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# An Assessment of Level of Accessibility and Adequacy of Primary Health Care (PHCs) Services in Taraba State Nigeria

**Anger, R.T., Oruonye, E.D., Ibrahim Abdullahi, Yusuf, M.B.**
Department of Geography, Taraba State University, Jalingo Nigeria

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**Abstract**

This study assesses the level of accessibility and adequacy of Primary Health Care (PHC) services in Taraba State, Nigeria, by combining spatial access metrics with service readiness indicators. The research employed a mixed-methods design, integrating Geographic Information Systems (GIS) for spatial analysis with a facility-level service readiness assessment. Data were sourced from the Taraba State Ministry of Health, OpenStreetMap, and satellite imagery for spatial analysis, while the WHO's Service Availability and Readiness Assessment (SARA) methodology was used for facility data collection. The study's specific objectives were to quantify spatial accessibility, evaluate service readiness, examine disparities by urban-rural location, and relate findings to policy instruments like PHCUOR and BHCPF. Results from the buffer analysis showed that only a small portion of settlements fall within the WHO-recommended 0-3 km zone for convenient access, indicating significant accessibility gaps. Overlaid maps revealed an inverse relationship between distance from PHC facilities and immunization coverage, with coverage being highest within the 0-3 km buffer and declining as distance increases. The ANOVA analysis demonstrated statistically significant differences in PHC characteristics across different locations, suggesting that accessibility is not uniformly distributed. The findings underscore the need for targeted interventions to address both geographic barriers and persistent service-readiness gaps, thereby strengthening equitable PHC access in Taraba State.

**Keywords:** Accessibility, Geographic Information Systems (GIS), Primary Health Care (PHC) Service Adequacy and Underserved

## 1. Introduction

Primary Health Care (PHC) is the foundation of equitable health systems and a key pathway to universal health coverage (UHC). The World Health Organization (WHO) defines PHC as a whole-

of-society approach that delivers promotive, preventive, curative, rehabilitative, and palliative services as close as feasible to people's everyday environments, emphasizing equity and people-centredness (World Health Organization [WHO], 2025). Global commitments, reaffirmed by the 2018 Declaration of Astana, call on countries to strengthen PHC so that everyone, everywhere can access quality essential services without financial hardship (WHO, 2018). In measuring access, WHO recommends practical metrics such as the percentage of the population living within 5 km or about one hour's travel of a comprehensive PHC facility, alongside indicators of service availability and readiness (WHO, 2022). Nigeria has pursued several reforms to revitalize PHC, notably the Primary Health Care Under One Roof (PHCUOR) policy approved in 2011 to integrate and reduce fragmentation of PHC governance across federal, state, and local levels, and the Basic Health Care Provision Fund (BHCPF) established by the National Health Act (2014) to finance a basic minimum package of services and strengthen PHC nationwide (Network for Health Equity & Development, 2021; National Health Insurance Authority, n.d.). Recent implementation analyses of the BHCPF show progress but also highlight variation across Northern states in how funds translate into accessible, quality services at facility level (Igbokwe et al., 2024). At the facility level, evidence from Nigeria indicates persistent service-readiness gaps such as shortfalls or non-functionality of basic equipment and inconsistent availability of essential medicines that undermine the adequacy of care and effective coverage (Oyekale, 2017). In national assessments that included Taraba State, functioning rates of key equipment (e.g., weighing scales) were among the lowest, underscoring potential deficits in service readiness that may interact with geographic barriers to limit effective access. Despite these national reforms and investments, PHC access and adequacy remain uneven in Nigeria, and Taraba State with substantial rural populations and difficult terrain in parts of the state faces particular risks of geographic inaccessibility and under-resourced facilities. There is limited, up-to-date, Taraba-specific evidence that jointly quantifies spatial accessibility (e.g., distance/time to facilities vis-à-vis the WHO 5 km/1-hour benchmark) and service adequacy/readiness (e.g., infrastructure, equipment functionality, essential medicines, staffing) within the policy context of PHCUOR and BHCPF. Without such integrated, state-level assessment, policymakers cannot reliably target investments or monitor whether PHC arrangements are delivering equitable, people-centred care across Taraba's Local Government Areas (LGAs). This study therefore aims to assess the level of accessibility and adequacy of PHC services in Taraba State, Nigeria, by combining spatial access metrics with service-readiness/ adequacy indicators aligned to WHO guidance and national PHC policy frameworks. The specific objectives are: (1) to quantify spatial accessibility to PHC facilities across Taraba State by ward and LGA, benchmarking the share of the population within 5 km or approximately one hour of a PHC facility (WHO, 2022); (2) to evaluate the adequacy (service readiness) of PHC facilities covering infrastructure, basic equipment functionality, essential medicines availability, and staffing using an adapted WHO/Nigeria framework; (3) to examine disparities in accessibility and adequacy by urban–rural location and LGA to identify geographic and system bottlenecks relevant to Taraba State; and (4) to relate findings to policy instruments (PHCUOR, BHCPF) to generate actionable recommendations for strengthening PHC access and adequacy in the state.

## 2. Methodology

This study employed a survey and mixed-methods research design that integrated Geographic Information Systems (GIS)-based spatial analysis with a facility-level service readiness assessment to comprehensively evaluate the level of accessibility and adequacy of Primary Health Care (PHC) services in Taraba State, Nigeria. This approach was chosen to allow simultaneous measurement of geographic access and facility performance in alignment with the World Health Organization's (WHO) Primary Health Care Measurement Framework, which emphasizes multidimensional monitoring of service delivery, including physical access, service availability, and readiness indicators (WHO, 2022). The study area, Taraba State, is located in Nigeria's North-East geopolitical zone and features diverse topography, including mountainous areas in the Mambilla Plateau, lowlands, and riverine zones. This varied geography, coupled with predominantly rural settlement patterns, poses significant challenges to the equitable distribution and accessibility of health services (National Population Commission [NPC], 2020).

Data for the study were sourced from multiple channels. Spatial data on PHC facility locations, settlement patterns, and road networks were obtained from the Taraba State Ministry of Health, OpenStreetMap, and satellite imagery repositories. Facility-level service readiness data were collected through field surveys using the WHO Service Availability and Readiness Assessment (SARA) methodology, which provides a standardized approach to assessing whether health facilities have the required infrastructure, equipment, medicines, and human resources to deliver essential services (WHO, 2015). Population estimates disaggregated by ward and age group were extracted from NPC projections based on the 2006 National Population and Housing Census.

A purposive sampling technique was adopted to ensure representation of urban, peri-urban, and rural areas across the state's 16 Local Government Areas (LGAs). Within each selected ward, all functional PHC facilities were included in the analysis. For the spatial accessibility component, GIS tools (ArcGIS 10.8 and QGIS 3.22) were used to create buffer zones at 0–3 km, 3–5 km, and 5–10 km radii around PHC facilities, in line with WHO's recommended maximum distance or travel time for reasonable physical access to primary care (WHO, 2022). Settlements within the 0–3 km buffer were classified as "served," those within 3–5 km as "less served," and those within 5–10 km as "underserved." In addition, road network quality categorized as major roads, minor roads, and footpaths was overlaid on the buffers to assess how transportation infrastructure influenced accessibility. Topographic constraints, particularly in mountainous regions such as Nguroje Ward, were also incorporated into the analysis to more accurately reflect travel challenges.

The adequacy of PHC services was assessed by evaluating four main domains of service readiness: infrastructure, basic equipment, essential medicines, and human resources. The infrastructure domain included assessment of the physical condition of buildings, water supply availability, and sanitation facilities. Basic equipment readiness was determined by the availability and functionality of WHO-recommended essential items such as weighing scales, thermometers, and blood pressure apparatus. Essential medicines availability focused on the consistent presence of tracer drugs specified in Nigeria's Basic Minimum Package of Health Services (Federal Ministry of Health [FMOH], 2019). Human resources adequacy was evaluated by comparing staffing levels and skill mix against the National Primary Health Care Development Agency's (NPHCDA) minimum

staffing standards. Each domain was scored, and the results were aggregated to create an overall service readiness index for each facility.

Data analysis involved both spatial and statistical techniques. Spatial accessibility results were visualized using thematic maps to illustrate service coverage and gaps by ward and LGA. Descriptive statistics summarized the service readiness indicators, while inferential statistical tests, including Analysis of Variance (ANOVA), were used to detect significant differences in readiness scores between LGAs. Correlation analyses were conducted to explore relationships between population size, the under-five population, and immunization coverage rates. Ethical approval for the study was obtained from the Taraba State Ministry of Health Ethical Review Committee, and informed consent was sought from all facility heads before data collection commenced, in line with ethical guidelines for health systems research (WHO, 2011).

## 3. Result of the Findings

**Buffer Analysis of PHC Accessibility of Settlements in the Study Area**

Each PHCC were buffered with type such as 1 – 3km, 3 – 5km and 5 – 10km buffer zones. According to world health organisation people can conveniently travel 3km to PHCCs to be vaccinated and settlement within this buffer is considered as served areas. 3 – 5km distance is considered less served as its little far, 5 – 10km is underserved because of the fact that distance is discouraging to the people who wanted to be vaccinated.

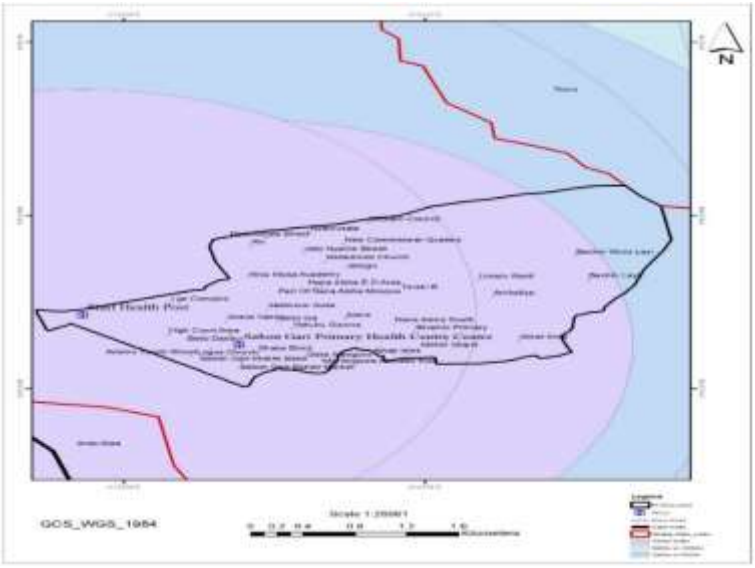



Figure 1 Map of Turaki B Ward Showing the Buffer (0-3km, 3-5km, 5-10).

