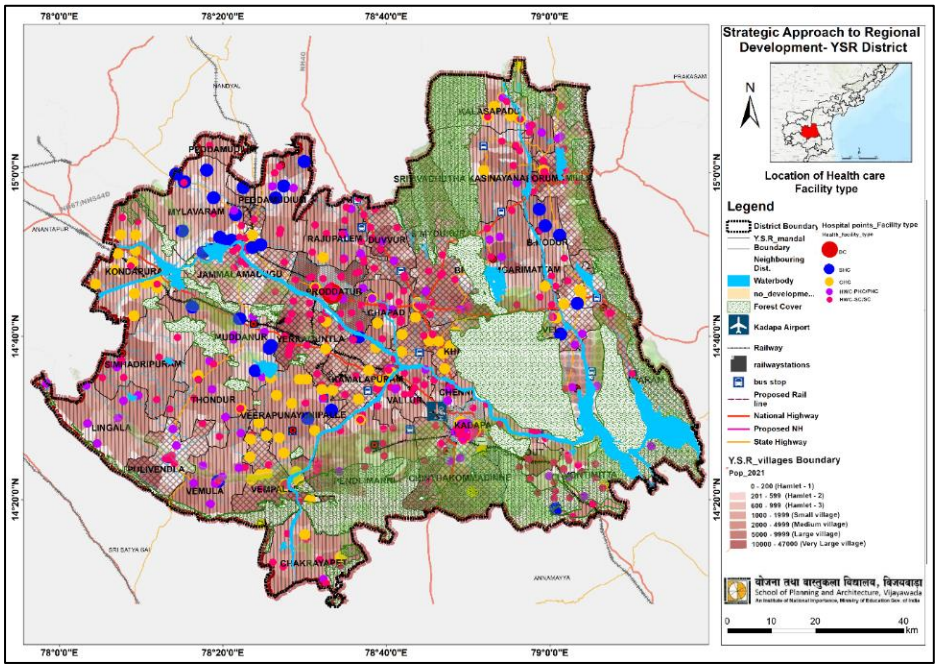
Source: Author (2023)

3.6 Health Infrastructure

3.6.1 Classification of Health Care Infrastructure Facility

In the YSR District (Kadapa) of Andhra Pradesh, a total of 702 hospitals were identified, illustrating the healthcare delivery model of the changing face of healthcare. Out of the total number identified, 271 hospitals (87.7% of the total) have modern and systematic service delivery methods and primarily considering modern allopathic methods of treatment. The remainder of hospitals practicing traditional systems of medicine included Ayurveda (13 hospitals, 4.2%); Homeopathy (11 hospitals, 3.6%), Unani (10 hospitals, 3.2%), and Naturopathy (4 hospitals, 1.3%). On ownership patterns, 66.6% (468 hospitals) are publicly managed, and 33.3% (234 hospitals) are privately managed. This demonstrates a significant public presence in the healthcare delivery model. Identified healthcare centers include the District Hospital (DH) located in Proddatur and the Sub-District Hospitals (SDHs) in Jammalamadugu and Pulivendla, which serve as major healthcare centers in the district. The data from these healthcare providers (Figure 5).

