Spatial analysis of accessibility disparities to basic facilities among Adivasi settlements using GIS in Kottathara Panchayat, Wayanad, India

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Abstract

Spatial accessibility to essential services is a crucial determinant of socio-economic development among Adivasi communities. This study examines disparities in accessibility to basic infrastructural facilities among Adivasi settlements in Kottathara Panchayat, located in Wayanad district. Despite Kerala's overall progress in human development, tribal communities in Wayanad continue to experience spatial marginalisation due to geographical isolation, rugged terrain, and inadequate road connectivity. The study aims to assess inter- community variations in access to schools, primary health centres, administrative offices, and financial institutions. The research integrates primary and secondary data within a Geographic Information System (GIS) framework. All 98 Adivasi colonies were geo-located using GPS, and road networks were digitised to conduct network-based closest facility analysis. A stratified random sample of 274 households representing major communities' like *Kurichiya, Paniya, Kattunayakar, Uraalikurumar, and Kurichiya converts* was surveyed to contextualise spatial findings. Average road distance to major facilities was used as the principal indicator of accessibility. Results reveal significant spatial inequality shaped by settlement location, slope conditions, and infrastructure availability. *Paniya* settlements exhibit relatively better accessibility (6.25 km), whereas *Uraalikurumar* settlements record the highest average distance (8.86 km). Although *Kattunayakar* settlements show moderate average distance (7.73 km), their lack of formal road connectivity makes them the most physically isolated. Overall, 22 colonies lack direct road access. The study highlights the need for targeted infrastructure planning to reduce spatial exclusion and promote inclusive development.

Keywords: Spatial accessibility; Adivasi settlements; GIS-based network analysis; Infrastructure inequality; Road connectivity; Tribal marginalisation; Socio-spatial exclusion; Kottathara Panchayat; Wayanad district; Inclusive development.

Introduction

Indigenous communities in India, officially recognised as Scheduled Tribes (STs) and commonly referred to as *Adivasis,* have historically experienced structural marginalisation in terms of access to land, resources, and basic infrastructural facilities. In Kerala, social relations and spatial organisation were profoundly shaped by caste-based hierarchies that regulated

access to public spaces, economic resources, and settlement locations, thereby institutionalising patterns of spatial and social exclusion (Robert, 1964; Sanal Mohan, 2016). Although Kerala has made significant progress in human development indicators, *Adivasi* communities continue to remain on the margins of development, particularly in regions such as Wayanad district, which has the highest concentration of *Adivasi* population in the state. Major *Adivasi* communities in this region, including the *Paniya, Kurichiyar, Uraalikurumar, Kattunayakar*, and *Kurichiya converts* (*Kurichiya* people converted to Christianity), exhibit considerable variation in socio-economic conditions, access to land, and integration with mainstream development processes. Historical and ethnographic evidence suggests that the *Kurichiyar* community has relatively better access to land and resources, whereas other communities, such as the *Paniya and Kattunayakar*, have experienced prolonged socio-economic deprivation and exclusion (Therakam, 2010; Sebastian, 2018).In this study, the terms *Adivasi* and *Tribal* are used interchangeably to refer to communities officially recognized as Scheduled Tribes (STs) under the Constitution of India. The term *Adivasi* is commonly used in socio-cultural and political discourse to denote indigenous communities, while *Tribal* is the administrative and policy term used in official records. Both terms are employed in this article to maintain contextual relevance without implying conceptual differences.

One of the most critical yet often overlooked dimensions of this marginalisation is spatial accessibility to essential services. Many *Adivasi* settlements are located in geographically isolated areas characterised by rugged terrain, forest fringes, and limited transportation infrastructure. Such spatial isolation significantly limits these communities' access to basic facilities, such as educational institutions, healthcare centres, administrative offices, and financial services. The physical distance between settlements and facilities, combined with poor road connectivity and difficult terrain, creates barriers that restrict mobility, limit access to opportunities, and reinforce existing socio-economic inequalities. Therefore, the question of accessibility is not merely a matter of physical distance but reflects deeper structural inequalities embedded in the spatial organization of rural settlements.

In this context, the present study focuses on analysing the disparity in accessibility between *Adivasi* settlements and the available basic facilities in Kottathara Panchayat of Wayanad District Kerala. The study seeks to systematically examine the spatial distribution of *Adivasi* colonies and evaluate their level of accessibility to key public facilities such as schools, healthcare centres, panchayat offices, village offices, and financial institutions. To achieve this objective, Geographic Information System (GIS) techniques are employed to accurately map the locations of Adivasi settlements and infrastructural facilities and to analyse their spatial relationships using road network based accessibility measures. By calculating road distances and examining connectivity patterns, the study identifies spatial variations in access and highlights areas where infrastructural disadvantages are most pronounced.

By emphasising spatial accessibility as the central analytical framework, this study aims to demonstrate that inequalities in development among *Adivasi* communities are closely linked to their geographical location and infrastructural connectivity. The integration of GIS-based spatial analysis with field-based observations provides a systematic and scientific approach to understanding accessibility disparities. The findings of this study are expected to contribute to a deeper understanding of the spatial dimension of marginalisation and to highlight the importance of equitable infrastructure planning in promoting inclusive and balanced regional development in Kottathara Panchayat.