Figure 1 presents a buffer analysis of PHCC accessibility in Turaki B Ward using 1–3 km, 3–5 km, and 5–10 km zones around each health facility. In this ward, the map shows that only a portion of the settlements falls within this ideal access range, indicating that a limited number of communities are adequately served. This spatial distribution reveals accessibility gaps and supports the utility of GIS in identifying communities at risk of healthcare exclusion. The findings underscore the need for strategic interventions such as improved transportation, mobile outreach, or establishing new PHCCs to enhance equitable access to primary health care in Turaki B Ward.

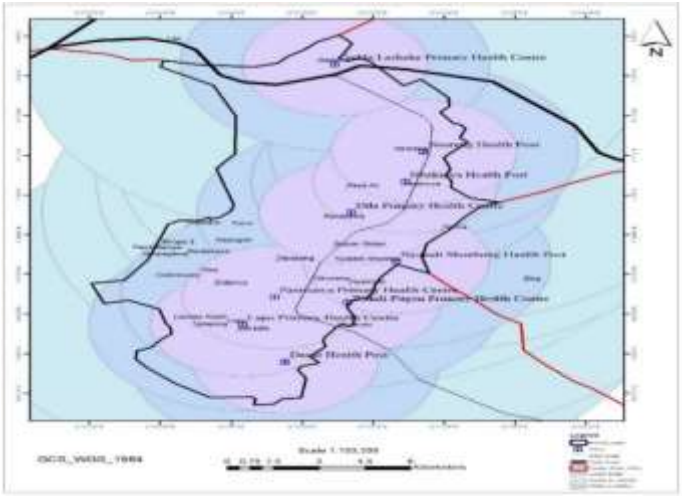


Figure 2 Map of Pantisawa Ward Showing the Buffer (0-3km, 3-5km, 5-10).

Figure 2 illustrates the spatial distribution of PHC accessibility in Pantisawa Ward using WHO-recommended buffer zones of 0–3 km (served), 3–5 km (less served), and 5–10 km (underserved). The map reveals that only a small portion of settlements falls within the optimal 0–3 km range, suggesting limited convenient access to PHCCs. A larger number of settlements lie within the 3–5 km and 5–10 km zones, where distance becomes a barrier to regular healthcare access, especially for routine services like immunization. This spatial pattern highlights significant accessibility challenges for many residents and demonstrates the value of GIS in identifying underserved areas.

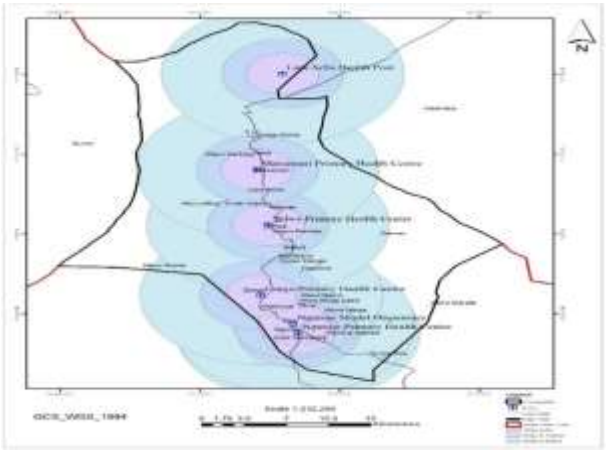


Figure 3 Map of Nguroje Ward Showing the Buffer (0-3km, 3-5km, 5-10).

Figure 3 displays the buffer zones around PHCCs in Nguroje Ward, segmented into 0–3 km (served), 3–5 km (less served), and 5–10 km (underserved) areas. The map indicates that only a limited portion of settlements falls within the 0–3 km zone, meaning few communities enjoy convenient access to PHC services. A significant number of settlements are located beyond 3 km many in rugged, highland areas placing them in less served or underserved zones. These physical and spatial constraints likely contribute to reduced healthcare utilization.

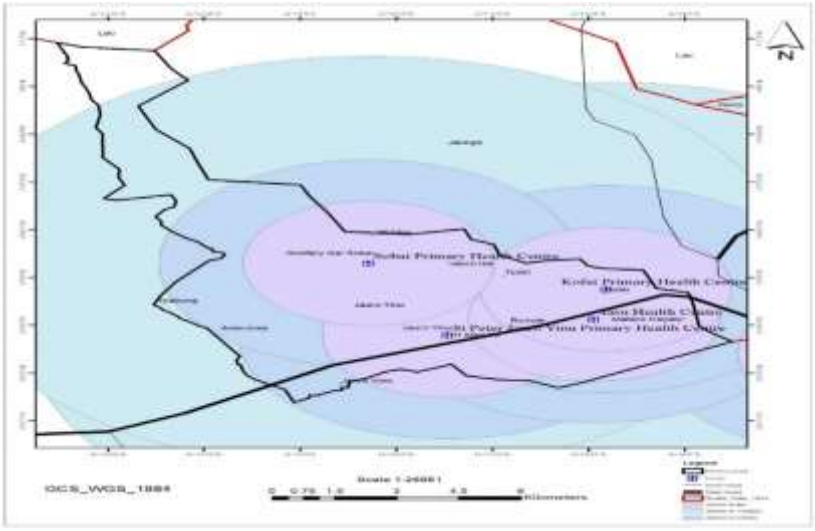


Figure 4 Map of Jauro Yinu Ward Showing the Buffer (0-3km, 3-5km, 5-10).

Figure 4 illustrates the buffer zones around PHCCs in Jauro Yinu Ward, categorized into 0–3 km (served), 3–5 km (less served), and 5–10 km (underserved). The map shows that only a small portion of the ward's settlements falls within the optimal 0–3 km zone, where access to PHC services is considered adequate. A larger number of communities lie in the 3–5 km and especially 5–10 km zones, indicating reduced accessibility and likely lower health service utilization due to distance.

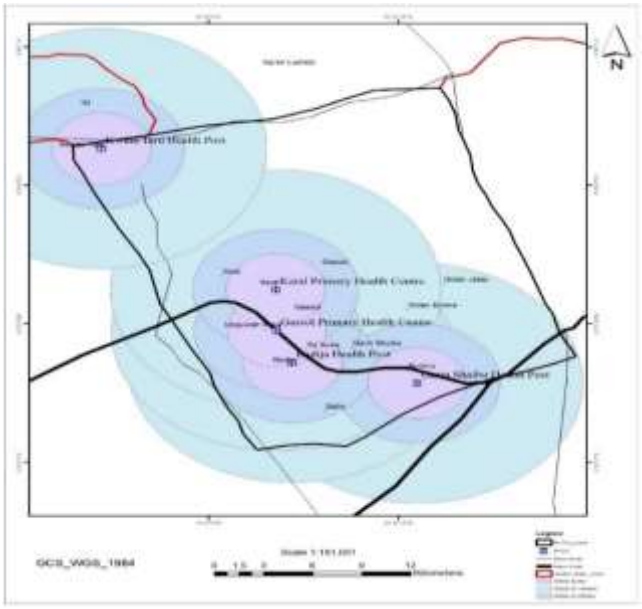


Figure 5 Map of Gassol Ward Showing the Buffer (0-3km, 3-5km, 5-10).

Figure 5 presents the spatial buffer zones around PHCCs in Gassol Ward, divided into 0–3 km (served), 3–5 km (less served), and 5–10 km (underserved) areas. The map indicates that while some settlements fall within the 0–3 km range, a significant portion of the population resides beyond this ideal access zone. Many communities are located in the 3–5 km and 5–10 km buffers, where distance becomes a barrier to accessing primary health care services.

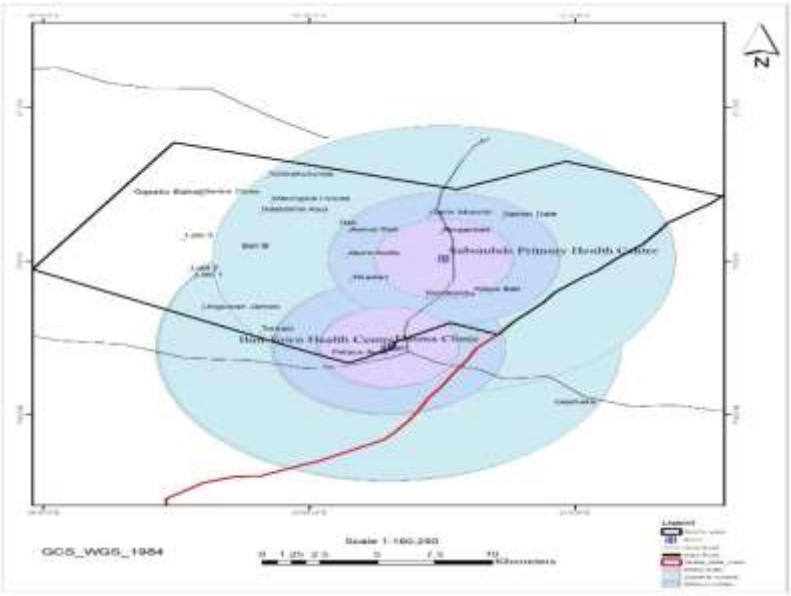



Figure 6 Map of Bali B Ward Showing the Buffer (0-3km, 3-5km, 5-10).