Figure 5: Spatial distribution of health facilities across the Y.S.R district



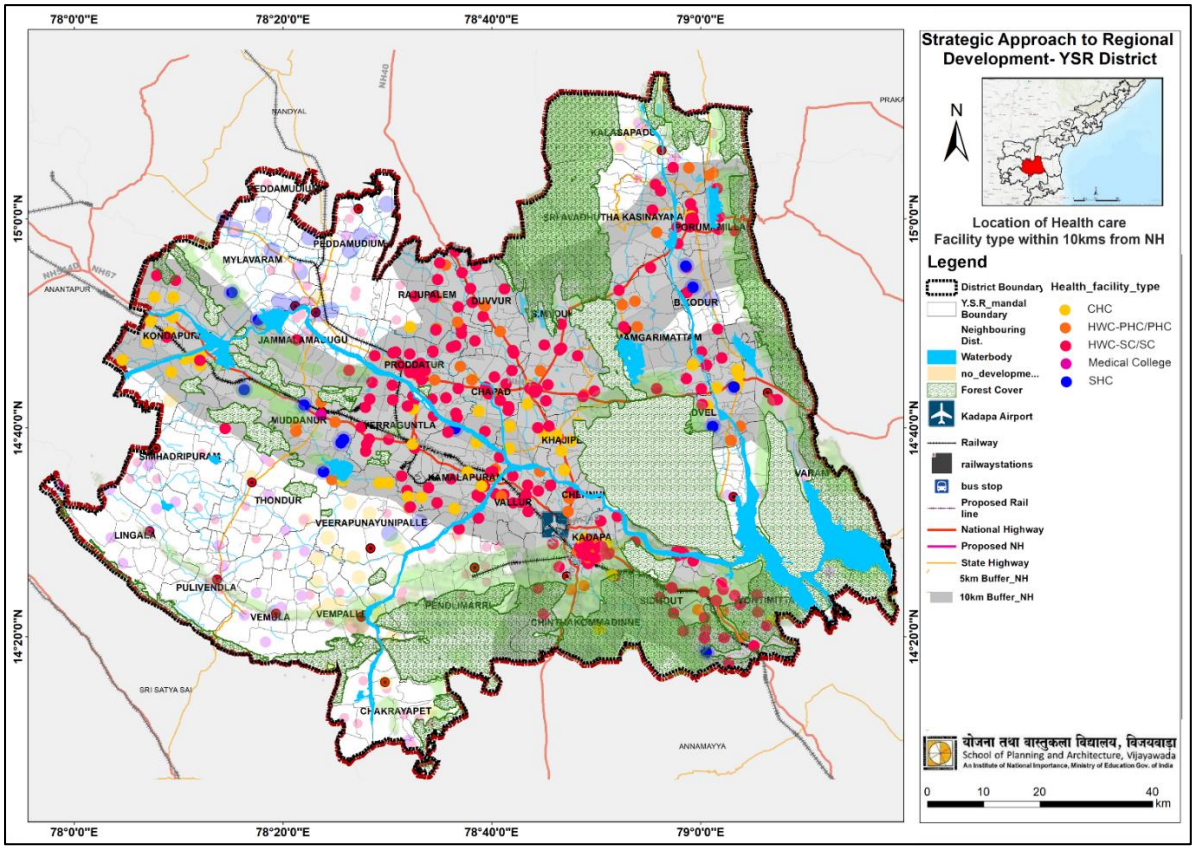
Source: Author (2023)

3.6.2 Buffer Analysis of Health Care Facilities

In the YSR District, distance from major transport routes is a key determining factor for access to hospitals or healthcare facilities. Having said this, from the remaining, 72.6% of all health facilities are within a 10 km buffer of the National Highway; about 60% are situated just 5 km away. Based on its location on key transport corridors, the health facility is easily accessible to a large population. While considering access from public transport points like bus stands, railway stations, etc., nearly 60.4% of hospitals are placed within 5 km of these points, thereby making a relatively well-connected health network in the urban and semi-urban zones. Public sector facilities such as SDHs, CHCs, and PHCs have about 54% average accessibility. HWC-SCs enjoy a more worthwhile rate, with 63.8% within that convenient distance, thereby highlighting their role in enhancing local-level outreach. Analysis of other particular types of facilities further stresses the role of spatiality in healthcare planning. Out of 109 CHCs, 51.4% (56 facilities) lie within 5 km of the major access points and 66.1% (72 facilities) within 10 km. For PHCs, 57.1% (68 of 119) are located within 5 km, whereas 68.1% (81 facilities) lie

within 10 km. HWCs-SCs, which constitute the largest segment of public health units, also register encouraging coverage, with 281 of 468 or 66.7%, being located within 5 km and 332 (70.94%) within 10 km (Figure 6).