Literature Review

The literature on Tribal development in India emphasises that spatial location and access to basic infrastructure play a crucial role in shaping socio-economic conditions and development outcomes. Geographic isolation, poor transportation networks, and inadequate infrastructural provision have been identified as major factors contributing to the continued marginalisation of Adivasi communities. Unlike mainstream rural settlements, many Adivasi colonies are located in remote forested areas, hill slopes, and marginal lands, which significantly restrict their access to essential services such as education, healthcare, administrative centres, and markets (Mathur, 1977; Burman, 1994). These spatial constraints limit mobility and reduce opportunities for social and economic advancement, thereby reinforcing patterns of marginalisation.

Early studies on Adivasi settlements in India highlighted that infrastructural accessibility is closely linked to settlement location and terrain characteristics. Adivasi communities living in remote and forested regions often experience poor road connectivity, which increases travel distance and time required to access essential services (Planning Commission, 2008). Inadequate transportation infrastructure not only restricts physical mobility but also affects access to education, healthcare, employment, and welfare programs. Studies conducted in *tribal*-dominated regions have shown that villages located farther from roads and service centres exhibit lower levels of educational attainment, higher health risks, and limited participation in development programs (Xaxa, 2011).

In Kerala, despite significant achievements in social development, spatial inequality in access to infrastructure persists among Adivasi communities, particularly in districts such as Wayanad. Research indicates that many *tribal* settlements in Wayanad are located in geographically isolated areas with limited access to basic services, including schools, healthcare facilities, and administrative institutions (Rajan, 2011). The spatial separation of Adivasi settlements from mainstream village centres has been identified as a major barrier to inclusive development. Poor road connectivity and difficult terrain conditions further exacerbate accessibility problems, especially during monsoon seasons, when many settlements become temporarily isolated (Kumar, 2016).

Accessibility studies have demonstrated that physical distance and connectivity significantly influence the utilization of public services. Greater distance from healthcare centres and educational institutions reduces the frequency of service utilization and contributes to lower health and educational outcomes among *tribal* populations (World Bank, 2012). Similarly, inadequate access to administrative centres limits the ability of *tribal* communities to benefit from government welfare programs and institutional support systems. These findings highlight the importance of spatial accessibility as a key determinant of development and social inclusion.

The application of Geographic Information System (GIS) techniques has significantly improved the ability to analyse spatial accessibility and infrastructural disparities. GIS-based network analysis enables the accurate measurement of road distances, connectivity patterns, and spatial relationships between settlements and facilities (Longley et al., 2015). Several studies have used GIS to examine accessibility patterns in rural and *tribal* areas and have demonstrated its effectiveness in identifying spatial inequalities and underserved regions (Chakraborty & Armstrong, 1997; Talen & Anselin, 1998). GIS provides a scientific and visual

approach to understanding spatial disparities and supports evidence-based planning for infrastructure development.

Studies focusing on *tribal* regions have emphasized that accessibility analysis using GIS is essential for identifying infrastructural gaps and improving service delivery (Government of India, 2014). Mapping settlement locations and analysing road network connectivity help planners identify remote and underserved areas and prioritize infrastructure development. GIS-based accessibility analysis also helps in understanding how terrain, road infrastructure, and settlement patterns influence access to services, thereby providing a spatial perspective on development inequality.

Although several studies have examined socio-economic conditions and infrastructural development among *tribal* communities, limited research has focused on spatial accessibility analysis at the Panchayat level using GIS techniques, particularly in tribal-dominated regions such as Wayanad. Most existing studies have examined accessibility at broader regional or district levels without providing detailed micro-level analysis of settlement-level disparities. Therefore, there is a need for localized spatial analysis to understand the extent of accessibility inequality among Adivasi settlements.

In this context, the present study addresses this research gap by analysing the disparity in accessibility of Adivasi settlements to basic infrastructural facilities in Kottathara Panchayat using GIS techniques. By mapping the spatial distribution of settlements and facilities and analysing road network connectivity, the study provides a detailed assessment of accessibility patterns and identifies spatial inequalities in access to essential services. This approach helps in understanding how geographic location and infrastructure availability influence accessibility and contribute to evidence-based planning for improving infrastructural provision and reducing spatial inequality among Adivasi communities.

Geographical Profile of the Study Area

The present study is conducted in Kottathara Panchayat, located in Vythiri Taluk of Wayanad district in the northern part of Kerala, India. Wayanad district forms part of the Western Ghats, a biodiversity-rich mountainous region characterized by a unique socio-ecological environment and a significant concentration of Scheduled Tribe populations. Kottathara Panchayat lies between approximately 11°39′ North latitude and 76°01′ East longitude and covers a total geographical area of 31.75 sq. km. The Panchayat is bounded by Panamaram Panchayat in the north, Kalpetta Municipality and Vengappally Panchayat in the south, Muttil Panchayat in the east, and Padinjarethara and Tariode Panchayats in the west. The administrative headquarters is located at Venniyod, which serves as a local service center connecting surrounding settlements through road networks.

Geographically, the Panchayat forms part of the Wayanad plateau and is characterized by undulating terrain, rolling highlands, and intervening valleys. The elevation and slope vary from moderately high to rugged highland regions, with general slope direction towards the northwest. The area consists of two major land categories: low-lying wetlands locally known as *Vayal* or *Kandam*, primarily used for paddy cultivation, and upland regions known as K*ara*, which support plantation agriculture such as coffee, arecaunut, pepper, and coconut. The Panchayat is drained by tributaries of the Kabani River, including the Venniyod River and Cherupuzha, forming a dendritic drainage pattern. The soil is predominantly lateritic loam

derived from weathered crystalline rocks under humid tropical conditions, supporting plantation and subsistence agriculture. The region experiences a humid tropical monsoon climate, with high rainfall during the southwest monsoon, moderate temperatures, and high relative humidity throughout the year.