Figure 6, which shows the buffer zones (0–3 km, 3–5 km, and 5–10 km) around PHCs in Bali B Ward, illustrates the varying levels of accessibility to primary health care services. Fig. 6 reveals that a substantial portion of the ward lies outside the ideal access range, highlighting spatial inequality in PHC distribution.

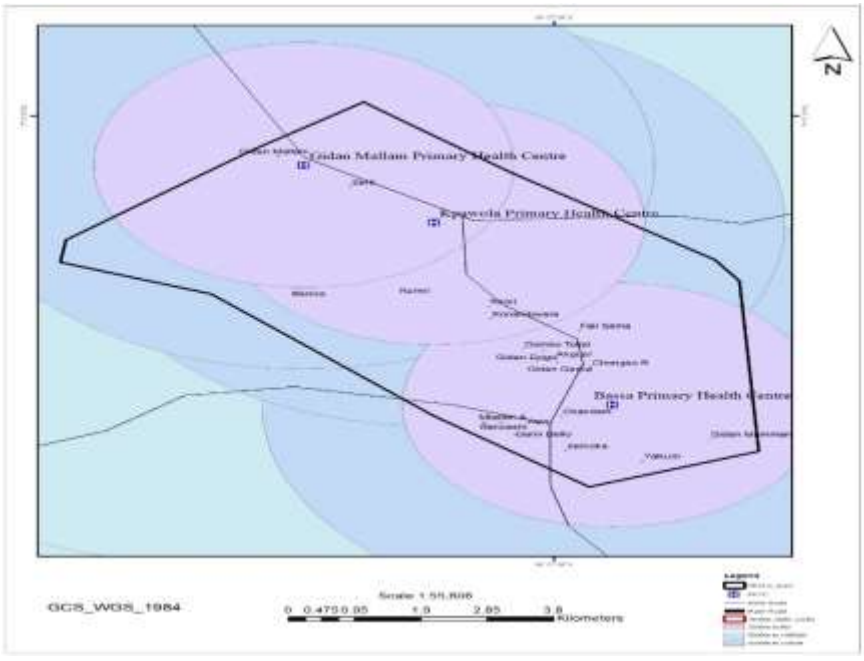



Figure 7 Map of Baissa Ward Showing the Buffer (0-3km, 3-5km, 5-10).

Figure 7 illustrates the buffer zones around PHCCs in Baissa Ward, segmented into 0–3 km (served), 3–5 km (less served), and 5–10 km (underserved). The map reveals that only a few settlements fall within the optimal 0–3 km buffer, indicating limited direct access to PHC services. A large portion of the ward's settlements lies in the 3–5 km and especially the 5–10 km range, where distance and possibly poor infrastructure reduce healthcare access and utilization.

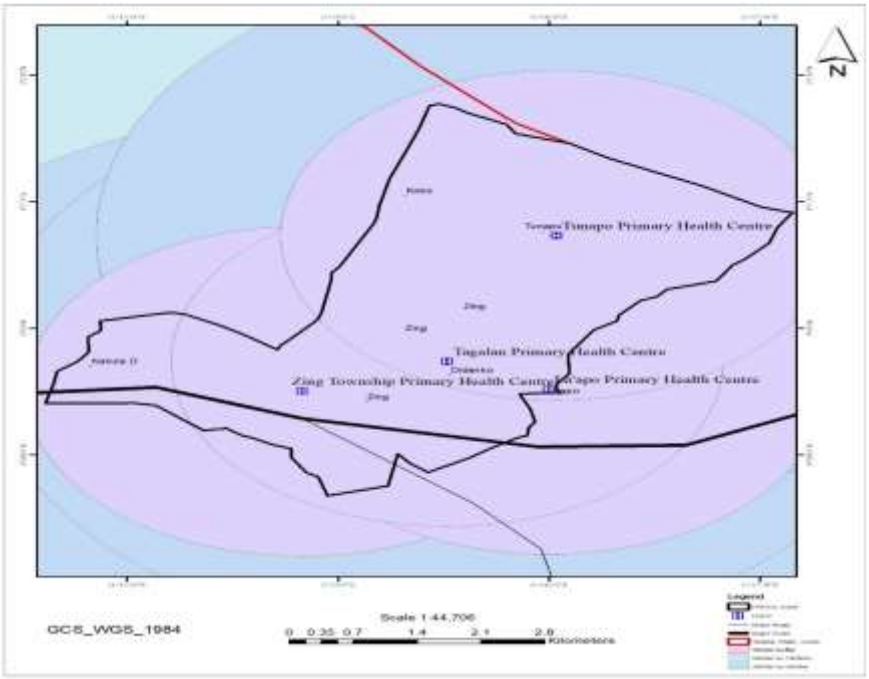



Figure 8 Map of Zing Ward Showing the Buffer (0-3km, 3-5km, 5-10).

Figure 8, which shows the buffer zones (0–3 km, 3–5 km, and 5–10 km) around PHCs in Zing Ward, illustrates the spatial distribution of accessibility to primary health care services. The map reveals that many parts of Zing Ward fall within the 5–10 km buffer, suggesting inadequate PHC coverage and highlighting the need for improved service provision through the establishment of new health centers or outreach programs in underserved areas.

**Overlaid Immunization Density and Accessibility Buffers**

The following maps were made by overlaying 3km, 3 – 5km, 5 – 10km buffered zones on vaccination density maps to analyse the relationship between number of people immunized and the accessibility to those PHCCs. The map shows that, number of children vaccinated is inversely proportional to the distance from town and major villages.

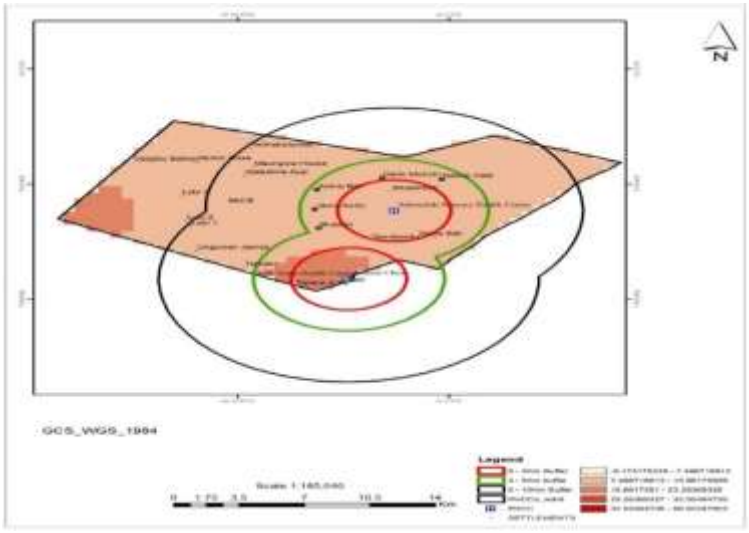



Fig. 9. Overlaid map of buffer zones and vaccination density of Bali B Ward

Figure 9 presents the relationship between physical accessibility and immunization coverage in Bali B Ward by overlaying 3 km, 3–5 km, and 5–10 km buffer zones on vaccination density data. The map shows that vaccination coverage is highest within the 0–3 km buffer, where communities are closest to PHCCs and accessibility is relatively easy. Immunization density declines as distance increases, with significantly fewer children vaccinated in areas beyond 5 km from the PHCCs. This suggests that physical proximity strongly influences healthcare utilization, with distance acting as a barrier, particularly for residents in remote or sparsely populated areas. Although immunization services are technically available in these farther zones, uptake remains low likely due to limited awareness, difficult terrain, and scattered settlements.

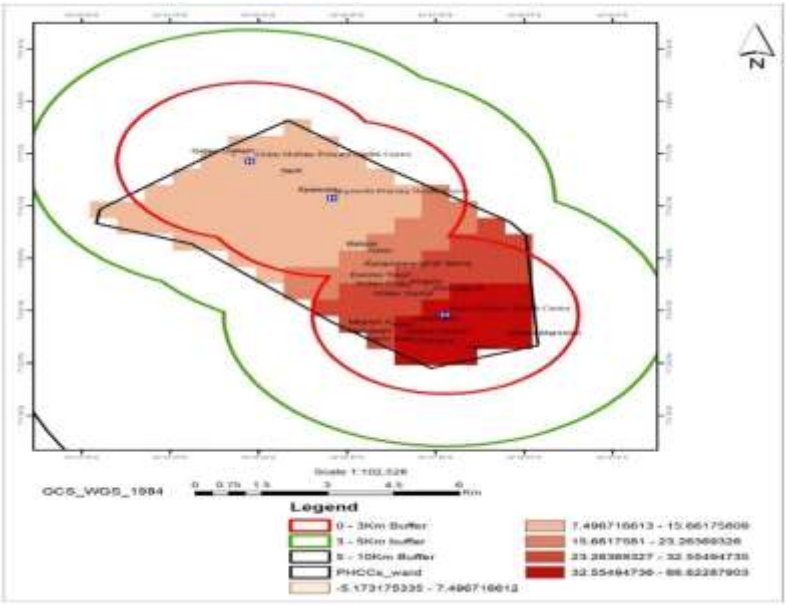



Fig. 10. Overlaid map of buffer zones and vaccination density of Baissa Ward

Figure 10 illustrates the spatial relationship between vaccination coverage and proximity to PHCCs in Baissa Ward using buffer zones of 0–3 km, 3–5 km, and 5–10 km. The map reveals that the highest vaccination density occurs within the 0–3 km range, where physical access to PHCCs is easiest. Coverage decreases noticeably in the 3–5 km zone and is lowest beyond 5 km, reflecting the typical trend of declining healthcare utilization with increasing distance from health facilities. This inverse relationship suggests that despite the presence of immunization services in remote areas, physical distance, low population density, and limited awareness contribute to lower turnout.

