Odisha Health Facility Coverage Analysis

Village-Level Access to PHCs and HSCs (2025)

Data Sources

This analysis integrates multiple geospatial and tabular datasets to assess the geographic coverage of Primary Health Centres (PHCs) and Health Sub-Centres (HSCs) in Odisha at the village level.

Layer	Description	Source	Strengths	Limitations
Village Points	Village-level centroids with LGD codes, 2024 projected population, and rural/urban status	Esri India (Living Atlas), derived from Census 2011 and Registrar General of India projections (2020 report)	High-resolution village granularity, downscaled from district level using validated factors	Not official administrative boundaries; projection accuracy depends on base-year alignment
PHC/HSC Facility List	Health facility name, coordinates, district/block, standardized type (PHC/HSC)	Government of India Health Facilities Directory (data.gov.in), validated against HMIS 2024	An authoritative public database, manually verified with HMIS active facilities	Some misclassifications in the source data were corrected during cleaning
Routing Output	Computed geodesic distances from villages to the nearest PHC/HSC	OSRM local engine + cleaned road network	Reproducible, scalable, and efficient for large-scale modeling	Uses geodesic straight-line distance; no travel time or mode-specific adjustment
Odisha Boundary	Administrative district-level boundaries	GADM v4.1 (Level 2), filtered for Odisha	Compatible with public spatial standards	May vary slightly from official state government definitions

Methodology

This study conducts a district-wise spatial analysis of healthcare coverage in Odisha, focused on Primary Health Centres (PHCs) and Health Sub-Centres (HSCs), using village-level geospatial and demographic data. The methodology follows a five-stage pipeline:

1. Data Preparation and Cleaning

- **Village Dataset**:
  Village boundaries and centroids were obtained from Esri India's 2024 Living Atlas layer, based on Census 2011 administrative boundaries and population projections from the Technical Group on Population Projections (MoHFW, 2020). This layer provides LGD codes, sub-district/district classifications, rural–urban status, and projected population up to 2036.
- **PHC and HSC Datasets**:
  Health facility locations and attributes were sourced from the National Health Centre Directory (Data.gov.in), validated against the Ministry of Health and Family Welfare's HMIS portal (2024). Each facility was uniquely identified using its National Identification Number (NIN) and categorized by standardized type.
- **Matching and Cleaning**:
  - Villages were matched using the LGD village code, treated as the primary `village_id`.
  - Exact ID-based joins ensured clean one-to-one mapping between facility/village datasets and coverage outputs.
  - All datasets were reprojected to EPSG:4326 (WGS 84) for geospatial consistency.

Urban Undercount Limitation: While the dataset includes 214 villages tagged as "urban" (`tru_2011 = Urban`), this underrepresents actual urban healthcare coverage due to the absence of ward-level boundaries and municipal centroid data for cities like Bhubaneswar and Cuttack. As a result, the analysis is primarily focused on **rural and peri-urban healthcare access gaps**, not full urban coverage.

2. Geodesic Distance–Based Coverage Analysis

- **Coverage Thresholds**:
  - PHCs: 5 km geodesic distance from a village centroid.
  - HSCs: 3 km geodesic distance from a village centroid.
- **Analysis**:
  - For each village, the nearest PHC and HSC were computed using vector-based geodesic distance calculations (great-circle distance).

    - If a facility was within the respective distance threshold, the village was labeled as
- **Covered**; otherwise, **Uncovered**.
  A unified "covered" status was also created, representing villages covered by either a PHC or an HSC.

3. Spatial Join and Coverage Layer Creation

- The geodesic coverage results were merged with cleaned village geometries using LGD codes as the join key.
- Separate spatial layers were created for:
    - PHC coverage
    - HSC coverage
    - Combined PHC + HSC overlay
    - Unified coverage status (covered by either tier)

4. Visualization Design

- Odisha district boundaries were overlaid on each map to provide administrative context.
- Visualizations used geospatial plotting libraries (GeoPandas and Matplotlib), with high-contrast, accessible color palettes:
    - **Green / Light Blue** – Covered villages
    - **Red / Blue** – Uncovered villages (PHC or HSC specific)
    - All visualizations maintain consistent projection and styling, suitable for policy briefing and technical interpretation.