Land use in Kottathara Panchayat is dominated by plantation agriculture, accounting for approximately 44.98% of the total area, followed by paddy cultivation (24%), settlements (18.71%), scrublands (9.2%), and water bodies (3.12%). Agriculture and allied activities such as cattle rearing constitute the primary economic base of the population. The occupational structure reveals a predominance of agricultural labourers, marginal workers, and small cultivators, reflecting a semi-agrarian rural economy with limited industrial development.

Demographically, Kottathara Panchayat had a total population of 19,375 as per the Census of India 2011, with a population density of 610 persons per sq. km. The Panchayat has a significant Scheduled Tribe population, constituting approximately 26.35% of the total population, which is substantially higher than the state average. The major Adivasi communities residing in the Panchayat include *Paniya, Kurichiya, Uraalikurumar, and Kattunayakar,* living in 98 distinct colonies distributed across 13 administrative wards. These colonies are spatially segregated settlements, often located in geographically isolated and environmentally marginal areas, reflecting historical processes of exclusion and marginalization. Among these communities, the *Kurichiya* are relatively better off due to land ownership and agricultural engagement, whereas the *Paniya* and *Kattunayakar* communities remain socio-economically marginalized, with high dependence on wage labor and forest-based livelihoods.
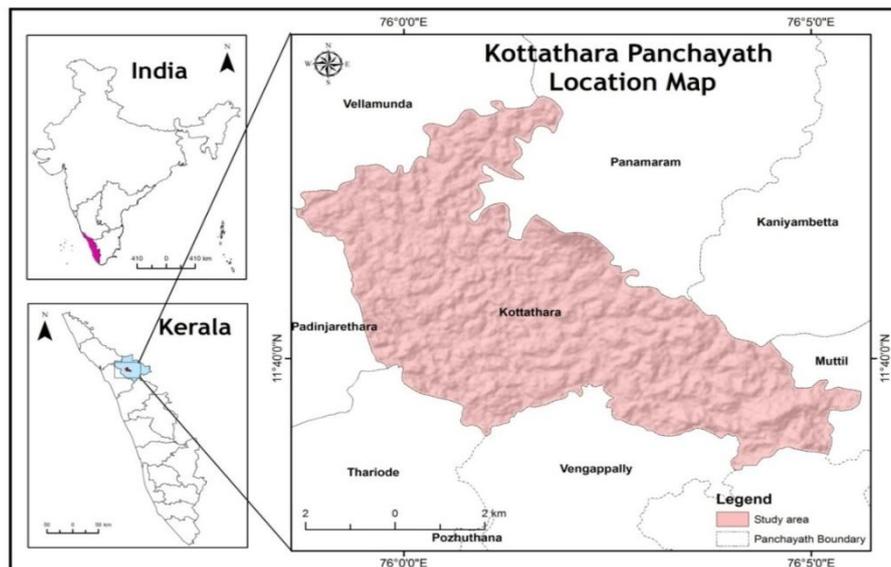

Fig: 1 Geographical location of the Study Area

The Panchayat exhibits moderate literacy levels compared to the state average, with disparities across social groups and settlements. Limited access to educational institutions, healthcare facilities, and transportation infrastructure, particularly in remote Adivasi colonies, contributes to persistent socio-economic inequalities. The settlement pattern is predominantly rural and clustered, with clear spatial differentiation between *tribal* colonies and non-*tribal* settlements.

This socio-spatial configuration makes Kottathara Panchayat an appropriate study area for examining caste-based social stratification, spatial inequality, and differential access to resources among Adivasi communities within a localized geographical context.

Database and Methodology

The present study integrates both primary and secondary data sources to ensure comprehensive spatial, demographic, and socio-economic analysis. Spatial datasets include Survey of India topographical maps, satellite imagery, and Global Positioning System (GPS) observations, while socio-economic and demographic information was obtained from census records, Panchayat-level statistics, and primary field surveys. The Survey of India topographical maps at 1:50,000 scale were used as the base layer for preparing the study area map and delineating settlement and infrastructural features. Multi-temporal satellite imageries, including Landsat 5 Thematic Mapper, Landsat 8 Operational Land Imager, and Sentinel imagery, were used for spatial referencing, land use interpretation, and GIS-based mapping. GPS was used to collect precise ground control points of *Adivasi* colonies and infrastructural facilities such as schools, health centres, and administrative offices.

Socio-economic and demographic data were obtained from the Primary Census Abstract (2011), Panchayat-level statistics (2011), Panchayat handbooks, and records from local administrative offices, including the Panchayat Office, Village Office, Integrated *Tribal* Development Project (ITDP), and *Tribal* Extension Office (TEO). These datasets provided detailed information on population characteristics, literacy levels, occupational structure, landholding patterns, and infrastructure distribution. In addition, road network data and accessibility information were digitized using Google Earth and integrated into a GIS environment to analyze spatial accessibility of *Adivasi* settlements to essential services. Supplementary information was also collected from published literature, government reports, and academic sources to support contextual and analytical interpretation.

