Geospatial Analysis of Healthcare Accessibility in Sabah, Malaysia

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Background

Sabah faces significant **challenges in healthcare delivery** due to its complex geography and uneven distribution of facilities:

- Large land area with widely dispersed rural settlements
- Mountainous and rugged terrain that increases travel times
- Health facilities concentrated along the west coast and major towns
- Highest poverty rate in Malaysia (17.7% in 2024), intensifying access barriers
- Limited facility capacity and specialist coverage in interior districts

These factors create **major urban–rural inequalities** in healthcare access, thus highlighting the need for **geospatial accessibility assessment**.

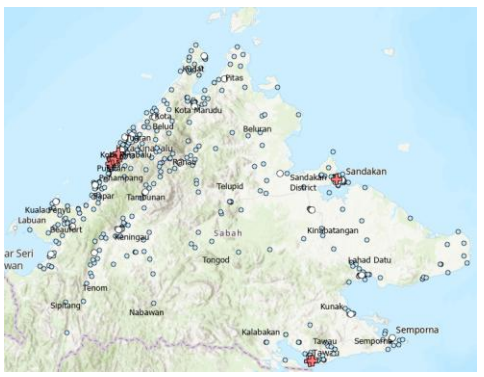
Objectives

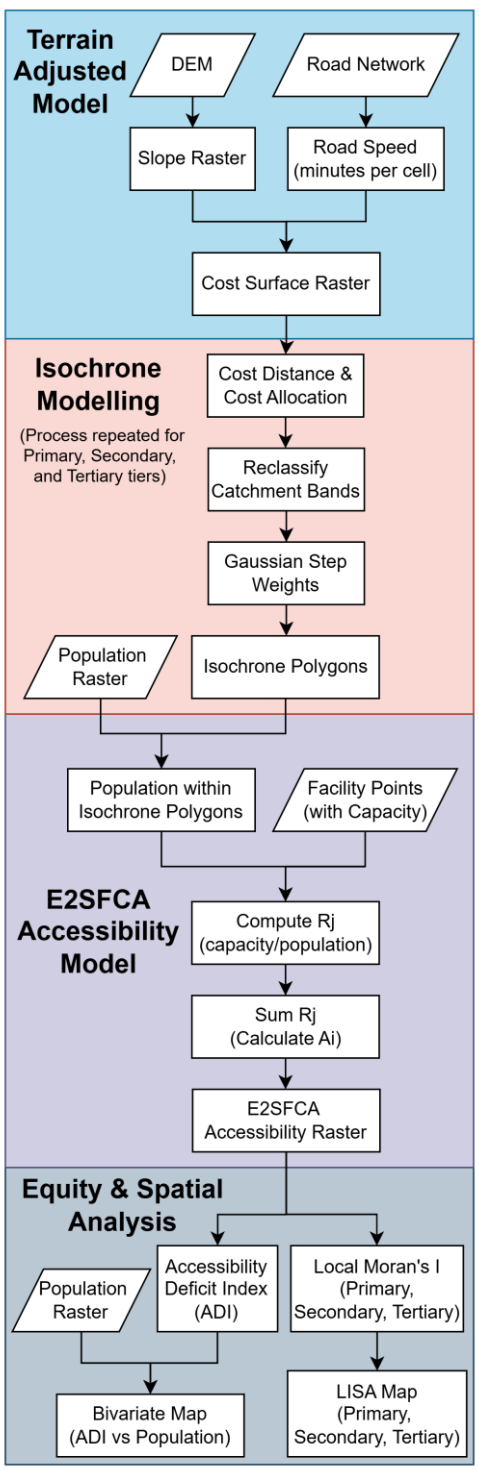
1. To measure and visualise healthcare accessibility across all 27 districts of Sabah
2. To identify underserved districts and size of the equity gap

Research Area

State: Sabah, Malaysia
Administrative Units: 27 districts
Healthcare facilities:

- 1119 Primary facilities
- 62 Secondary facilities
- 12 Tertiary facilities



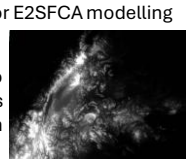


Methodology

1. Data Collection & Pre-processing

Healthcare facilities: categorised into primary, secondary, and tertiary facilities. Geocoded coordinates and derived capacity attributes for E2SFCA modelling

Digital Elevation Model (DEM): Obtained DEM and converted into slope and terrain friction (minutes per cell). Used to build the Terrain Adjusted Model (TAM).

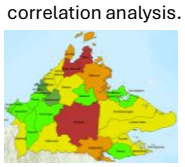


Road Network: Imported OSM road data and corrected missing speed values with existing category median. Used to derive travel cost per cell.

Administrative Boundaries: Cleaned and verified state and 27 district boundaries for accurate zonal statistics and spatial joins.

Population Raster (2025): Estimated population at 100m grid cell resolution

District-level poverty data : Supports bivariate and correlation analysis.



District-level population data : Supports bivariate and correlation analysis.