5. Analytical Summaries

Summary charts were created to quantify:
Total and uncovered villages by tier
Rural vs urban disparities in coverage
Proportion of statewide coverage via bar charts and pie charts
All statistics were based on the final cleaned datasets with 51,404 villages across 30 districts.

Assumptions

- Villages are represented adequately by their centroid point.
- The shortest geodesic distance is a valid proxy for travel time/accessibility.
- The coverage threshold (3 km for HSC, 5 km for PHC) aligns with WHO norms and Indian rural health infrastructure planning norms.
- Facility locations are assumed to be correctly geo-coded after cleaning.

- All villages are assigned to a single nearest facility (not multiple referral paths).
- Limited Urban Representation: Urban core areas like Bhubaneswar and Cuttack show sparse village representation due to the exclusion of municipal wards; thus, this map emphasizes rural and peri-urban access gaps.

Visualizations

Figure 1: Odisha Villages and District Boundaries

- **Description**: This map plots all 51,404 cleaned and deduplicated villages across Odisha, overlaid on accurate administrative district boundaries.
- **Purpose**: Establish the spatial extent of analysis and reference base layer for all maps.
- **Data Source**:
    - Village geometries: ESRI India (2024), derived from Census 2011 base and Cohort Component projections to 2024.
    - District boundaries: GADM Level 2, validated against Survey of India alignments.

Figure 1: Odisha Villages and District Boundaries

Figure 2: PHC Coverage Map – Odisha Villages

- **Description**: Green dots represent villages within a 5 km geodesic radius of a PHC. Blue upward triangles mark PHC-uncovered villages.
- **Purpose**: Show geographic coverage of PHCs and identify spatial gaps.