Table 1: Secondary data sources used in the study

Sl. No	Data Source	Year of Acquisition	Path	Row	Resolution / Scale
1	Survey of India Topographical Map	1967–1971	—	—	1:50,000
2	Landsat 5 Thematic Mapper	02 February 1991	145	52	24 m
3	Landsat 8 Operational Land Imager	16 December 2011	145	52	15 m
4	Sentinel Satellite Imagery	26 January 2021	145	52	10 m

The methodological framework of the study combines geospatial analysis, quantitative socio-economic analysis, and qualitative field-based investigation. Kottathara Panchayat consists of 13 administrative wards and 98 Adivasi colonies inhabited by different *adivasi* communities, including *Kurichiya, Paniya, Kattunayakar, Uraalikurumar*, and *Kurichiya converts*. All *Adivasi* colonies were geo-located using GPS and mapped using Geographic Information System (GIS) software to analyze their spatial distribution. Accessibility analysis was carried out using GIS-based network analysis tools, where road networks digitized from Google Earth were used to calculate the distance between Adivasi settlements and essential infrastructural facilities such as schools, healthcare centres, and administrative institutions. This spatial

analysis enabled the identification of accessibility disparities and spatial marginalization patterns.

Primary data collection was conducted through detailed household surveys, structured questionnaires, and field observations. The study adopted a stratified random sampling technique to ensure representation of major Adivasi communities. Out of the total 1,616 *Adivasi* households in the Panchayat, 274 households were selected for detailed investigation. This includes 115 households from the *Kurichiya* community, 108 households from the *Paniya* community, and a complete enumeration (census method) of smaller communities, including *Kurichiya* converts (7 households), *Kattunayakar* (21 households), and *Uraalikurumar* (23 households). The researchers use questionnaire survey and collected detailed information on socio-demographic and socio-economic characteristics, including age, gender, household size, education level, occupation, annual household income, housing condition, landholding size, land use, and access to infrastructure.

In addition to the household survey, focus group discussions were conducted with Scheduled Tribe promoters and local community representatives to gain qualitative insights on spatial isolation. Secondary data collected from administrative offices were compiled and analysed using statistical techniques in spreadsheet and GIS environments. Spatial analysis and thematic mapping were carried out using GIS software to visualise settlement distribution, infrastructure accessibility, and socio-spatial inequalities.

Results and Discussion

The spatial distribution and accessibility of basic infrastructural facilities play a crucial role in determining the socio-economic development and social inclusion of indigenous communities.
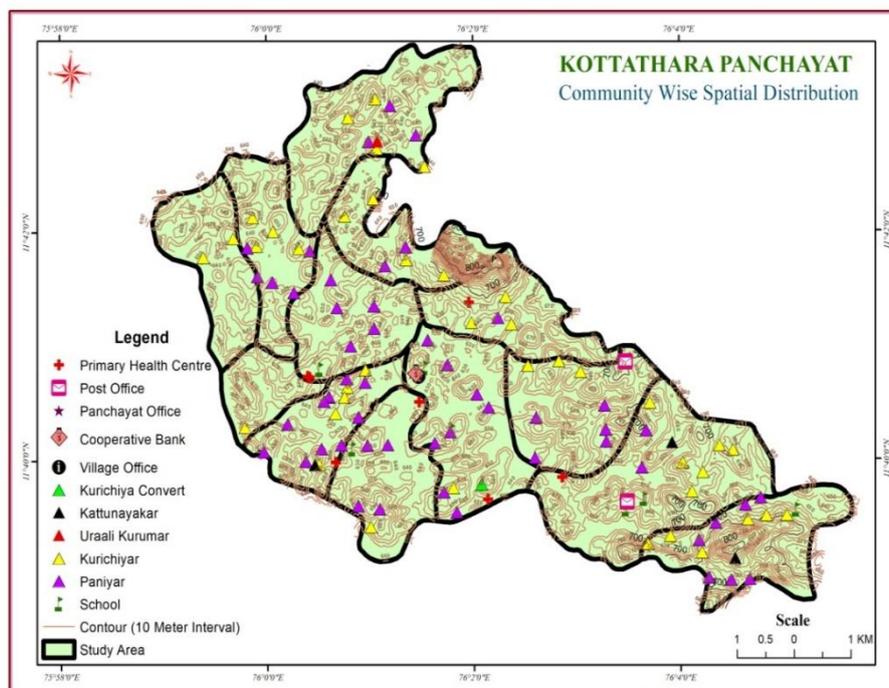

Fig: 2 Spatial distribution of Adivasi colonies

In Kottathara Panchayat, *Adivasi* communities are unevenly distributed across 98 colonies with a total population of 5,106, (Census,2026), comprising predominantly *Kurichiya* (2,541) and *Paniya* (2,422) communities, along with smaller populations of *Uraalikurumar*, *Kattunayakar*, and *Kurichiya converts*. The spatial isolation of these colonies, combined with physiographic constraints and socio-historical marginalisation, has resulted in significant inequalities in accessibility to essential services such as education, healthcare, administrative centers, and financial institutions. The results derived from GIS-based spatial analysis, network analysis, and field survey reveal pronounced inter-community and intra-community disparities in accessibility.