Figure 6: Location of healthcare Facility type within 10 km from NH



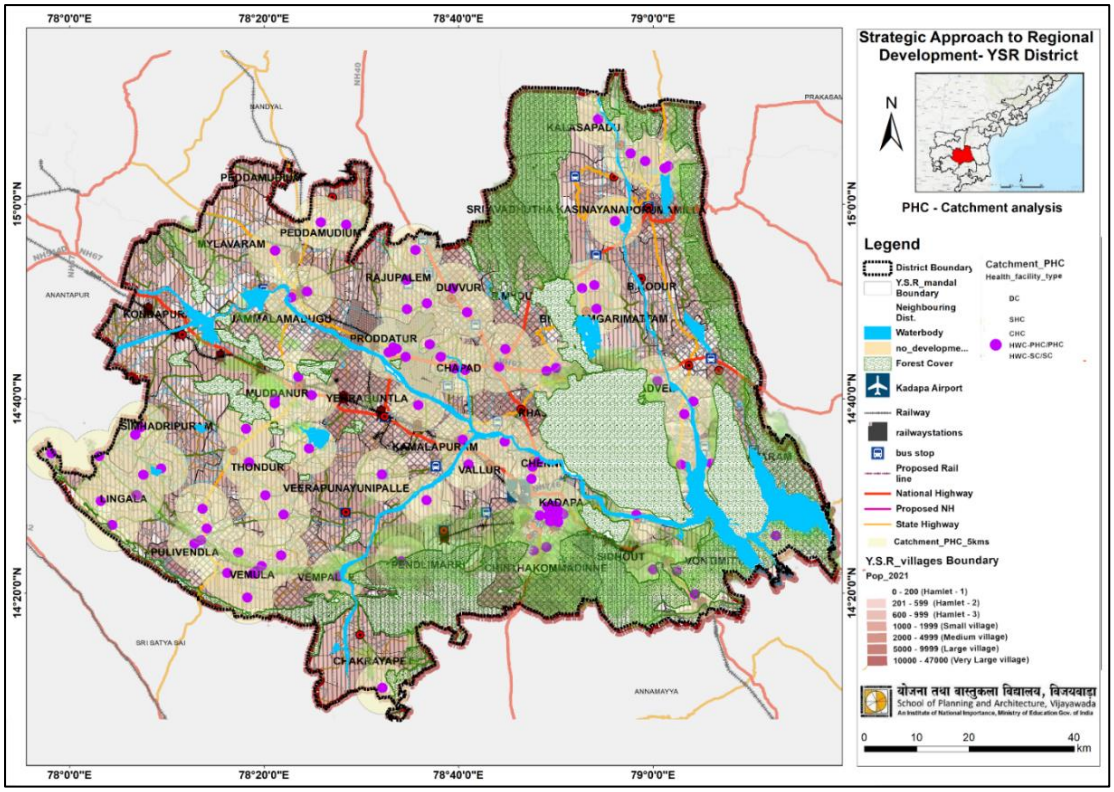
Source: Author (2023)

3.6.3 Health Care Facility Catchment Analysis

The catchment analysis for Primary Health Centres (PHCs) in YSR District found a total number of 523 functional health centres covering around 74.5% of villages under the 5 km buffer zone specified in the Indian Public Health Standards (IPHS). This implies considerable progress has been achieved by the district in maintaining an effective spatial arrangement of primary healthcare infrastructure. The bulk of the population in central and easily accessible mandals is served well by PHCs, which are positioned within a reasonable distance so that timely access can be obtained to basic health care services, including maternal care, immunization, and

The examination of healthcare access indicates that there has been substantial development of the treatment of common conditions throughout the region. But it must also be noted that spatial inequities persist, especially in the northernmost peripheral mandals. Many of the villages in these mandals are currently beyond the crucial 5-kilometer radius of adequate access to health care coverage, and face additional challenges, including limited road access and terrain challenges. Furthermore, there has been insufficient investment in health infrastructure to meet community needs, resulting in areas with marginal access to basic health services. The consequences of these spatial inequities in health access contribute to entrenched inequities in access to health care, especially affecting rural, vulnerable, and marginalized populations. It is imperative that action is taken to remediate these gaps, not just for equity in health care access, but also to pursue the possibility of universal health coverage (Figure 7).