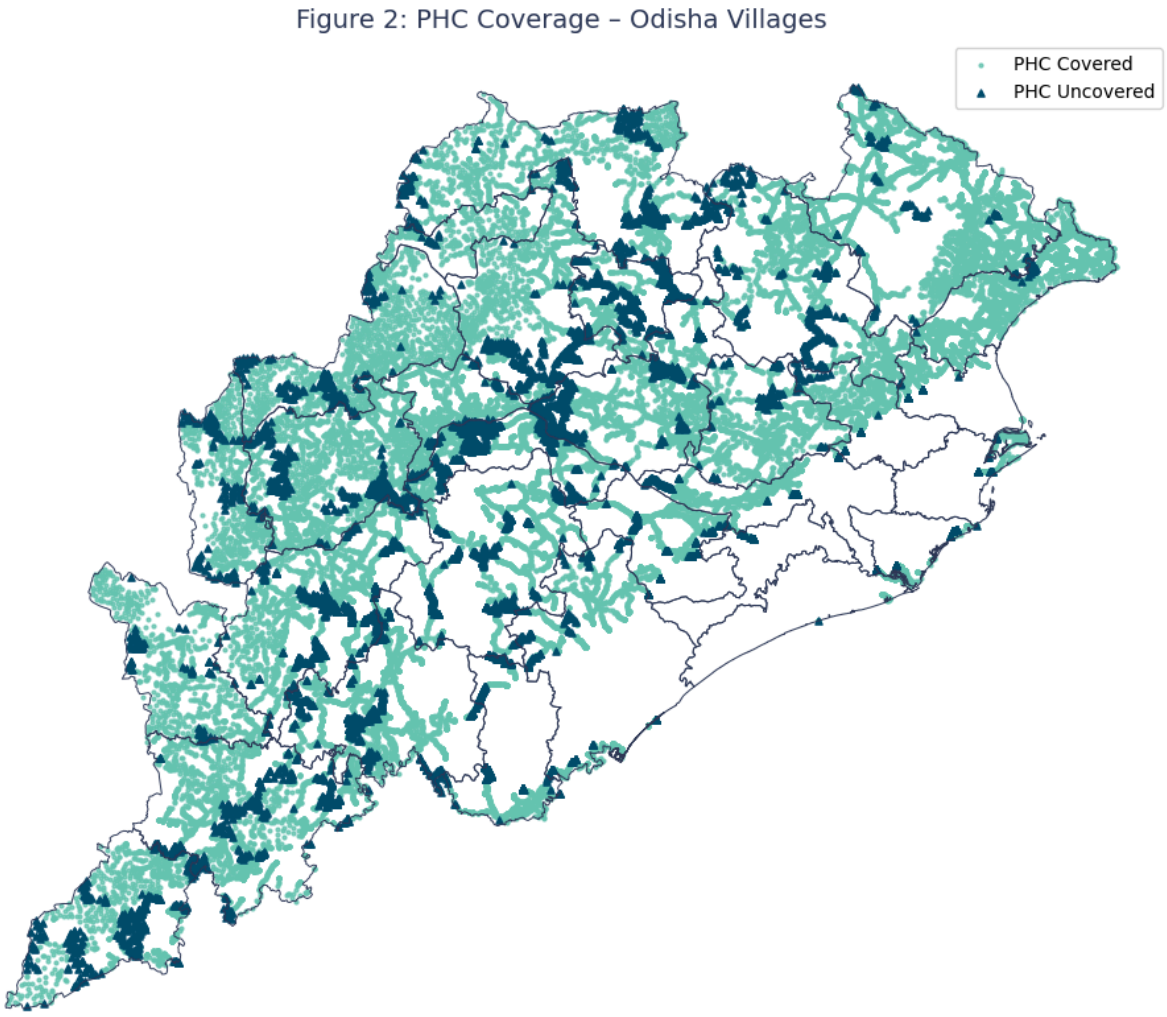


Figure 3: HSC Coverage Map – Odisha Villages

- **Description**: Sky-blue dots represent HSC-covered villages. Red squares indicate villages not within 3 km of any HSC.
- **Purpose**: Highlight granular coverage of health sub-centers across Odisha.
- **Data**: Cleaned hsc_coverage_with_geometry.geojson file.