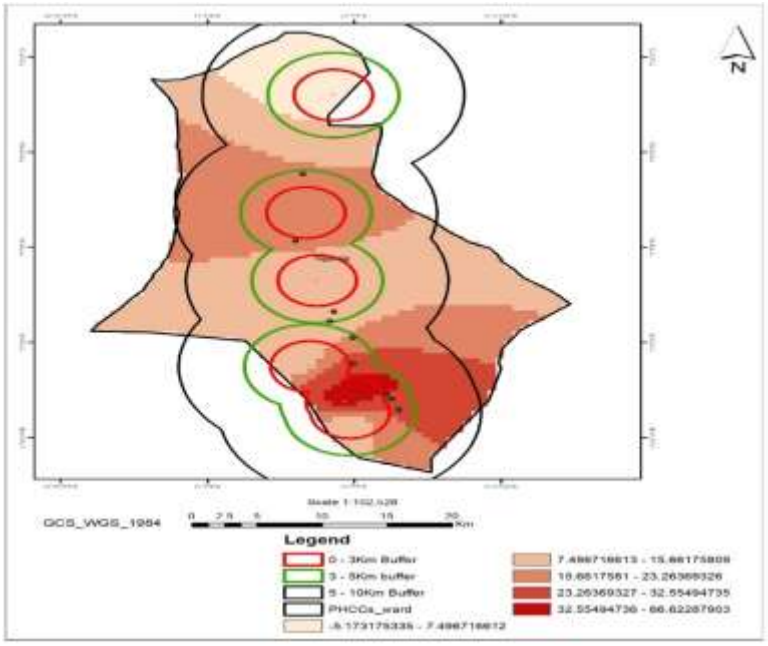



Fig. 11. Overlaid map of buffer zones and vaccination density of Nguroje Ward

Figure 11 shows the overlay of vaccination density with 0–3 km, 3–5 km, and 5–10 km buffer zones around PHCCs in Nguroje Ward. The map reveals that vaccination coverage is highest within the 0–3 km zone and decreases progressively with distance. Areas beyond 5 km show the lowest immunization density, indicating that physical distance from PHCCs significantly limits access and service utilization. In Nguroje, this pattern is further influenced by rugged terrain and sparse settlement in highland areas, which make travel more difficult. Although services may be present in remote areas, low population density and poor awareness also contribute to low turnout.

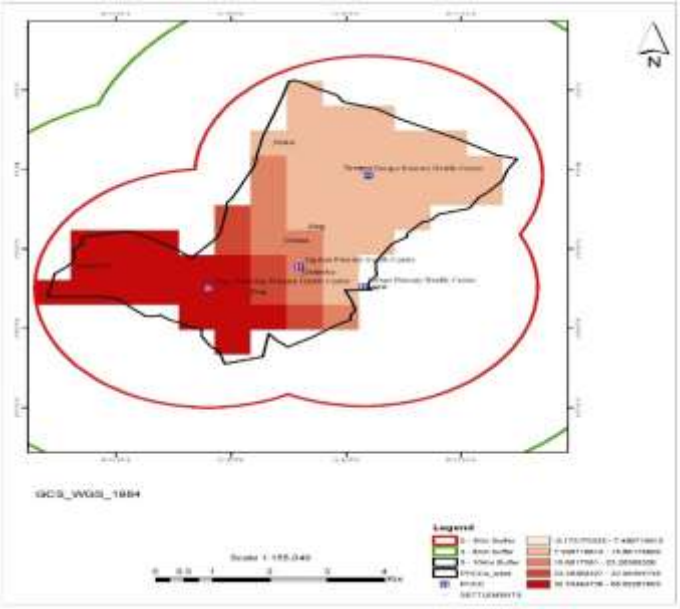



Fig. 12. Overlaid map of buffer zones and vaccination density of Zing Ward

Figure 12 overlays vaccination density with 0–3 km, 3–5 km, and 5–10 km buffer zones around PHCCs in Zing Ward, revealing a clear inverse relationship between distance and immunization

coverage. The highest number of vaccinated children is concentrated within the 0–3 km zone, where access to PHCCs is easiest. Coverage declines in the 3–5 km range and is lowest in the 5–10 km zone, where travel barriers, poor infrastructure, and low population density reduce service utilization. Despite the availability of PHC services in some distant areas, awareness and accessibility remain key challenges.

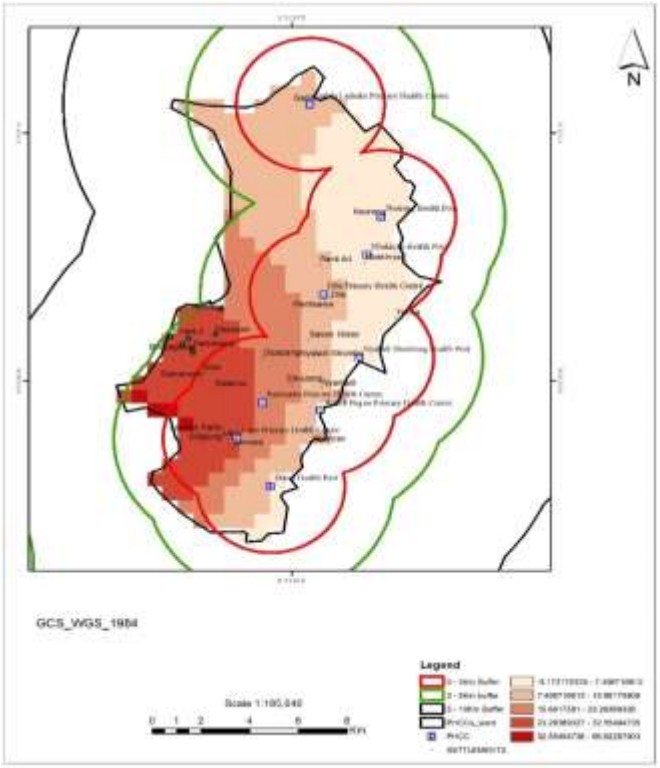



Fig. 13. Overlaid map of buffer zones and vaccination density of Pantisawa Ward

Figure 13 illustrates the spatial relationship between immunization coverage and distance from PHCCs in Pantisawa Ward using 0–3 km, 3–5 km, and 5–10 km buffer zones. The map shows that vaccination density is highest within the 0–3 km buffer, where communities are closest to health facilities. A noticeable decline is observed in the 3–5 km zone, with the lowest coverage occurring beyond 5 km. This trend confirms that distance negatively affects access to PHC services. Despite the existence of health facilities in remote areas, low population density, difficult terrain, and limited awareness contribute to reduced turnout.

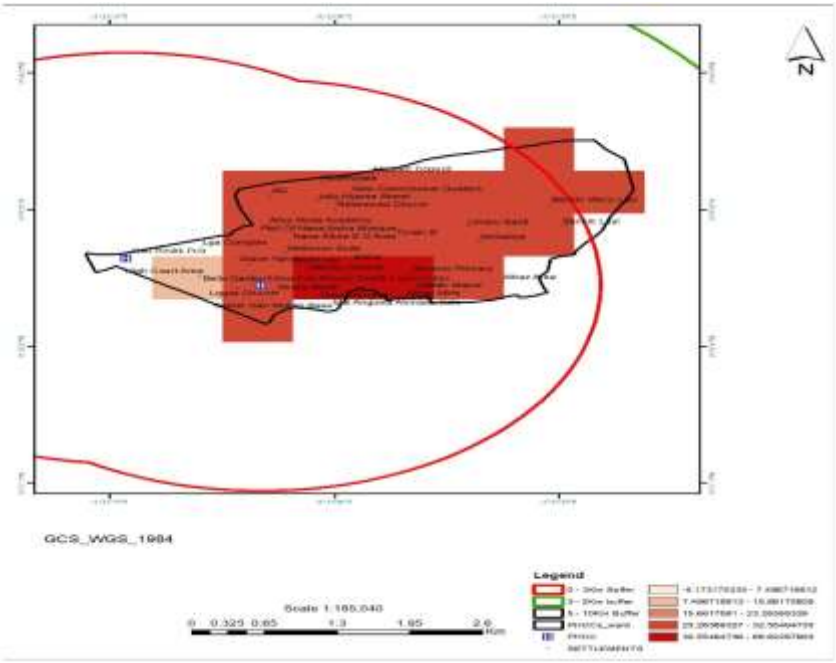



Fig. 14. Overlaid map of buffer zones and vaccination density of Turaki B Ward

Figure 14 presents the overlay of vaccination density with 0–3 km, 3–5 km, and 5–10 km buffer zones around PHCCs in Turaki B Ward. The map shows that vaccination coverage is highest within the 0–3 km buffer, indicating that communities located near PHCCs have better access and higher service utilization. As distance increases, particularly beyond 5 km, immunization density drops significantly. This pattern suggests that physical distance remains a major barrier to accessing PHC services. The decline may also be influenced by poor road networks, scattered settlements, and limited awareness in remote areas.

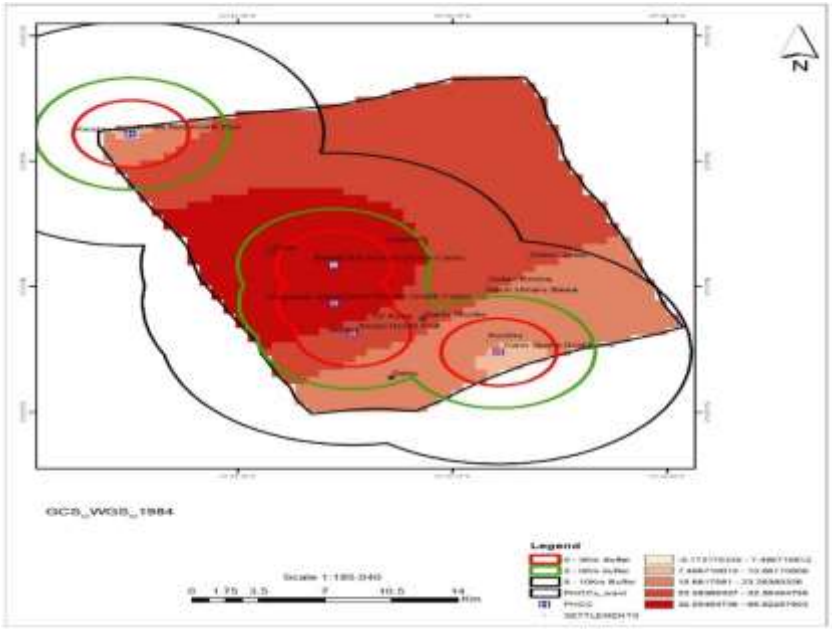



Fig. 15. Overlaid map of buffer zones and vaccination density of Gassol Ward

Figure 15 shows the overlay of vaccination density and 0–3 km, 3–5 km, and 5–10 km buffer zones around PHCCs in Gassol Ward. The highest vaccination coverage is concentrated within the 0–3 km buffer, where communities are in close proximity to health facilities. A gradual decline in immunization density is observed as distance increases, with the lowest figures beyond 5 km. This inverse relationship highlights how physical distance from PHCCs directly affects access to immunization services.