Figure 7: Catchment analysis of Primary health care centers.



Source: Author (2023)

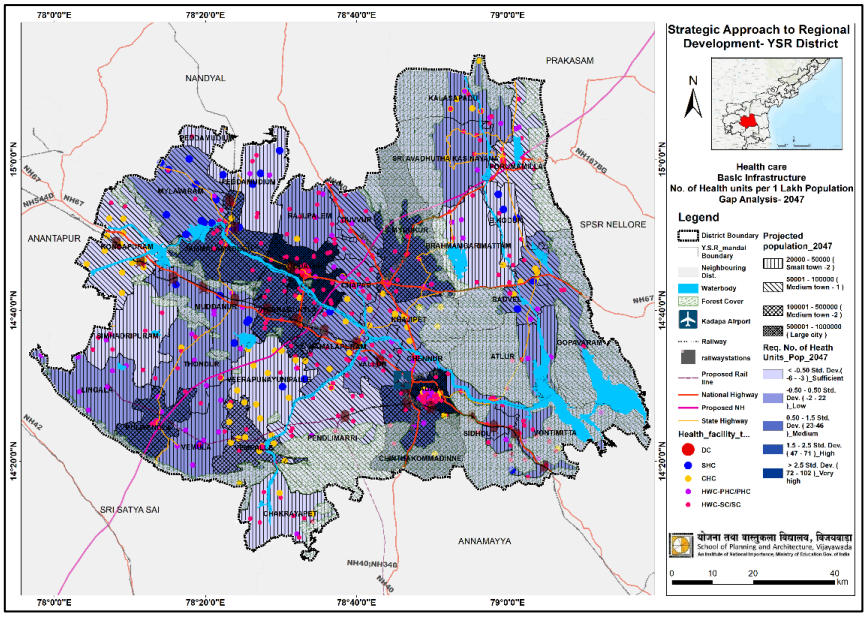
3.6.4 Causative Relationship Between Location Factors and Healthcare Accessibility

Across YSR District, accessibility outcomes are influenced by the spatial structure of settlements and their proximity to transport corridors. Northern mandals are on the peripheries of the district and lack adequate road infrastructure. There are many villages in the poorer road network and hilly terrain mandals that are double the 10 km PHC coverage buffer. The steep terrain and limited transport network has a spatial scenario in which travel time increases and healthcare use decreases reinforcing spatial inequity. However, those settlements within 10 km seem to have a higher density of facilities resulting in supply clusters, which are mostly concentrated on transport corridors like National Highways. Transport corridors seem to attract greater levels of infrastructure investment while rural areas remain obstructed. Emerging from urban centers like Kadapa and Proddatur regardless of the greater accessibility, are overused hospitals in which the populations of medical visitors outnumber available doctors and beds creating disproportionate doctor-population ratios. Semi-urban areas adjacent to transport nodes have relatively better accessibility, in part because good road access helps patients move and enables staff to mobilize effectively. Access seems most severely affected for socio-economically deprived rural settlements with limited access to relatively nearby basic services for patients due to poverty, lack of knowledge, and cultural barriers associated with poor health indicators such as higher infant mortality and incidence of tuberculosis. Thus, location in terms of terrain, access to highways, and socio-economic conditions influence levels of accessibility that directly correlate with healthcare coverage and health outcomes throughout the district.

3.6.5 Health Care Facility Indicators

Spatial analysis, as seen in Figure 8, presents hospitals in YSR District, passing from the 100,000 population, a great concentration of health infrastructure along the national highway, mainly in Kadapa and Proddatur Mandals. In essence, there happens to be clustering due to the density of population and the best transport connectivity being offered into the development of infrastructures in these areas. The national highway fosters access for patients and health professionals along these two mandals, and hence, a higher number of healthcare units is seen per lakh population over there compared to remote areas. While services in central urban zones are better delivered, it still means the uneven location of facilities favors a relatively served condition for peripheral areas and rural mandals.