Figure 3: HSC Coverage – Odisha Villages

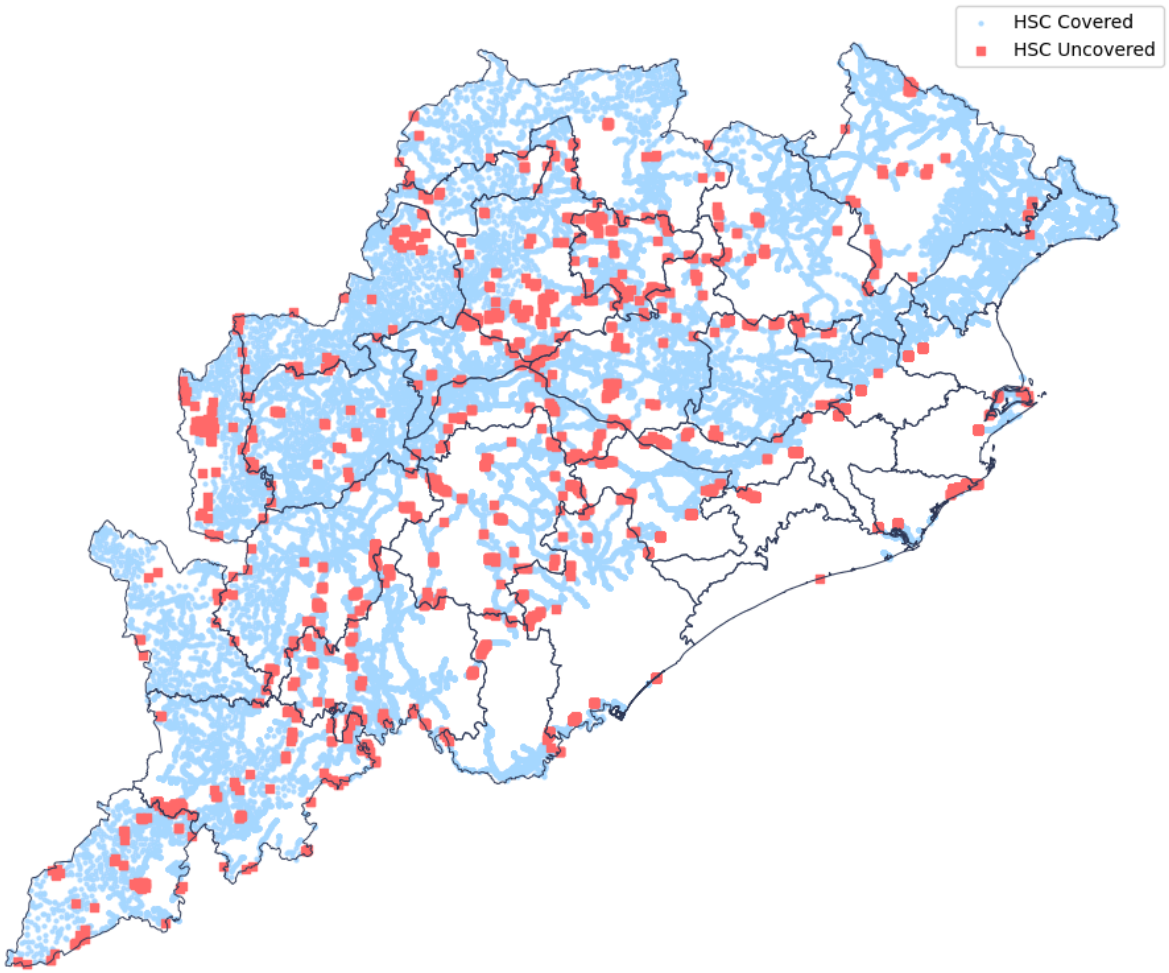


Figure 4: Combined PHC + HSC Coverage Map

- **Description**: Merges visual layers of both PHC and HSC.
  - Light blue = PHC covered
  - Sky blue = HSC covered
  - Red square = HSC uncovered
  - Blue triangle = PHC uncovered
- **Purpose**: Provide a holistic overlay to detect dual gaps and overlaps.