The figure 3.0 clearly illustrates that *Adivasi* colonies are scattered across all 13 wards of the Panchayat, but their concentration varies significantly. *Kurichiya* colonies are mainly concentrated in Venniyod, Myladi, Cheerathu, and Mechana wards, whereas *Paniya* colonies are more widely dispersed across Venniyod, Vandiyambetta, Karimkutty, and Madakkunnu wards. Smaller communities such as *Kattunayakar* and *Uraalikurumar* have very limited spatial presence, with only three colonies with the former and one colony with the latter respectively, indicating their extreme marginalization both spatially and demographically. The dispersed and peripheral location of these settlements reflects a pattern of spatial exclusion rooted in historical land alienation, socio-economic deprivation, and forest dependence.
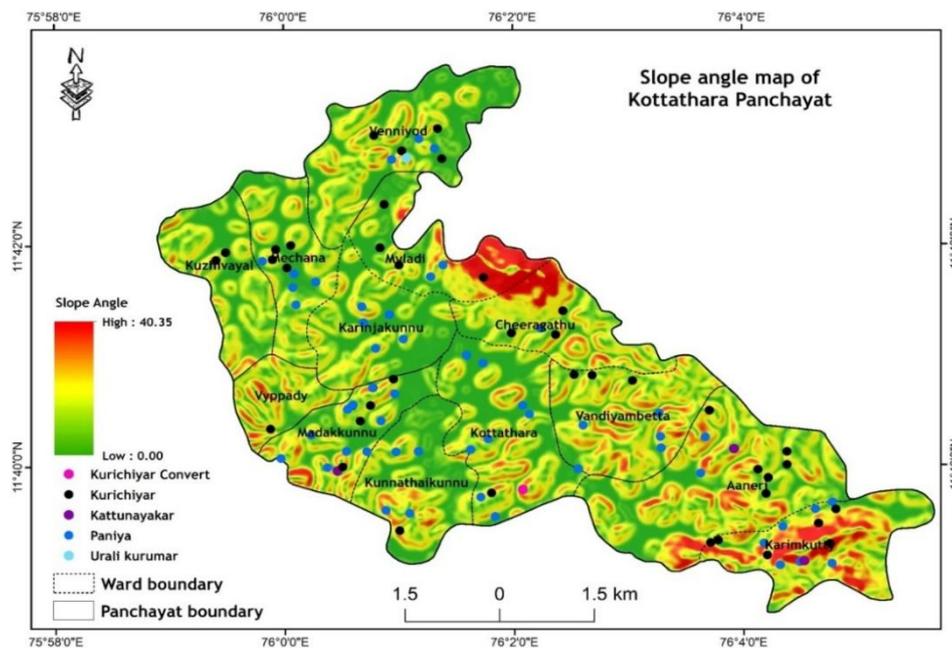

Fig: 3 Location of settlement colonies concerning the slope

The physiographic characteristics of the Panchayat significantly influence settlement accessibility. As shown in Fig. 3, many *Adivasi* colonies are located in moderately high to highland regions characterized by rugged terrain, steep slopes, and forested landscapes. *Kurichiya* and *Paniya* settlements are often located near agricultural lands, particularly paddy fields and plantation areas, while *Kattunayakar* settlements are primarily located in interior forest regions with extremely limited road infrastructure. The topographic barriers increase travel distance, reduce transport connectivity, and restrict access to essential facilities. Settlements located on steep slopes and hilltops face severe physical isolation, particularly during monsoon seasons when mobility becomes further constrained.

Table 2: Average Road Distance from Adivasi Settlements to Major Facilities in Kottathara Panchayat

Sl.No	Name	Total Colony	Average GVHSS Distance (in Km)	Average GHSS Distance (in Km)	Average PHC Distance (in Km)	Average P, V, PNCT, CB Distance (in Km)	No Road Connectivity	Total Average Distance (in Km)	Rank
1	Kurichiya Convert	1	3.94	1.87	6.19	20	0	6.67	2
2	Paniyar	52	5.32	7.77	5.28	6.03	7	6.25	1
3	Kurichiyar	41	7.85	5.96	5.83	6.04	11	7.27	3
4	Uraali Kurumar	1	13.88	9.88	8.61	9.34	1	8.86	4
5	Kattunayakar	3	8.81	8.58	9.47	7.85	3	7.73	5

The GIS-based closest facility analysis reveals significant inequalities in accessibility among different Adivasi communities. The network analysis (Fig. 4 to 6) demonstrates that accessibility varies widely depending on settlement location, terrain characteristics, and proximity to transportation networks.
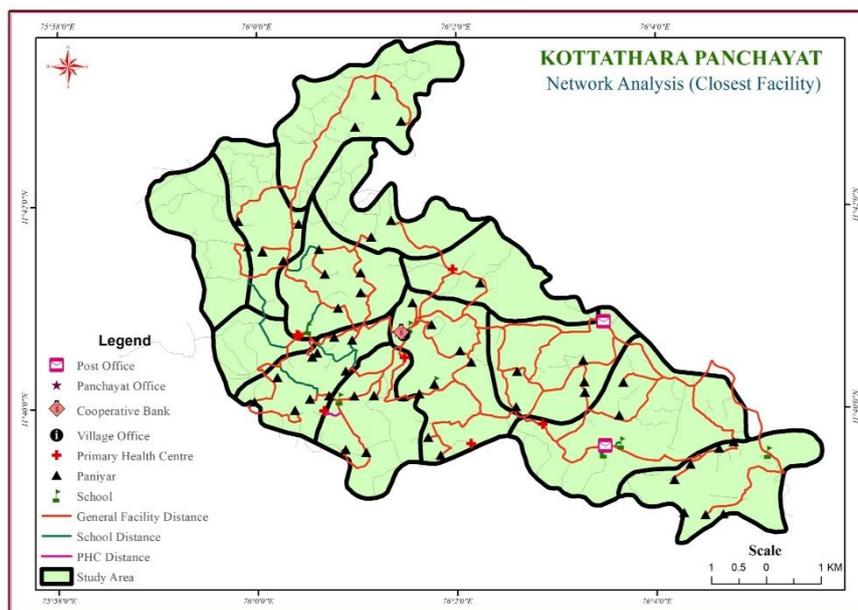

Fig: 4. Average Road distance from *Paniya* settlements to the major facilities

The average road distance analysis (Table 3.1) provides clear quantitative evidence of spatial inequality. The overall average distance to major facilities ranges from 6.25 km for *Paniya* settlements to 8.86 km for *Uraalikurumar* settlements. *Kurichiya* settlements have an average distance of 7.27 km, while *Kattunayakar* settlements show an average distance of 7.73 km. *Kurichiya* convert settlements show relatively better accessibility with an average distance of 6.67 km.