**Vaccination Density Map of Sampled Wards**

This map depicted the density of the number of children vaccinated per PHC per wards in the sampled localities. This maps compare vaccination covered in the ward. It help in understanding of where more vaccination is covered and where less is covered.

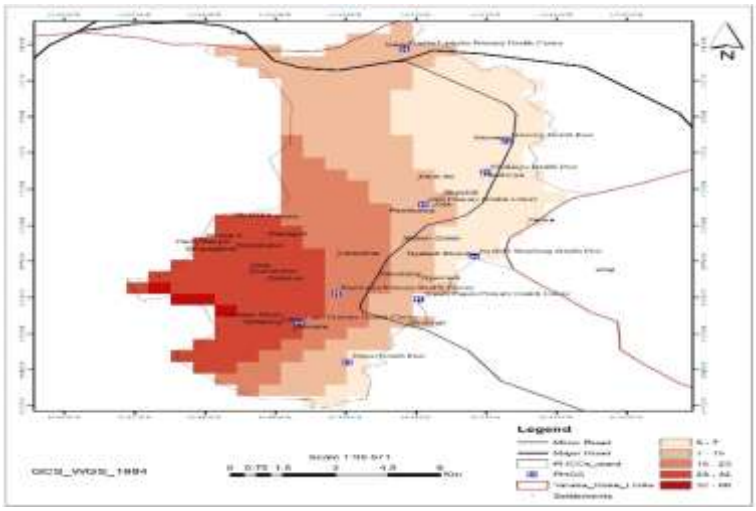



Figure 16. Vaccine Density Map of Pantisawa Ward

The Vaccine Density Map of Pantisawa Ward (Fig. 16) reveals spatial variation in the number of children vaccinated per PHC, highlighting areas of high and low immunization coverage within the ward. PHCCs with higher vaccine density likely serve populations with better physical access, possibly due to proximity, road connectivity, or terrain advantage. Conversely, areas with lower density may reflect limited access resulting from distance, poor infrastructure, or challenging topography.

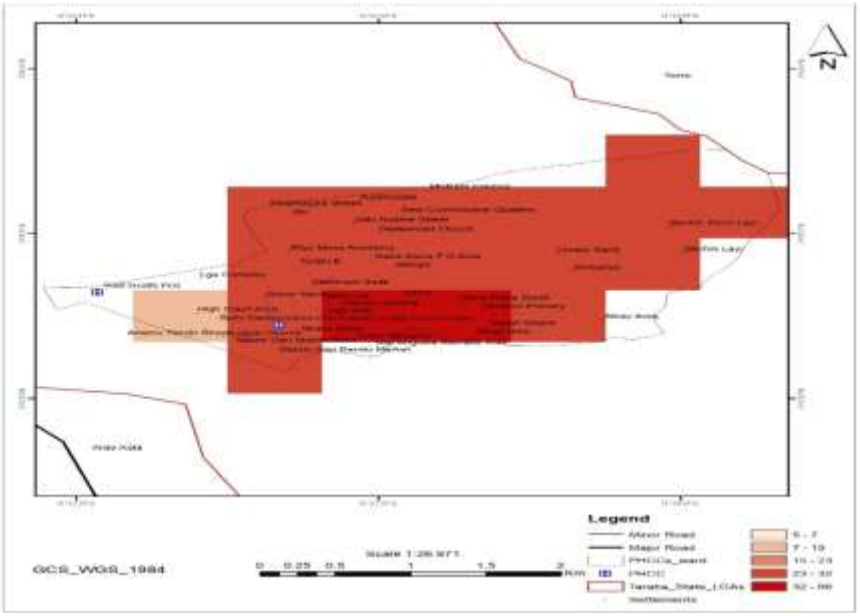



Figure 17. Vaccine Density Map of Turaki B Ward

The Vaccine Density Map of Turaki B Ward (Fig. 17) shows noticeable differences in vaccination coverage across PHCCs, with some areas recording high vaccine density while others remain low. High-density zones suggest better access to PHC services, likely influenced by favorable terrain, proximity to settlements, and available infrastructure. In contrast, low-density areas may reflect access barriers such as distance, poor road networks, or population dispersion.

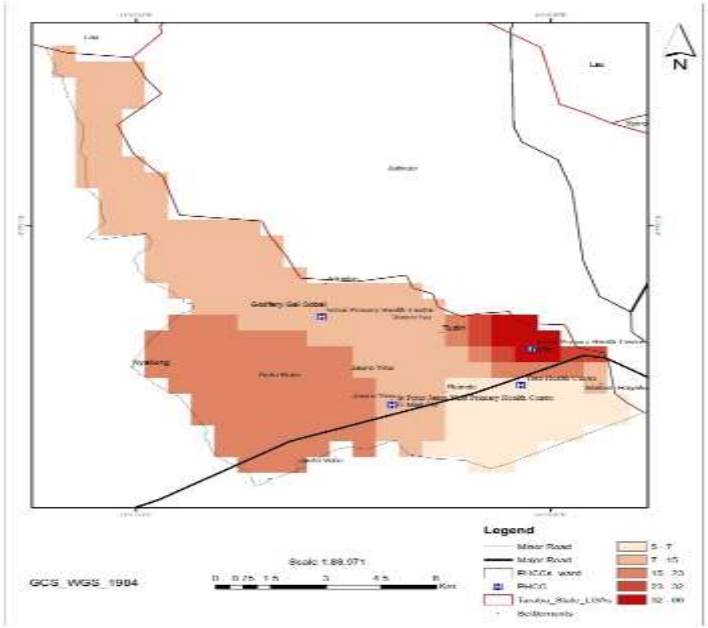



Figure 18. Vaccine Density Map of Jauro Yinu Ward

The Vaccine Density Map of Jauro Yinu Ward (Fig. 18) displays uneven vaccination coverage across PHCCs, with higher densities concentrated around more accessible locations. Areas with low vaccine density likely reflect physical and geographic barriers such as distance, poor road access, or scattered settlements.

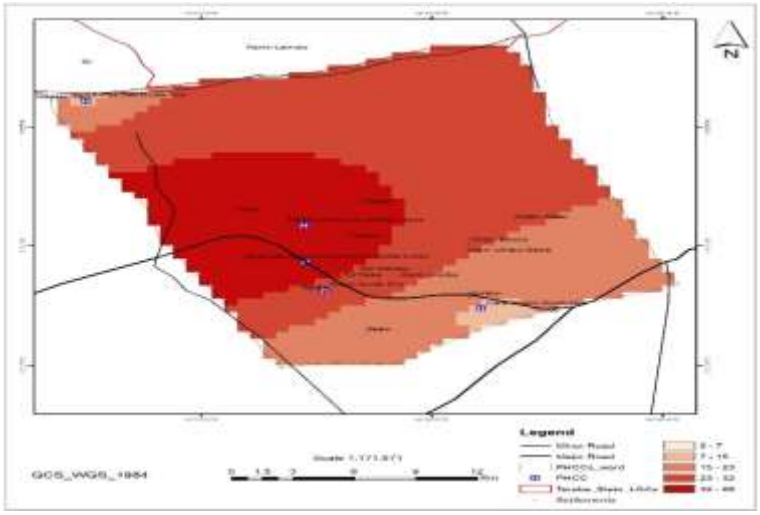



Figure 19. Vaccine Density map of Gassol Ward

The Vaccine Density Map of Gassol Ward (Fig. 19) reveals a clear spatial disparity in vaccination coverage among PHCCs. High-density zones correspond to areas with better physical access, likely due to favorable terrain, proximity to population centers, and functional road networks. In contrast, low-density areas may indicate limited accessibility caused by distance, poor infrastructure, or difficult terrain.

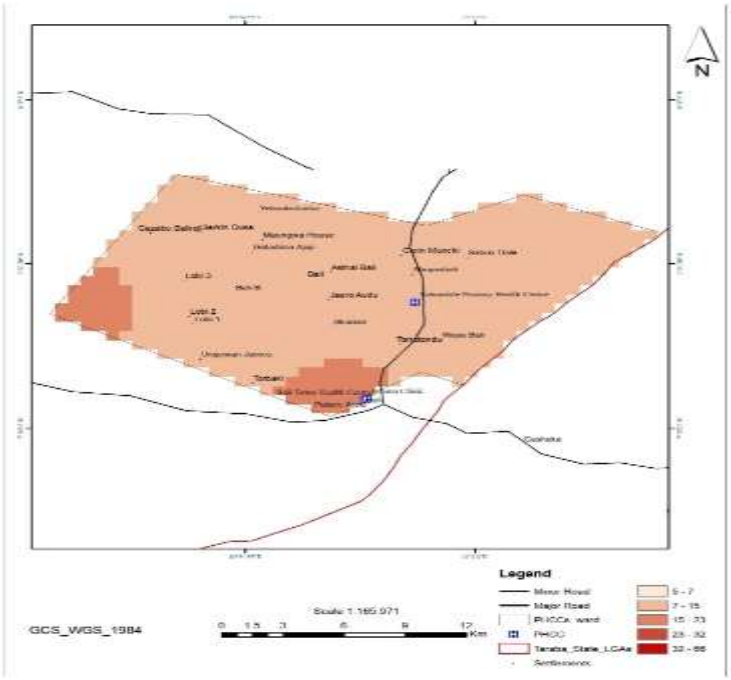



Figure 20. Vaccine Density Map of Bali B Ward

The Vaccine Density Map of Bali B Ward (Fig. 20) shows variation in vaccination coverage across PHCCs, with higher densities clustered in accessible, lowland areas. Lower vaccine densities are observed in more remote or topographically challenging locations, suggesting that physical accessibility significantly influences service utilization.