Figure 4: Combined PHC and HSC Village Coverage

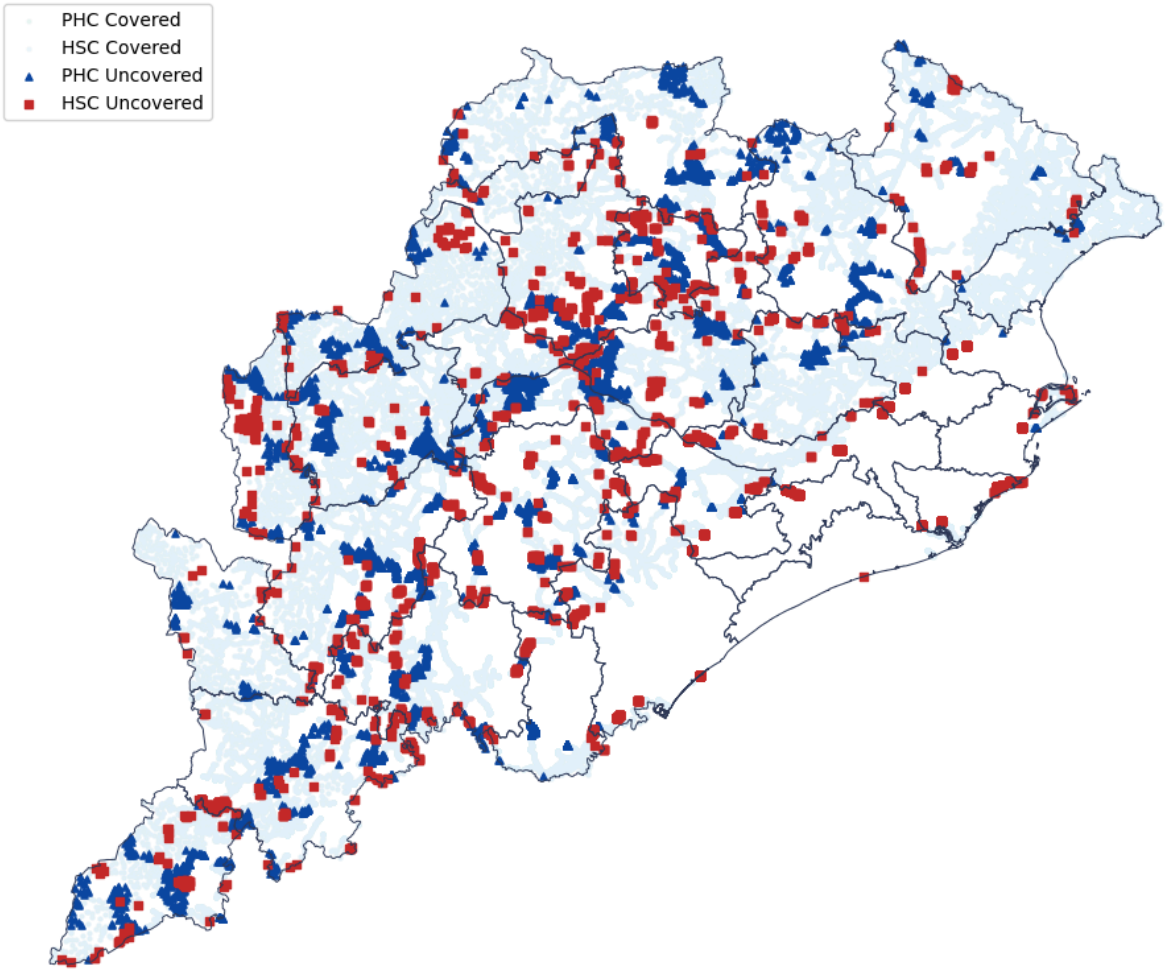


Figure 5: Combined PHC + HSC Coverage Map – Odisha (3 km Threshold)

Description:
This map visualizes all 51,404 villages in Odisha categorized by whether they lie within 3 km of either a Primary Health Centre (PHC) or a Health Sub-Centre (HSC).

- Green dots: Villages **covered** by at least one facility
- Red dots: Villages **uncovered** beyond the 3 km threshold

Key Inferences:

1. **Widespread Coverage Achieved:** Approximately **94.2%** of villages are within 3 km of a PHC or HSC, highlighting strong baseline access across most regions.

2. **Persistent Gaps in Interior and Tribal Belts:** Dense clusters of uncovered villages appear in southern and western districts (e.g., Kandhamal, Koraput, Malkangiri), signaling a need for targeted interventions such as Mobile Health Units (MHUs).