Among all communities, *Paniya* settlements show comparatively better accessibility, with the lowest overall average distance (6.25 km) to major facilities. This relatively better accessibility can be attributed to their location near agricultural lands and village peripheries, where road

infrastructure is relatively more developed. However, even within the *Paniya* community, seven settlements lack proper road connectivity, highlighting intra-community inequality. Despite their relatively favourable accessibility compared to other Adivasi groups, the Paniya community continues to experience marginalization due to socio-economic constraints, landlessness, and limited mobility options.
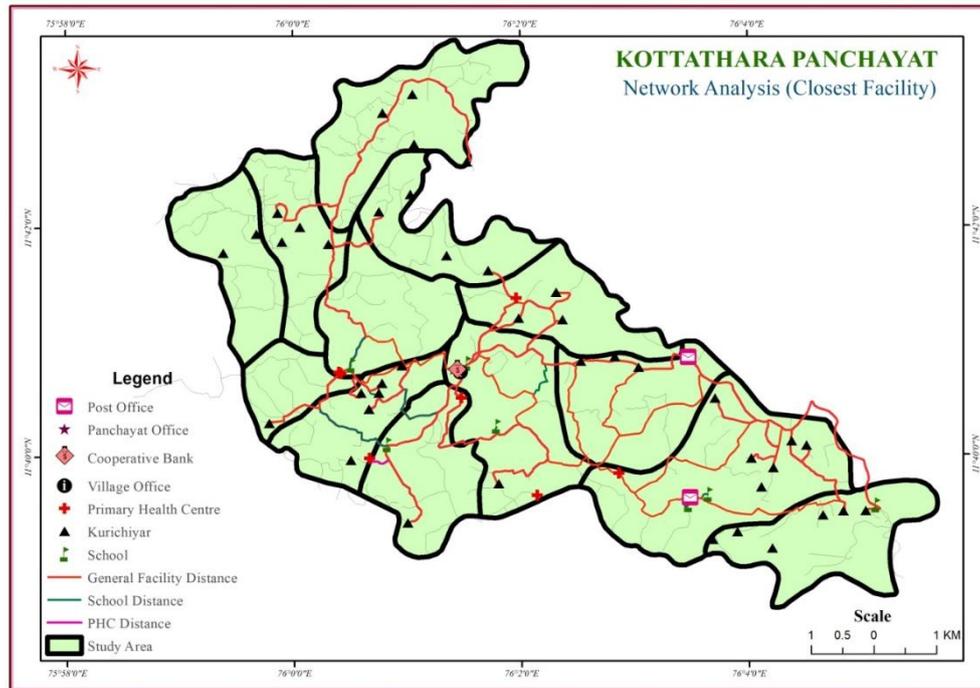

Fig: 5. Average Road distance from *Kurichiya* settlements to the major facilities

Kurichiya settlements, despite having a relatively larger population and socio-economic advantage compared to other *Adivasi* communities, show moderate accessibility levels, with an average distance of 7.27 km. Eleven *Kurichiya* settlements lack road connectivity, primarily due to their location on hill slopes and upland plantation regions. These geographic constraints significantly limit access to healthcare, education, and administrative services, particularly for vulnerable groups such as children, elderly persons, and pregnant women. The spatial dispersion of Kurichiya colonies reflects a historical pattern of settlement in agriculturally productive upland areas, which simultaneously provides economic opportunities and creates accessibility barriers.
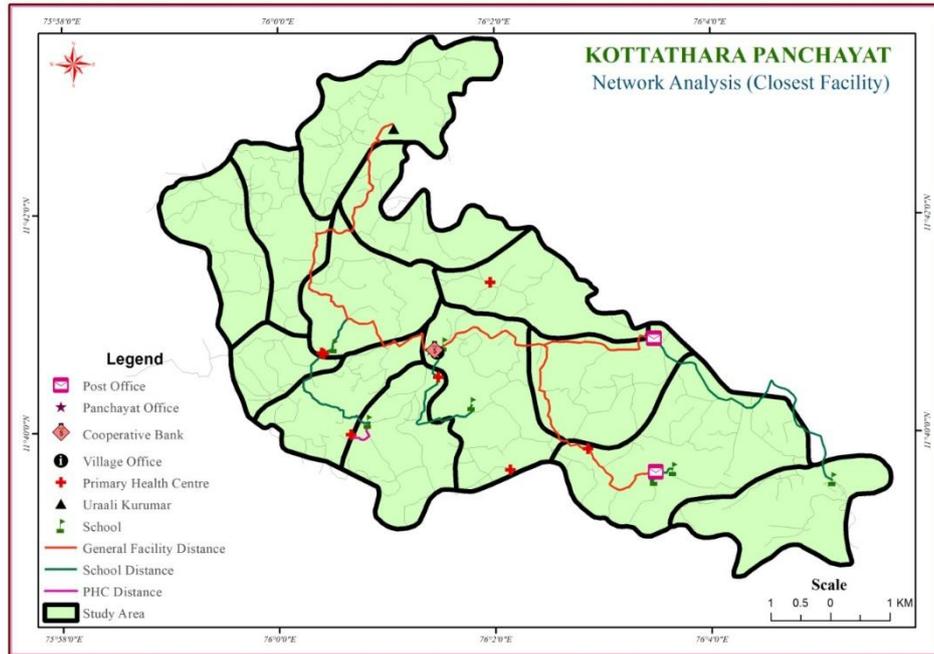
Fig: 6. Average Road distance from *Uraalikurumar* settlements to the major facilities