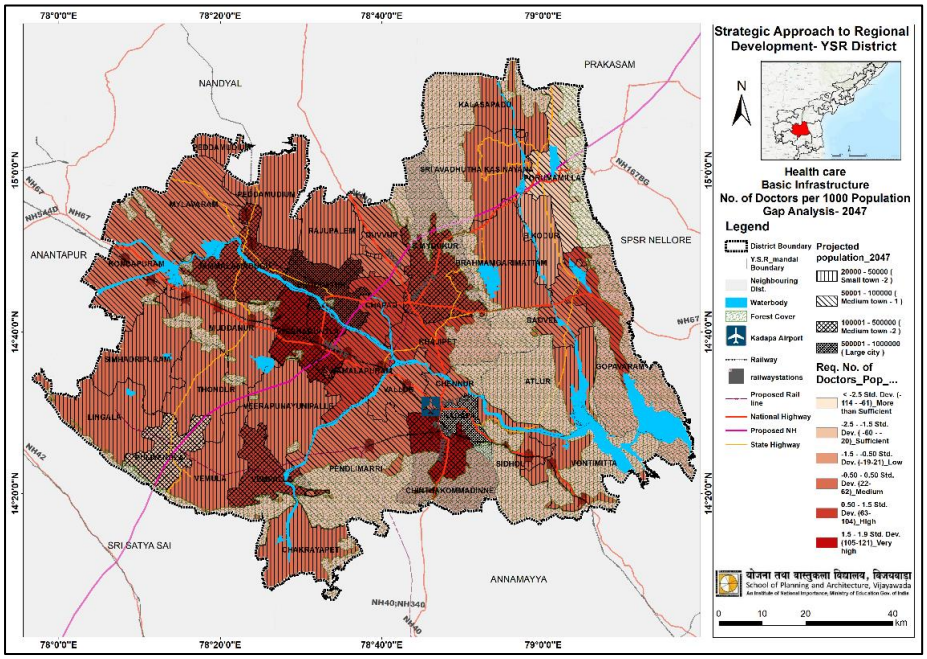
Figure 8: Number of Health care Units per 100000 population (Year 2023)



Source: Author (2023)

Figure 9, demonstrates the existing healthcare scenario of the mandals of Kadapa, Yerraguntla, Proddatur, and C.K. Dinne, which indicates a serious deficit in the provision of medical services. According to the World Health Organization (WHO), a minimum of one doctor for every 1,000 population is the standard on which to measure medical services. While these areas have the advantage of larger populations, they still have better transportation and communication systems. However, all of the mandals are suffering a massively disproportionate number of medical professionals. This disparity is not only a statistic, but rather an acute healthcare issue that has significant effects on public health and well-being. A combination of circumstances surrounding health-care delivery in these regions imposes significant strains on the current health infrastructure. The services provided by the hospitals and clinics operate under significant ineffectiveness caused by a lack of trained medical personnel while battling the ever-increasing demand for accessible health care clinics or hospitals. Hospitals and clinics have difficulty scheduling reasonable appointment times, patients endure long waits, services are sub-par due to over-utilization of preventive health measures, and at worst, delays in diagnoses resulting in missed diagnoses. The need for accessible and high level quality of care is amplified in spite of the challenge of an urbanizing geographic context.

Figure 9: No. of Doctors per 1000 population (Year 2023).