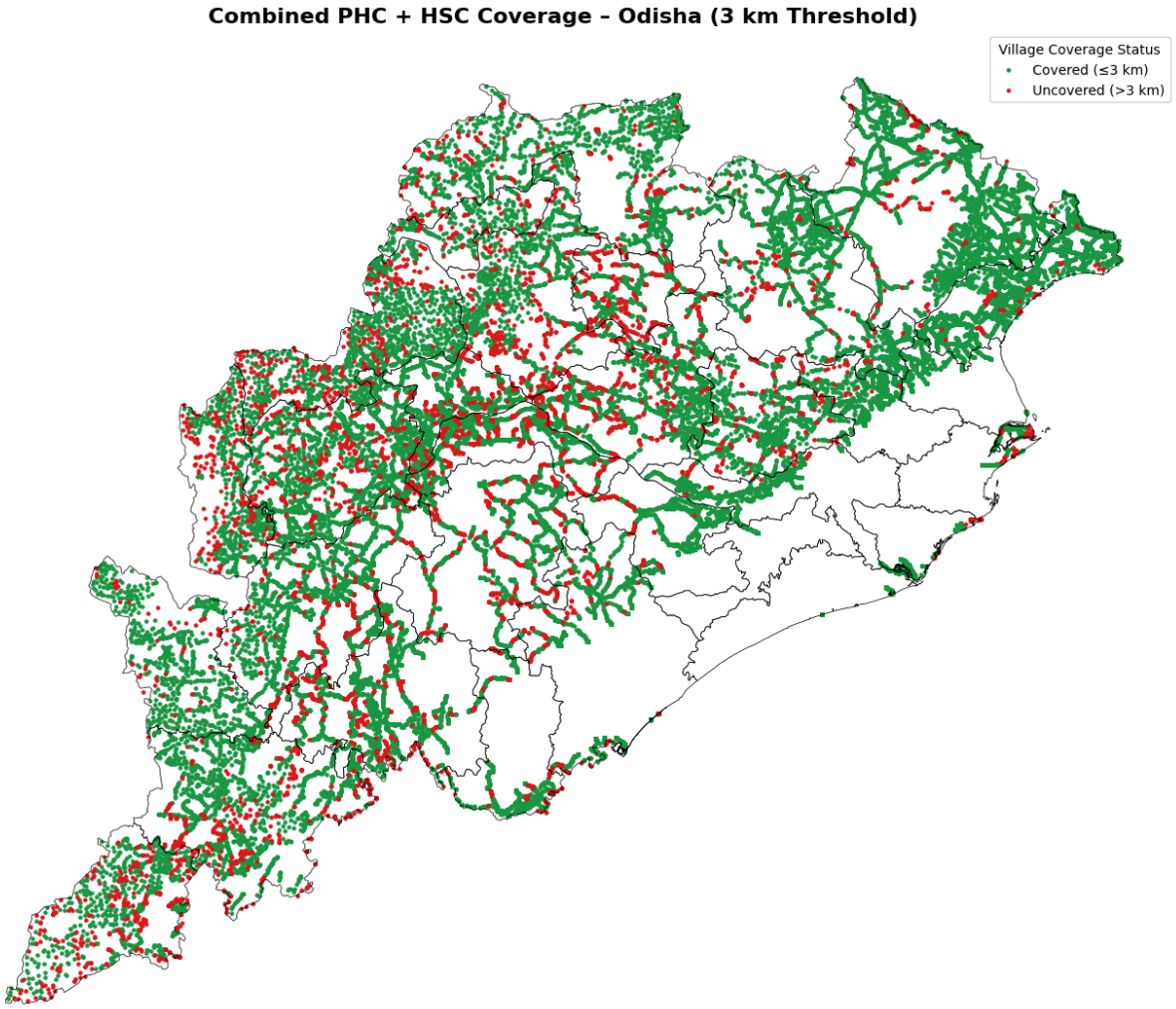


Figure 6: Bar Chart – Covered vs Uncovered Villages (PHC and HSC)

- **Y-axis**: Number of villages
- **X-axis**: Categories of Covered and Uncovered
- **Purpose**: Quantitative view of rural health access by tier.