Uraalikurumar settlements show the highest average distance (8.86 km) to essential facilities, indicating severe spatial marginalization. Although their settlement is not as geographically isolated as *Kattunayakar* settlements, poor road infrastructure and peripheral location significantly reduce accessibility. The limited number of colonies and their scattered distribution further restrict access to services and development opportunities. This spatial isolation contributes to lower socio-economic development and reinforces their marginal position within the *tribal* hierarchy.
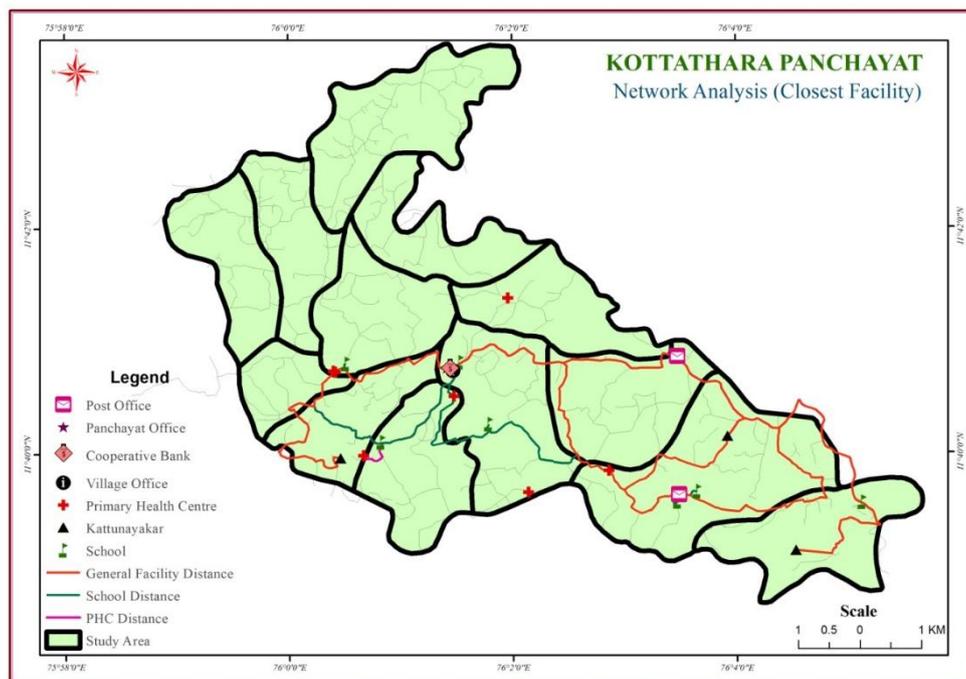

Fig: 7. Average Road distance from *Kattunayakar* settlements to the major facilities

Kattunayakar settlements (Fig.7) represent the most spatially isolated and marginalized community in the Panchayat. Although their overall average distance (7.73 km) appears lower than that of Uraalikurumar, their location in dense forest areas, lack of road connectivity, and extreme physical isolation make accessibility much more difficult in practical terms. All three *Kattunayakar* settlements lack proper road connectivity and depend on footpaths and forest trails for mobility. This physical isolation severely restricts access to healthcare, education, markets, and government services, reinforcing their socio-economic deprivation. Their continued residence in forested areas reflects both cultural traditions and structural exclusion from mainstream development processes.
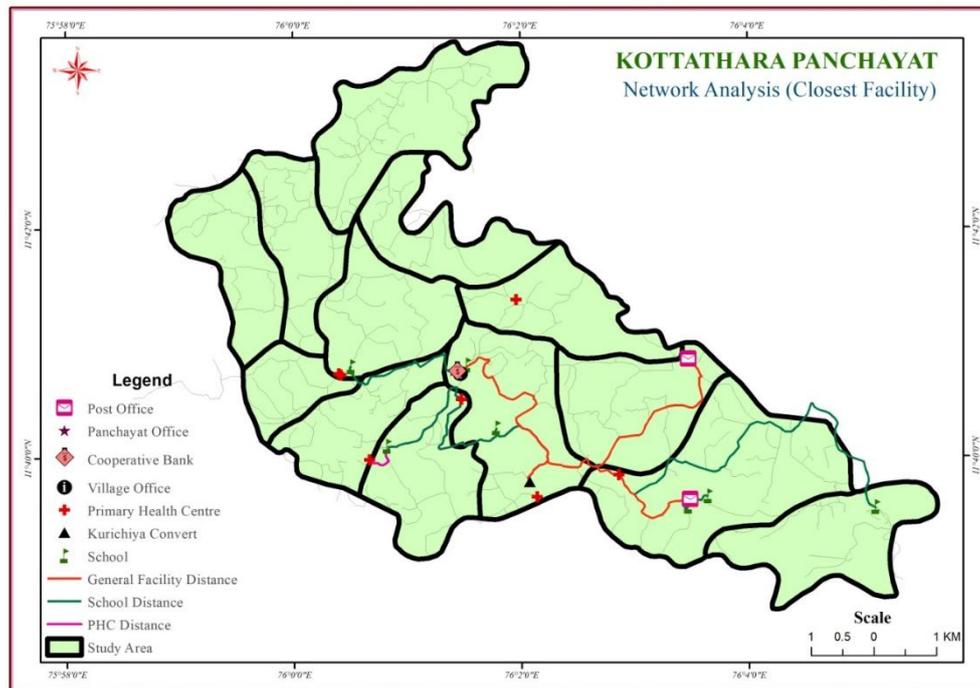