Source: Author (2023)

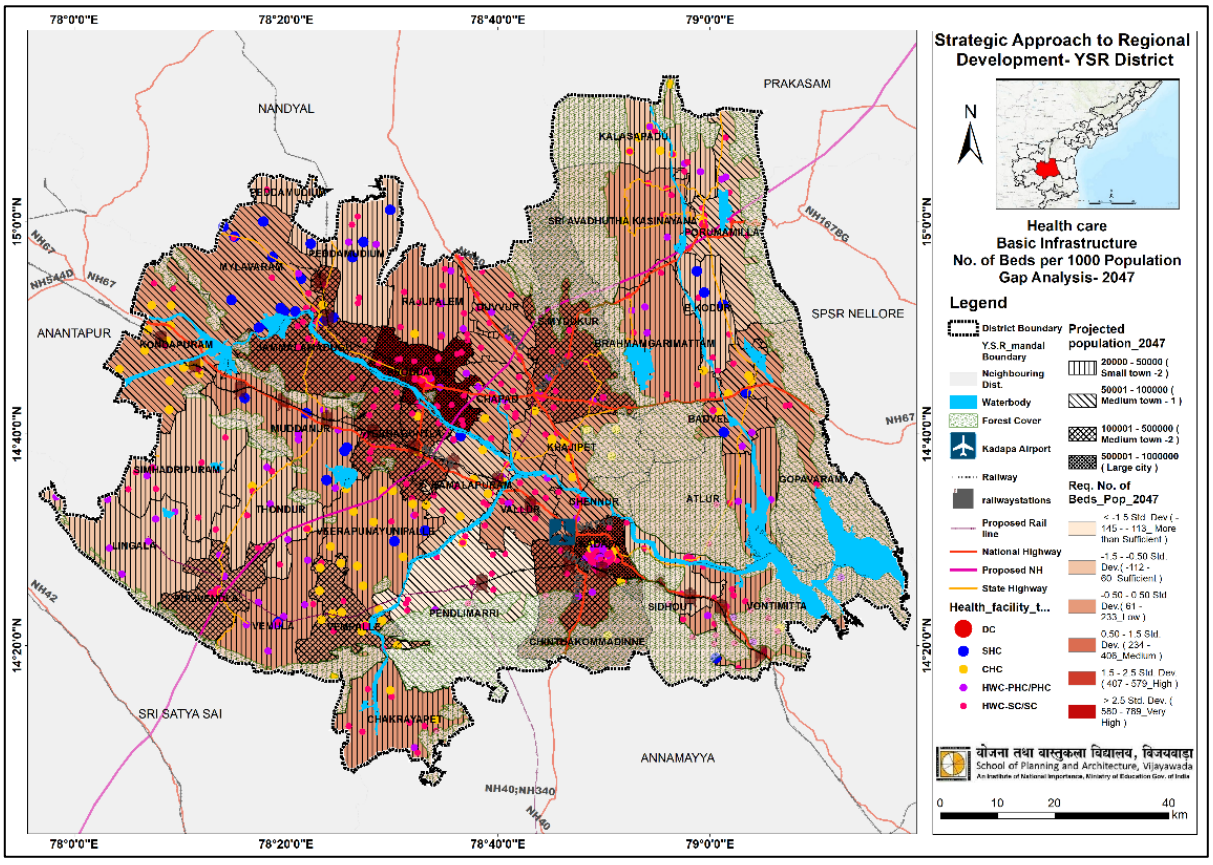
The spatial map in Figure 10 depicts an alarming pattern of mandals in Gopavaram, Proddatur, Yerraguntla, and Duvvur, where the number of hospital beds and the hospital beds to population ratio are marginally below the national standards. This represents a serious pressure on the healthcare infrastructure across the region. The discrepancy may not seem like a large amount when looked at, but the practical ramifications are extraordinarily severe when employing a use case like medical emergencies, seasonal outbreaks of diseases, or crises like a health pandemic. A lack of hospital beds disrupts timely patient admissions and the overall healthcare system's ability to adequately assess and respond to spikes in demand.

Interestingly, in the regional contexts employed, an example would be this issue of hospital bed shortages that could be compounded by having a very low doctor-to-population ratio.

There is an upward movement towards simply acknowledging that the health ecosystem, at those points of care, do not have the means to flex or cope with spikes in patient load or emergency medical needs. While there may be a couple of central urban pockets that adequately provide the level of bed supply and show better health infrastructure performance, that localized strength does not mean the rest of the region is able to leverage the inequitable supply and access. These imbalances necessitate a more sophisticated and context-dependent approach to health service planning and development.