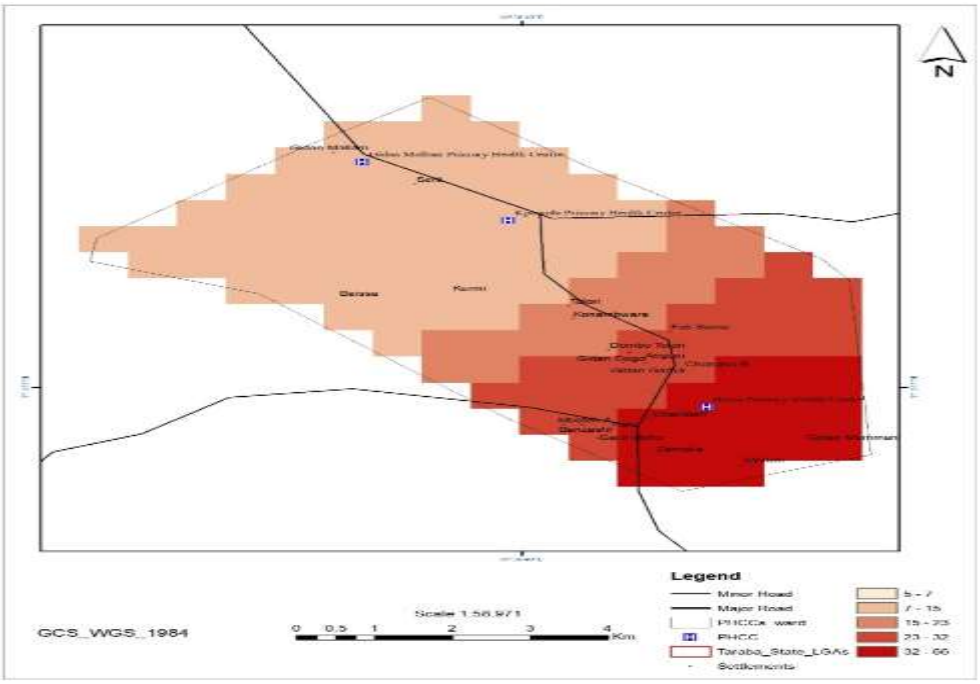



Figure 21. Vaccine Density map of Baissa Ward

The Vaccine Density Map of Baissa Ward (Fig. 21) reveals uneven distribution of vaccination coverage, with higher densities concentrated around easily accessible PHCCs. Areas with lower vaccine density are likely influenced by factors such as difficult terrain, poor road infrastructure, and long distances to health facilities.

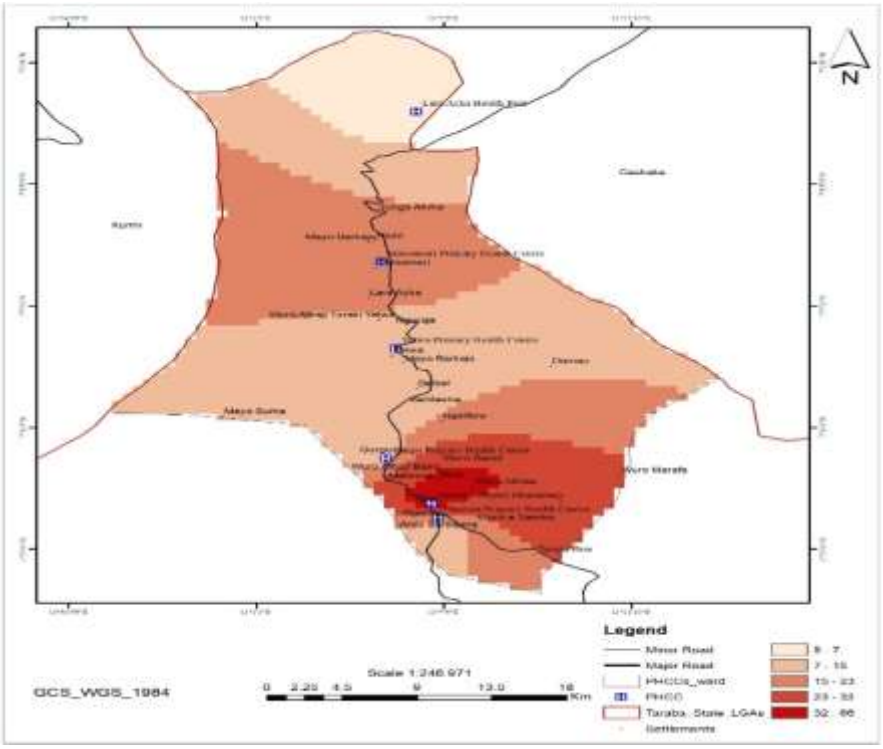



Figure 22. Vaccine Density map of Nguroje Ward

The Vaccine Density Map of Nguroje Ward (Fig. 22) illustrates clear spatial disparities in vaccination coverage, with higher densities concentrated around PHCCs located in low-lying and accessible areas. These areas likely benefit from better road infrastructure, shorter travel distances, and higher population concentrations, which facilitate easier access to healthcare services. In contrast, lower vaccination densities are observed in the more elevated and topographically rugged parts of the ward, where physical barriers such as steep slopes, poor road conditions, and dispersed settlements hinder residents' ability to reach health facilities. This pattern demonstrates the significant influence of terrain and physical accessibility on the utilization of primary healthcare services.

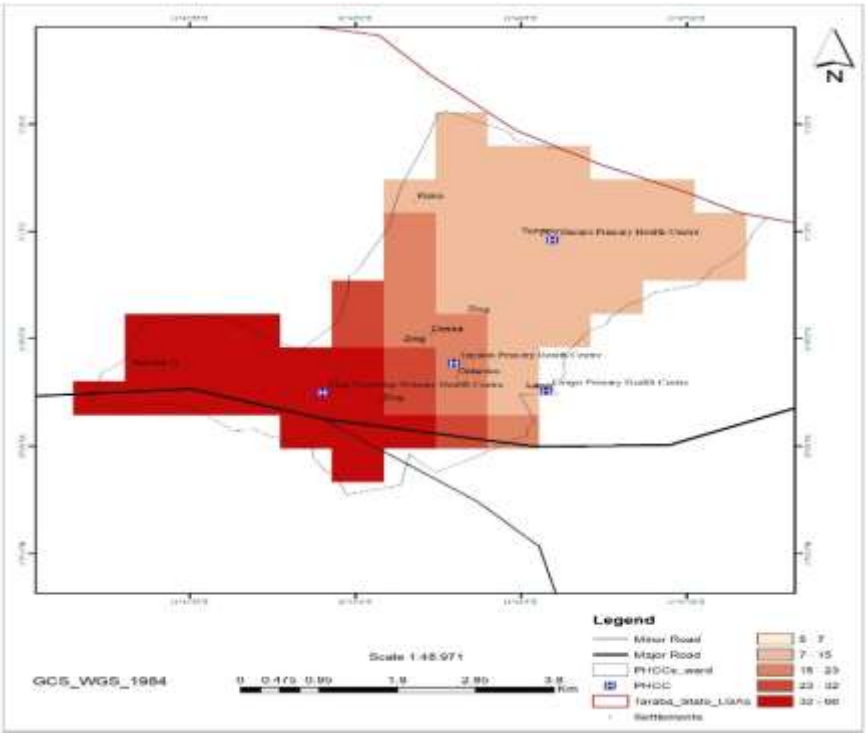



Figure 23. Vaccine Density map of Zing Ward

The Vaccine Density Map of Zing Ward (Fig. 23) reveals significant spatial variation in vaccination coverage across different PHCCs. Areas with high vaccine density are primarily located in low-lying, central, and more accessible parts of the ward, suggesting that physical proximity, good road networks, and relatively flat terrain contribute to better service utilization. Conversely, PHCCs situated in more remote or elevated areas show lower vaccination densities, indicating that distance, poor accessibility, and possibly scattered settlement patterns limit community access to primary health care services. This spatial pattern underscores the importance of terrain and infrastructure in shaping healthcare access and utilization.

**Analysis of Vaccinated Children Per Square Kilometer and Population of Under five Years Old Children**

The study purposely analyse the ration of number of children immunized per square kilometer and the number of vaccinated children per total under five years old children per ward.

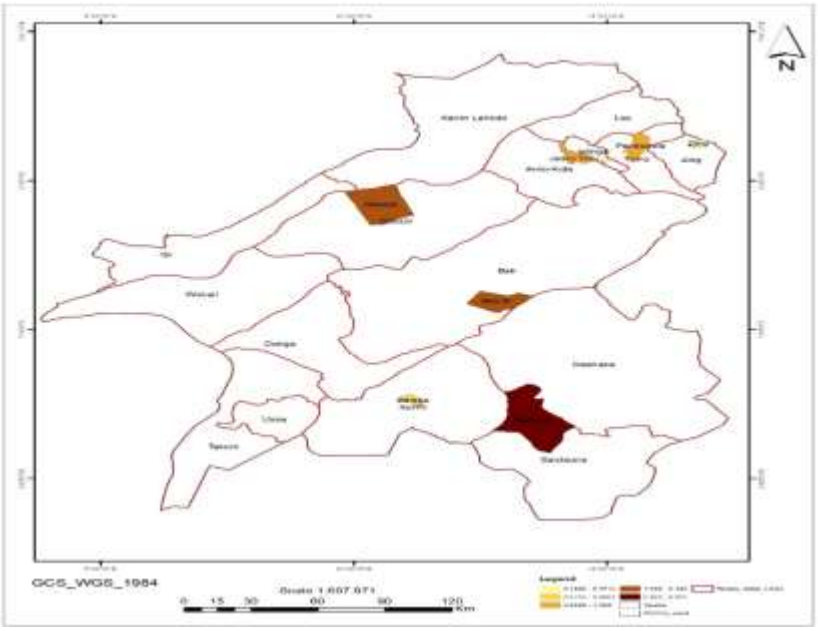



Fig. 24 Number of Vaccinated children to Ward Area Ration

Figure 24 illustrates the number of vaccinated children per square kilometer, highlighting spatial variations in immunization coverage across wards. Wards with a high density of vaccinated children relative to their land area suggest good geographic access to PHC services, likely due to the presence of centrally located or multiple health facilities, better road networks, or higher population concentration. In contrast, wards with low vaccination density may be experiencing challenges such as long distances to health centers, poor transportation infrastructure, or difficult terrain, all of which reduce physical access to care.