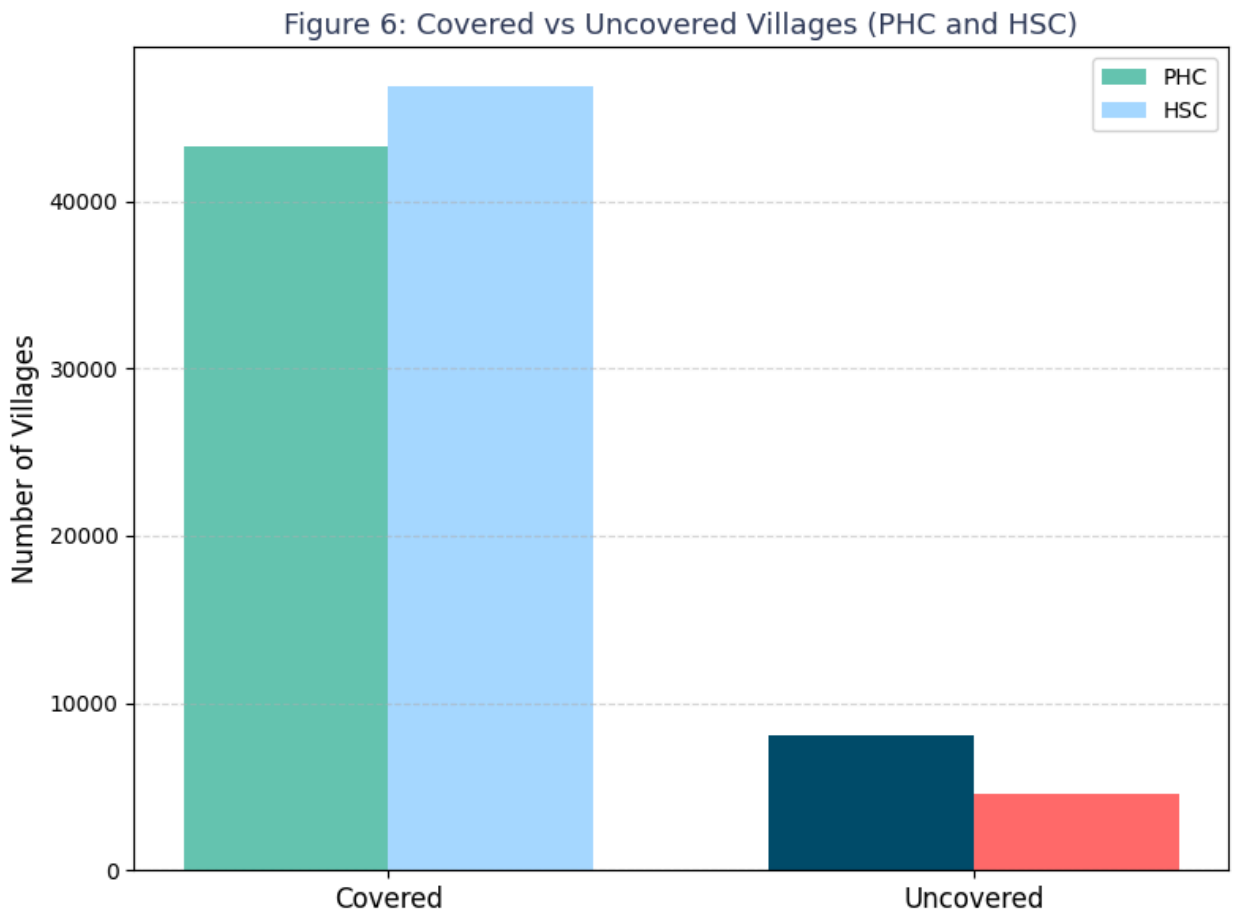
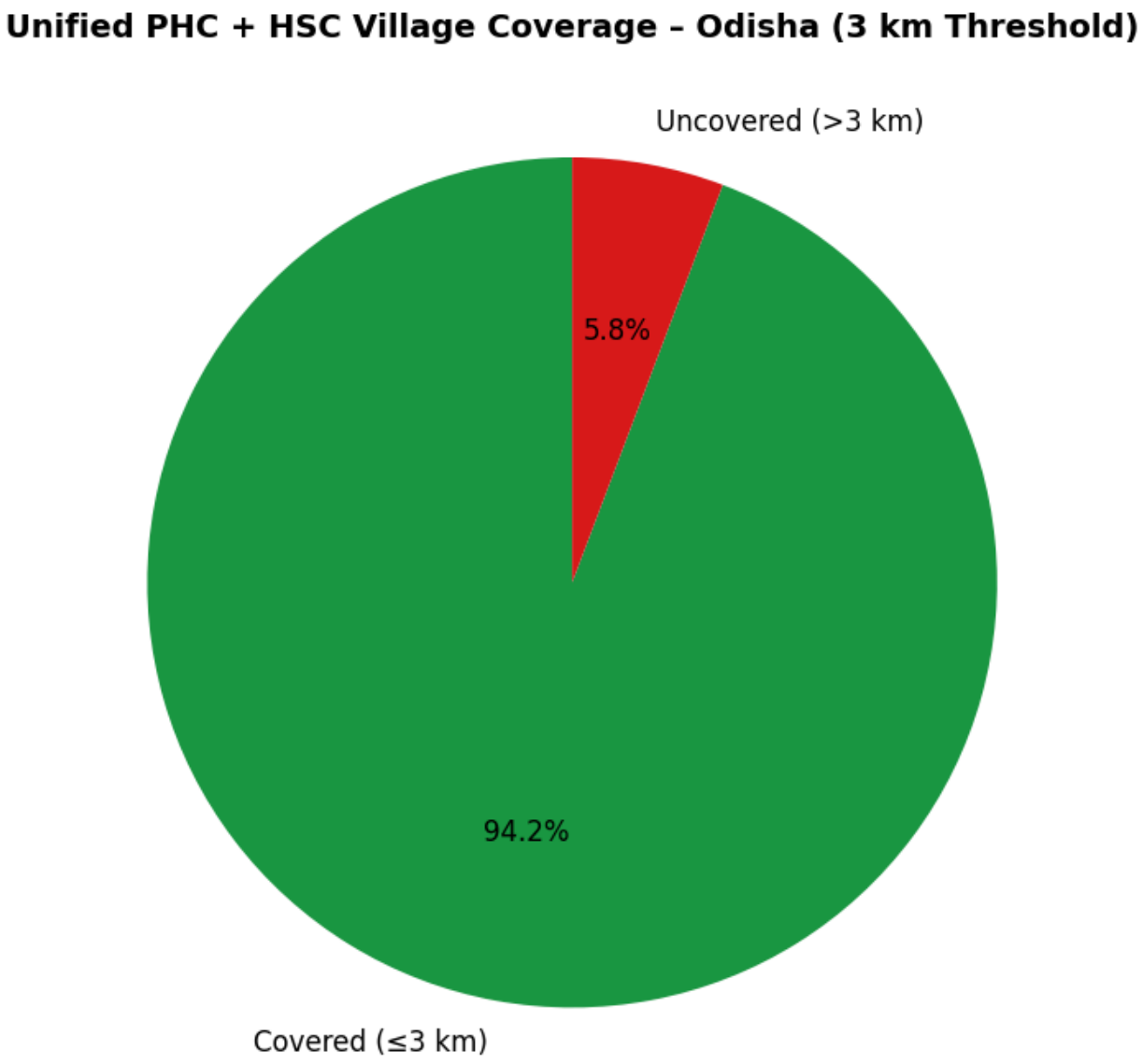


Figure 7: Pie Chart – Unified Village Coverage Proportion (3 km Threshold)

- Covered = 94.2%
- Uncovered = 5.8%



Output Summary

- **Total Villages Analyzed**: 51,404
- **PHC Uncovered**: 8,101 villages (15.75%)
- **HSC Uncovered**: 4,529 villages (8.81%)

Key Result Additions (Unified 3 km Threshold)

- **Total Villages Analyzed:** 51,404
- **Unified PHC + HSC Uncovered Villages (>3 km): 2,965**
- **Unified Coverage Rate: 94.23%** (48,439 covered villages)