Policymakers and planners should first think beyond the broad statistics and then conduct a detailed, micro-analysis of the service levels to identify which areas are 'underserved.' The activity of micro-analysis maps where the deliverables are lacking, and also gives evidence on a more accountable basis of where money is being spent. Providing detailed information will promote evidence-informed decision-making on where to invest healthcare dollars in order to prioritize work in underserved areas, particularly in critical shortage situations. This will assist with priorities such as opening a new hospital in an underserved region, upgrading and maintaining existing hospital services.

Figure 10: No. of Beds per 1000 population.

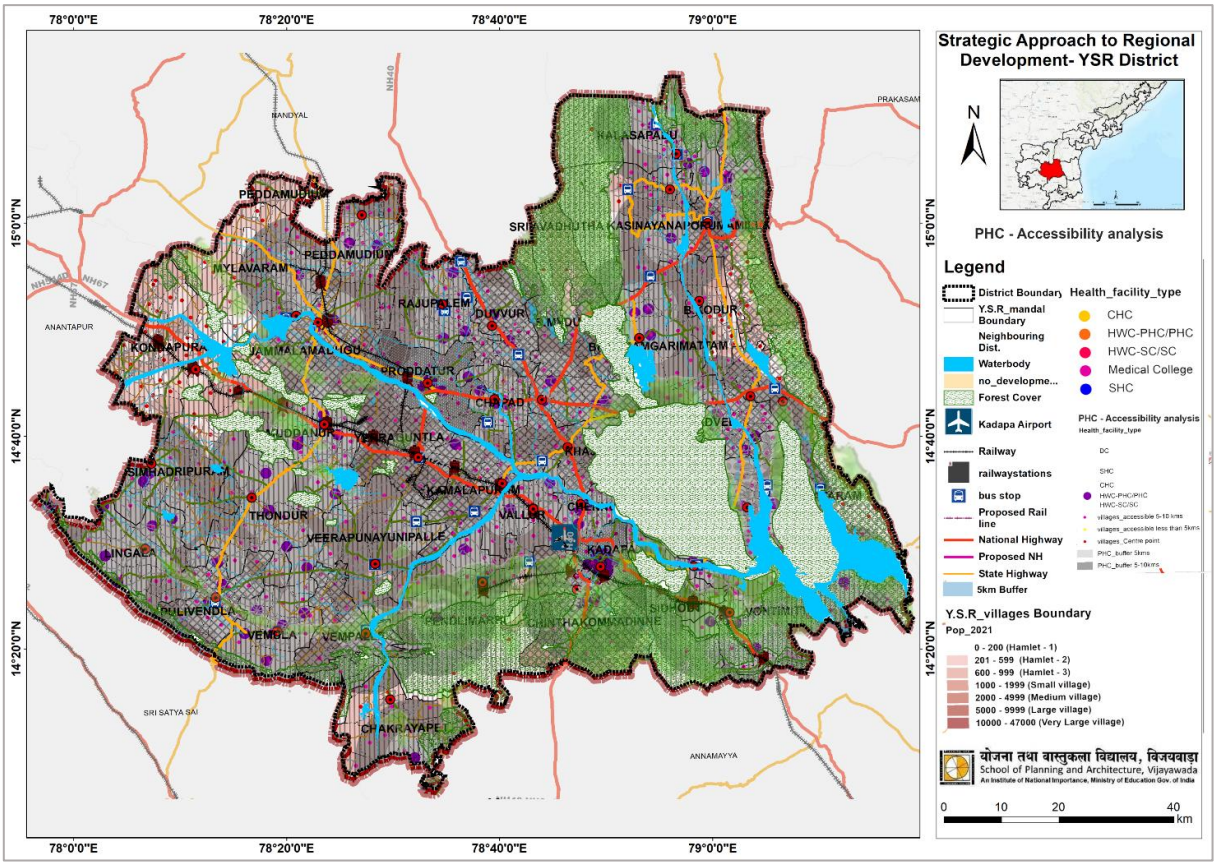


Source: Author (2023)