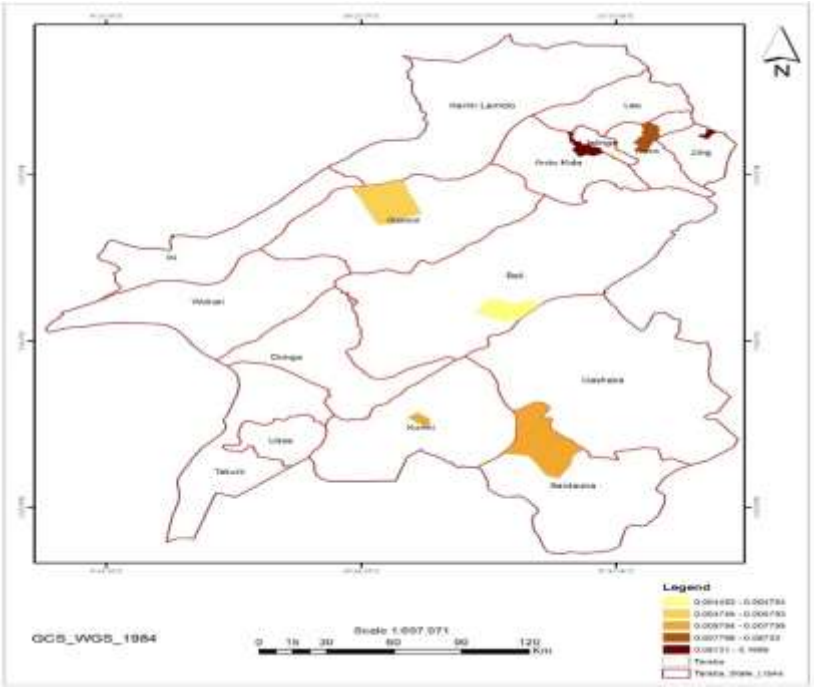



Fig. 25 Number of Vaccinated children to the total number of under 5 age children Ratio

Figure 25, which shows the ratio of vaccinated children to the total population of children under five years of age, serves as a proxy for functional PHC service coverage. High ratios indicate effective utilization of health services and suggest that the PHC system in those areas is functioning well, while low ratios may point to barriers such as lack of nearby facilities, inadequate staffing, vaccine shortages, or socio-cultural factors affecting service uptake. Together, these maps provide a comprehensive spatial understanding of both geographic and service-based accessibility to PHC, allowing for evidence-based identification of underserved areas and supporting strategic planning for improved health service delivery across the state.

**Descriptive Statistics**

The descriptive statistics for PHC characteristics (relating to utilization, capacity, or service provision) is presented in Table 1.

Table 1. Descriptives analysis of Primary Healthcare Center (PHC) characteristics in the study area

| | |
|---|---|
| Mean | 2607.589286 |
| Standard Error | 856.8160626 |
| Median | 163.5 |
| Mode | 36 |
| Standard Deviation | 9067.688884 |
| Sample Variance | 82222981.7 |
| Kurtosis | 21.24616606 |
| Skewness | 4.565051126 |
| Range | 54000 |
| Minimum | 0 |
| Maximum | 54000 |
| Sum | 292050 |
| Count | 112 |
| Largest(1) | 54000 |
| Smallest(1) | 0 |
| Confidence Level(95.0%) | 1697.838227 |

Table 1 present descriptive statistics of the Primary Healthcare Center (PHC) characteristics in the study area, crucial for assessing community accessibility. The finding of the study in Table 1 shows extreme skewness and high kurtosis in PHC characteristics, with a mean value of 2,607.6 and a median of only 163.5, revealing that a small number of PHCs serve disproportionately large populations while most operate at minimal capacity. This is further confirmed by the wide range in values, from 0 to 54,000, indicating severe imbalance in service provision.

**Table 2. ANOVA**

SUMMARY

| *Groups* | *Count* | *Sum* | *Average* | *Variance* |
|---|---|---|---|---|
| Baissa | 5 | 33163 | 6632.6 | 1.58E+08 |
| Bali B | 13 | 7995 | 615 | 3409220 |
| Gassol | 14 | 20308 | 1450.571 | 12195785 |
| Jauro Yinu | 9 | 57185 | 6353.889 | 3.2E+08 |
| Nguroje | 28 | 51663 | 1845.107 | 31659827 |
| Pantisawa | 24 | 23060 | 960.8333 | 8323858 |
| Turaki B | 1 | 43260 | 43260 | 0 |
| Zing | 6 | 55416 | 9236 | 4.67E+08 |
| Grand Total | 100 | 292050 | 2920.5 | 91301382 |

| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
|---|---|---|---|---|---|---|
| Between Groups | 2265477517 | 8 | 2.83E+08 | 3.420668 | 0.001063 | 1.987138 |
| Within Groups | 15812196077 | 191 | 82786367 | | | |
| Total | 18077673594 | 199 | | | | |

Table 2 present the ANOVA result which further highlights the spatial heterogeneity by comparing PHC characteristics across different localities. The ANOVA analysis reinforces this spatial heterogeneity, showing statistically significant differences in PHC characteristics between locations (F = 3.42, p = 0.001), with places like Turaki B and Zing recording much higher averages than underserved areas such as Bali B and Pantisawa. These findings suggest that PHC accessibility is not uniformly distributed, supporting the need for spatial modeling to target underserved areas.

**Correlations**

Table 3. Total population Vs various age groups

| | *Population* | *Under 1* | *Under 5* | *Under 15* |
|---|---|---|---|---|
| Population | 1 | | | |
| Under 1 | 0.999043 | 1 | | |
| Under 5 | 0.999043 | 1 | 1 | |
| Under 15 | 0.999523 | 0.999753 | 0.999753 | 1 |

Table 3 present the result of correlation analysis which provide critical insights into population demographics and immunization coverage. Table 3 shows extremely strong positive correlations (coefficients near 0.99 or 1) between total ward population and various young age groups (Under 1, Under 5, Under 15), as well as among these age groups themselves. This implies that as a ward's total population increases, the number of young, often vulnerable, individuals also increase

proportionally, serving as a reliable proxy for the potential demand for child-focused PHC services.

Table 4. Total population per ward vs total Immunized per ward, % Immunized

| | *T Population* | *T Immunized* | *% Immunized* |
|---|---|---|---|
| T population | 1 | | |
| T Immunized | 0.004673879 | 1 | |
| % Immunized | 0.817107233 | 0.525057922 | 1 |

Table 4 reveals a negligible linear relationship between total ward population and total immunized individuals (-0.004). More importantly, there is a strong negative correlation (-0.817) between total population and the *percentage* immunized. This suggests a significant challenge: more populous wards tend to achieve a lower percentage of immunization coverage, despite having a larger overall pool of individuals. This disparity highlights potential issues with PHC accessibility, outreach, or capacity in larger communities, indicating specific areas where immunization programs may be less effective. Conversely, a moderate positive correlation (0.525) exists between total immunized individuals and the percentage immunized. These findings are vital for the GIS-based model, enabling the identification and targeting of interventions in densely populated wards that currently face lower immunization coverage, thereby enhancing equitable access to primary healthcare services across Taraba State.