2. Modelling in ArcGIS Pro

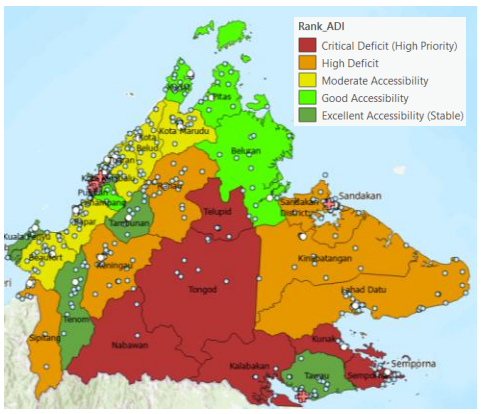
1. Terrain Adjusted Model (TAM)
2. Isochrone Modelling
3. Enhanced Two-Step Floating Catchment Area (E2SFCA)
4. Spatial & Equity Analysis
   i. Accessibility Deficit Index (ADI)
   ii. Bivariate Choropleth (Population vs Accessibility)
   iii. Local Moran's I Spatial Clustering

Travel Cost Surface

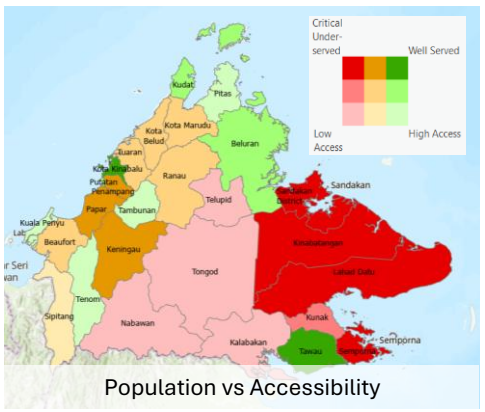
Isochrone Polygons (Primary Facilities)

Results

Accessibility Deficit Index (ADI)

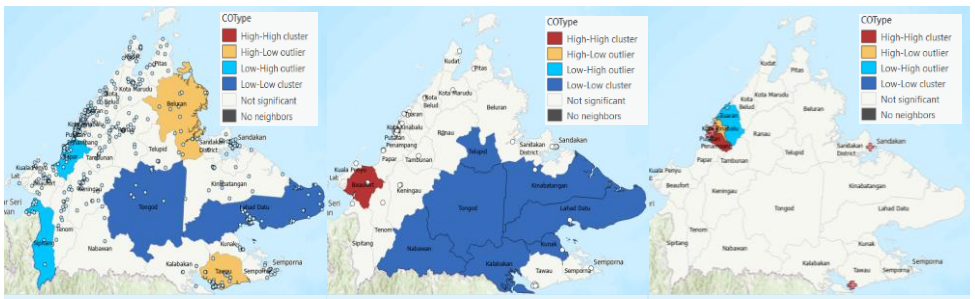


Bivariate Choropleth



Population vs Accessibility

Local Moran's I



Primary Care | Secondary Care | Tertiary Care

Findings

1. High-Population Districts with Critically Low Accessibility

Despite housing the largest populations in Sabah, districts such as **Sandakan (2nd most populated), Lahad Datu (4th), Semporna (5th), and Kinabatangan (7th)** exhibit insufficient catchment coverage. These areas carry high population burdens yet suffer from low E2SFCA accessibility scores, indicating structural under-provision and severely overloaded facility catchments.

2. Districts with the Lowest Overall Accessibility (ADI)

The Accessibility Deficit Index (ADI) reveals severe gaps across all healthcare tiers in interior regions. Na**bawan (ADI = 0.00), Kalabakan (ADI = 0.00043), and Tongod (ADI = 0.000999)** exhibit near-zero accessibility scores. These values confirm that service availability in these districts falls significantly below state averages.

3. Accessibility Spatial Clustering (Local Moran's I)

Local Moran's I analysis identifies statistically significant **'Low-Low' clusters** concentrated in **Sabah's central and eastern interior**. These clusters align closely with areas of rugged terrain, dispersed settlements, and limited road connectivity, forming persistent zones of structural disadvantage. Their overlap with low ADI scores and low population-accessibility values indicates that geographic and infrastructural barriers suppress healthcare accessibility in these regions.

Conclusion

Critical Disparities: Healthcare accessibility is deeply uneven. Urban centres (e.g., Sandakan) struggle with capacity overload, while interior districts (e.g., Nabawan) face geographic isolation.
Diagnostic Precision: Integrating E2SFCA, ADI, Bivariate Mapping, and Local Moran's I successfully pinpointed specific 'cold spots' of disadvantage.
Policy Impact: The resulting equity maps provide a concrete framework for prioritising infrastructure improvement and resource allocation.

Acknowledgement

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Data sources: Healthcare facilities (Ministry of Health Malaysia); DEM (Google Earth Engine); Administrative Boundaries (GADM & OpenStreetMap); Population raster (WorldPop); District Poverty & Population data (data.gov.my)