The accessibility analysis map, depicted as Figure 11, provides useful information on the spatial distribution and access to Primary Health Centers (PHCs) in the area. From this map, we can see that about 56.4% of villages have relatively good access to PHCs (within a 5km buffer). This number reflects a reasonably established primary healthcare network in just over half of the rural settlements. In addition, there are also about 36.6% of villages that are located within a 5–10 km distance of PHCs. Since these villages also represent significant populations where healthcare services can be accessed without too much of a travel burden, this is an encouraging statistic. These statistics also point out that there are just over 90% of the villages that are fairly located concerning essential healthcare services. However, the remaining 6.98% of villages fall outside of the 10 km accessibility threshold. This is concerning as for the residents of these isolated villages, distance is an important barrier to timely medical intervention, especially in emergencies, use of maternal care services, and management of chronic illnesses. The travel time advantage of these villages diminishes over long distances, and the determination of health risk to waiting for treatment increases significantly presence of even a small percentage of underserved areas highlights the critical need for

universal access to remain a priority for health care policy. Actionably addressing this gap would require focused interventions such as facilitating mobile health units; expanding road access to priority areas.

Figure 11: Accessibility analysis of PHC (Year 2023).



Source: Author (2023)

Gap Analysis and Policy Implications

The spatial assessment of the accessibility of healthcare in YSR district identifies three main gaps: (1) geographical inequity, whereby farther mandals and hilly areas fall outside of the service buffer of 5–10 km due to poor road access and sparse distribution of facilities; (2) distribution of infrastructure, whereby urban centres, such as Kadapa and Proddatur, show high clustering but overwhelmed hospitals, while semi-urban and rural areas lack mid-order and higher-order medical infrastructure; and (3) human resources, whereby the rates of doctors-to-population and beds-to-population fall below WHO and IPHS guideline levels in both rural and urban areas. These gaps together do not support universal health coverage and widen the gap in maternal and infant services, emergency service provision, and chronic disease management.

In order to address these deficits, policy interventions should focus on spatial equity and functional adequacy. For remote mandals, targeted investments in road systems and mobile health units may mitigate geographical constraints. Decentralizing secondary healthcare services—through the continued strengthening of Sub-District Hospitals and the upgrading and functioning of CHCs—would redistribute patients currently treated in Kadapa and Proddatur. State-level recruitment incentives, retention deals, and telemedicine can help provide care continuity through human resources. Lastly, a GIS (geographical information system) based decision-support system for future satellite facility planning can utilize spatially relevant data to allocate capital resources meeting WHO or IPHS standards. Collectively, spatially-oriented directions for policy will increase access and equity of healthcare delivery, consequently contributing to achievement of Sustainable Development Goal 3.

5. CONCLUSION

The schematic being realized in the physical atmosphere of Y.S.R District catalogs the trajectory of development with persistent disparities in infrastructural setup, accessibility, and human resources in the domain of health. While roughly seventy percent of such facilities in the district exist within 10 km distance from the national highway and transport hubs, those peripheral mandals, more so in the north and west, are yet facing problems with adequate access to primary and higher-order healthcare services. Per catchment analysis gives findings as well, wherein 74.5% of the villages fall under the coverage of PHCs within 5 km, and yet nearly 7% remain outside this range, which argues that interventions in spatial planning and facility distribution are required forthwith. The aforementioned mandals that have less doctor-to-population ratio and bed-to-population ratio just want outcries to be heard_indicating the pressing challenges. The times need a comprehensive multi-dimensional strategy to overcome these gaps. More Anganwadi

Centers, PHCs, SHCs, and mobile medical units need to come forth to serve the outreach in underserved regions. Equally vital are processes to support human resource development with attractive salary packages, good accommodations, and flexible staffing models, including those for super-specialty persons. With suitable infrastructure and special investment, the s ervices may really go through a metamorphosis in their quality and spread. The closer the district comes to creating spatial accessibility combined with a skilled human resource and facility upgrading, the closer to truly equitable and quality health care for all it gets

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