Fig: 8. Average Road distance from *Kurichiya Convert* settlements to the major facilities

Fig.8. shows the road connectivity from *Kurichiya* convert settlements to post office, panchayat office, bank, village office, school, and Primary Health Centre. The average distance between the facilities and the settlements has been calculated and a map has been prepared for easy understanding. *Kurichiya* converts settlements are located not very far from the main roads and they have moderate road connectivity.

The accessibility maps clearly demonstrate spatial clustering of better-connected settlements near roads and administrative centres, while poorly connected settlements are concentrated in peripheral, upland, and forested regions. This pattern reflects the strong relationship between physical geography, infrastructure development, and social inequality. Settlements located closer to road networks and administrative centres benefit from better access to education, healthcare, and employment opportunities, while those located in remote areas experience limited access to these essential services.

Road connectivity emerges as the most critical factor determining accessibility inequality. Out of 98 colonies, a significant number lack direct road connectivity, including eleven *Kurichiya* colonies, seven *Paniya* colonies, and all colonies of *Uraalikurumar* and *Kattunayakar*

communities. These settlements depend on informal paths and foot trails, which significantly increase travel time and physical effort required to access services. Lack of transportation infrastructure not only restricts mobility but also limits economic opportunities, access to markets, and integration with the broader socio-economic system.

The observed spatial inequality in accessibility reflects a complex interaction between physical geography, historical land alienation, socio-economic deprivation, and institutional neglect. Historically, *Adivasi* communities were displaced from fertile lands and relocated to marginal and forested areas, resulting in spatial segregation and limited access to infrastructure. This pattern continues to shape present-day accessibility and development outcomes. Communities located in geographically favorable areas with better road connectivity show relatively better socio-economic conditions, while those located in remote and forested regions remain severely disadvantaged.

Furthermore, accessibility inequality also reinforces intra-tribal stratification. Communities such as *Kurichiya*, who possess relatively better land ownership and economic resources, show comparatively better accessibility, while communities such as *Kattunayakar* and *Uraalikurumar*, who historically depended on forest-based livelihoods, experience severe spatial isolation and socio-economic marginalization. This demonstrates that spatial accessibility is both a cause and consequence of social inequality.

Overall, the results clearly demonstrate that accessibility to essential facilities in Kottathara Panchayat is highly uneven and strongly influenced by settlement location, terrain characteristics, and infrastructure availability. The spatial isolation of *Adivasi* settlements, particularly those located in forested and upland areas, significantly limits their access to education, healthcare, and administrative services. This spatial inequality contributes to persistent socio-economic deprivation and reinforces existing patterns of social stratification among *Adivasi* communities. The GIS-based spatial analysis and network analysis effectively reveal the geographic dimension of social exclusion and highlight the critical role of infrastructure development in reducing inequality and promoting inclusive development among indigenous communities.

Major Finding:

The GIS-based network analysis clearly reveals significant spatial inequality in accessibility to essential facilities among *Adivasi* settlements in Kottathara Panchayat. The results show that accessibility varies considerably between different *Adivasi* communities due to differences in settlement location, terrain characteristics, and road connectivity. Among the five communities, the *Paniya* settlements exhibit relatively better accessibility, with the lowest overall average distance of 6.25 km to major facilities, and are therefore ranked first in terms of accessibility. In contrast, the *Uraalikurumar* settlements show the highest average distance of 8.86 km, indicating severe accessibility constraints. Although the *Kattunayakar* settlements show a slightly lower average distance (7.73 km), their location in dense forest regions and complete lack of proper road connectivity make them the most physically isolated community. *Kurichiya* settlements show moderate accessibility (7.27 km), but eleven colonies lack road connectivity due to their location on slopes and upland areas. The analysis also reveals that a total of 22 colonies across different communities lack direct road connectivity, significantly restricting access to education, healthcare, and administrative services. The spatial pattern demonstrates that settlements located near roads and administrative centers have better

accessibility, while those located in forested, upland, and peripheral regions face severe accessibility disadvantages.

Conclusion:

The study concludes that there exists a clear and measurable spatial inequality in accessibility to essential facilities among *Adivasi* settlements in Kottathara Panchayat, primarily influenced by geographical location, terrain conditions, and infrastructure availability. Settlements located in remote forest areas, steep slopes, and peripheral regions experience greater isolation and reduced access to education, healthcare, and administrative services. The lack of road connectivity emerges as the most critical factor contributing to accessibility disparity and spatial marginalization. Communities such as *Kattunayakar* and *Uraalikurumar* remain the most disadvantaged due to their physical isolation and poor infrastructure, while *Paniya* and some *Kurichiya* settlements show relatively better accessibility due to their proximity to roads and village centers. These findings highlight that spatial location plays a crucial role in shaping development opportunities and social inclusion. Therefore, improving road infrastructure, transportation connectivity, and equitable distribution of public facilities is essential to reduce spatial inequality and promote inclusive and sustainable development among *Adivasi* communities in Kottathara Panchayat.

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