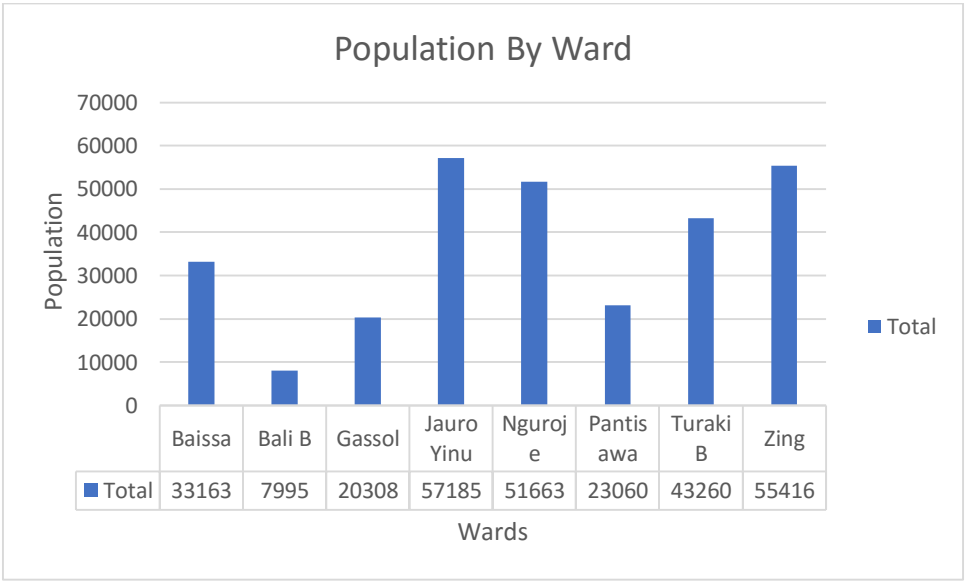
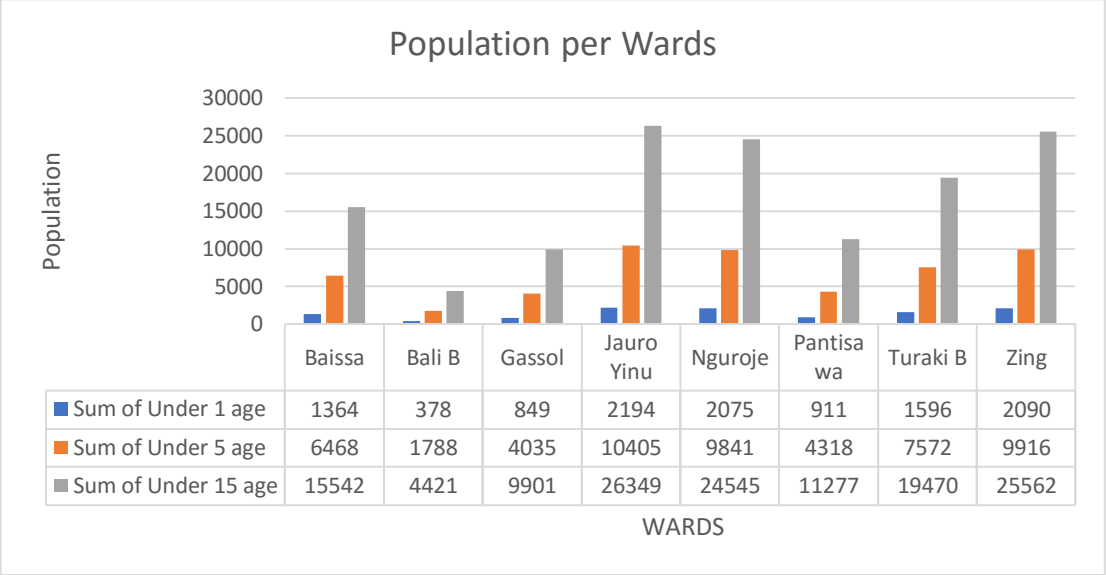



Fig. 26 Population of the Sampled wards




| | Baissa | Bali B | Gassol | Jauro Yinu | Nguroje | Pantisawa | Turaki B | Zing |
|---|---|---|---|---|---|---|---|---|
| Sum of Under 1 age | 1364 | 378 | 849 | 2194 | 2075 | 911 | 1596 | 2090 |
| Sum of Under 5 age | 6468 | 1788 | 4035 | 10405 | 9841 | 4318 | 7572 | 9916 |
| Sum of Under 15 age | 15542 | 4421 | 9901 | 26349 | 24545 | 11277 | 19470 | 25562 |

Figure 27. Population of under 1, 5 and 15 years per ward in the sampled localities

The Fig. 26, 27 & 28 illustrating total population, under-five population, and number of immunized children across various wards highlight significant disparities in the distribution and uptake of primary health care services in Taraba State. Wards such as Zing, Turaki B, and Jauro Yinu show very high bars for total population and immunization counts, indicating high service utilization likely due to better facility coverage, central location, or higher health awareness. In contrast, wards like Bali B and Pantisawa display noticeably shorter bars, suggesting either lower population densities or limited access to PHC facilities, possibly compounded by geographical or infrastructural barriers. These visual disparities align with the ANOVA results, which confirmed statistically significant differences in PHC characteristics between locations.

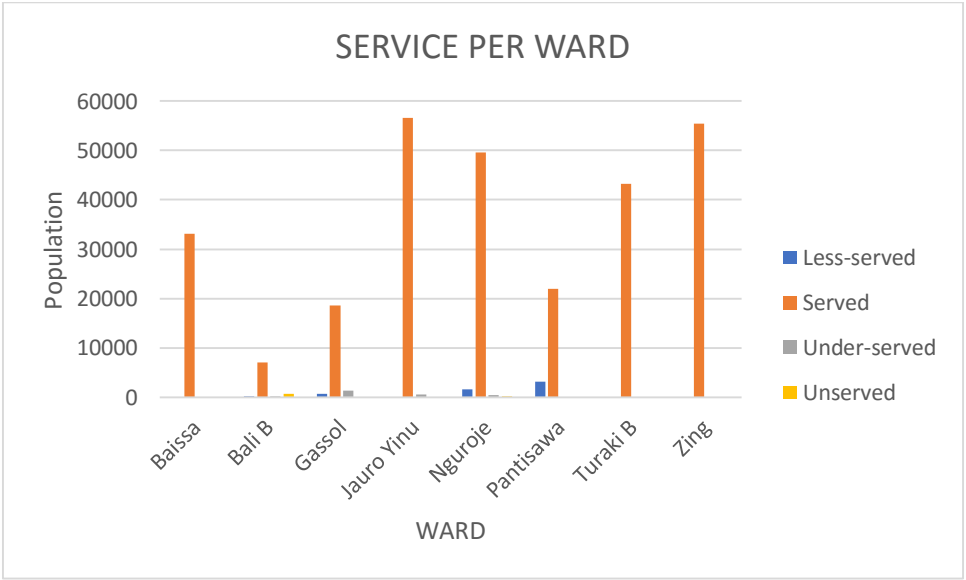



Fig. 28. Areas of PHCC Serviced, underserved, less served and unserved per ward

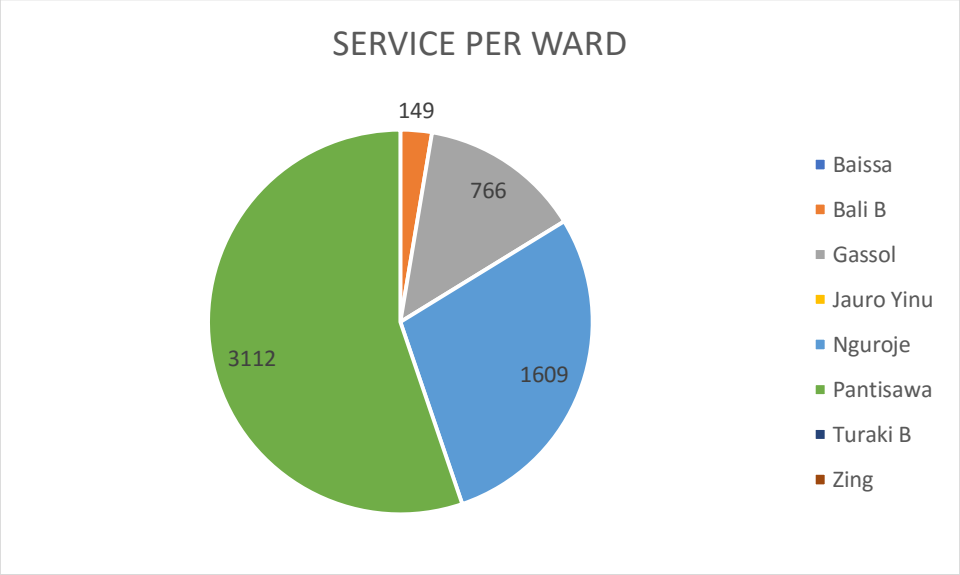



Fig. 29. Distribution of PHCC Services per ward

## 4. Conclusion

This study utilized a mixed-methods approach combining GIS-based spatial analysis and a facility-level service readiness assessment to evaluate the accessibility and adequacy of primary healthcare services in Taraba State, Nigeria. The findings reveal significant disparities in both geographic access and service delivery across the state, highlighting that national PHC reforms like the Primary Health Care Under One Roof (PHCUOR) policy and the Basic Health Care Provision Fund (BHCPF) have not yet resulted in equitable, uniform coverage. The spatial analysis confirmed that a substantial portion of the population lives in "less served" or "underserved" areas, located beyond the WHO-recommended 5 km or one-hour travel time from a PHC facility. The buffer analyses of various wards demonstrated that only a limited number of communities are adequately served, with physical distance and difficult terrain, particularly in mountainous regions like Nguroje Ward, acting as significant barriers to access.

The study also found a strong inverse relationship between distance to PHC facilities and immunization coverage. Wards with higher population density tended to achieve a lower percentage of immunization coverage. The statistical analysis further supported these findings, with ANOVA results showing statistically significant differences in PHC characteristics between locations, reinforcing the conclusion that accessibility is not evenly distributed. The descriptive statistics highlighted a severe imbalance in service provision, with a few PHCs serving disproportionately large populations, while most operate at minimal capacity. In conclusion, the goal of achieving equitable health coverage remains a significant challenge in Taraba State due to pervasive spatial and systemic barriers. The findings underscore the need for targeted, evidence-based interventions to improve both physical access and service readiness. This includes strategic placement of new facilities, enhancing transportation infrastructure, and improving the adequacy of existing PHCs through better infrastructure, equipment, medicine, and staffing, especially in underserved, rural, and topographically challenging areas.

## 5. Recommendations

Based on the study's findings, the following recommendations are made:

i. Target Investments to Underserved Areas: Use the GIS maps from the study to pinpoint and prioritize investments in underserved wards. This could involve establishing new PHC facilities or upgrading existing ones in areas with challenging terrain or low vaccination rates.

ii. Improve Physical Access: The study revealed that a significant portion of the population is located in "less served" or "underserved" areas beyond the WHO's recommended 5 km distance. To address this, it's crucial to improve road networks and transportation to connect remote settlements to PHC facilities. Additionally, mobile health outreach programs should be implemented to reach communities that are difficult to access.

iii. Enhance Service Adequacy and Capacity: Many PHCs in the study area operate at a minimal capacity, while a few serve a disproportionately large population. To fix this, all facilities should be equipped with the necessary infrastructure, essential medicines, and functional equipment, as per WHO and Nigerian frameworks. It is also recommended to increase staffing levels and skill mix to meet national standards.

iv. Strengthen Outreach and Awareness Programs: The study found that low immunization rates in some areas may be influenced by factors like limited awareness and scattered settlements. Public health campaigns should be initiated to educate the community on the importance of PHC services, especially in remote and sparsely populated areas, to boost service utilization.

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