Geospatial Mapping and Spatial Analysis of Informal Settlements Using GIS: A Case Study of Slum Mapping in Rajkot Municipal Corporation

Saish Sarikonda
Department of Geomatics / GIS, CEPT University, Ahmedabad

***Abstract*—Rapid urbanization in Indian cities has accelerated the expansion of informal settlements marked by insecure tenure, inadequate housing, weak service provision, and environmental vulnerability. This paper develops a Geographic Information System (GIS)-based framework for slum mapping and analysis within Rajkot Municipal Corporation (RMC). The study integrates spatial, infrastructural, demographic, economic, and housing indicators to derive a Slum Severity Index (SSI) and to support planning decisions related to redevelopment, relocation, and upgradation. A normalization-based multi-criteria approach was used to compute indicator values, assign weights, and generate a composite slum index. The results show a strong concentration of slums in the eastern zone of Rajkot, clear disparities in service availability across zones, and significant variation in dwelling-level conditions within individual slums such as Kitipara. The study also demonstrates how an SSI calculator and relocation model can be integrated into a decision support system for municipal planning.**

***Index Terms*—decision support system, GIS, informal settlements, slum mapping, slum severity index, urban planning.**

I. INTRODUCTION

According to the Census of India, a slum may be understood as a residential area where dwellings are unfit for human habitation because of dilapidation, overcrowding, poor design, narrow or irregular streets, and inadequate ventilation, light, or sanitation. In Indian cities, such settlements represent a complex spatial and socio-economic condition rather than only a housing problem. The growth of slums is closely linked to migration, urbanisation, poverty, unemployment, industrialisation, and the unequal distribution of basic amenities. As cities expand, low-income households often settle on marginal land near rivers, transport corridors, industrial zones, and other areas that remain outside formal planning and service networks. In this context, GIS provides a strong analytical framework for identifying slum patterns, integrating multiple indicators, and supporting targeted planning decisions. This study aims to develop a decision support system for slum redevelopment, relocation, and upgradation in Rajkot Municipal Corporation. The specific objectives are to identify the spatial pattern and structure of slums, derive indicators related to financial, infrastructural, demographic, amenity, health, and education conditions, and develop an index for prioritising slums for intervention.

II. POLICY CONTEXT AND STUDY AREA

The research is framed within the broader policy context of smart city planning and affordable housing. Core service components referenced in the project include water supply, electricity, sanitation, public transport, affordable housing, information technology connectivity, e-governance, sustainable environment, safety and security, and health and education. The study also draws from PMAY and related redevelopment and relocation guidelines, especially for settlements located near rivers, railway tracks, and major transit routes. Rajkot Municipal Corporation contains 135 notified slums covering approximately 5.4 km². Most slums are clustered along the river corridor and at the edges of industrial and commercial zones. The eastern zone contains the largest share of slums, accounting for 62.5% of the total, while Ward 15 has the highest number of slum pockets. This uneven distribution makes Rajkot an appropriate case for developing a GIS-based prioritisation framework.

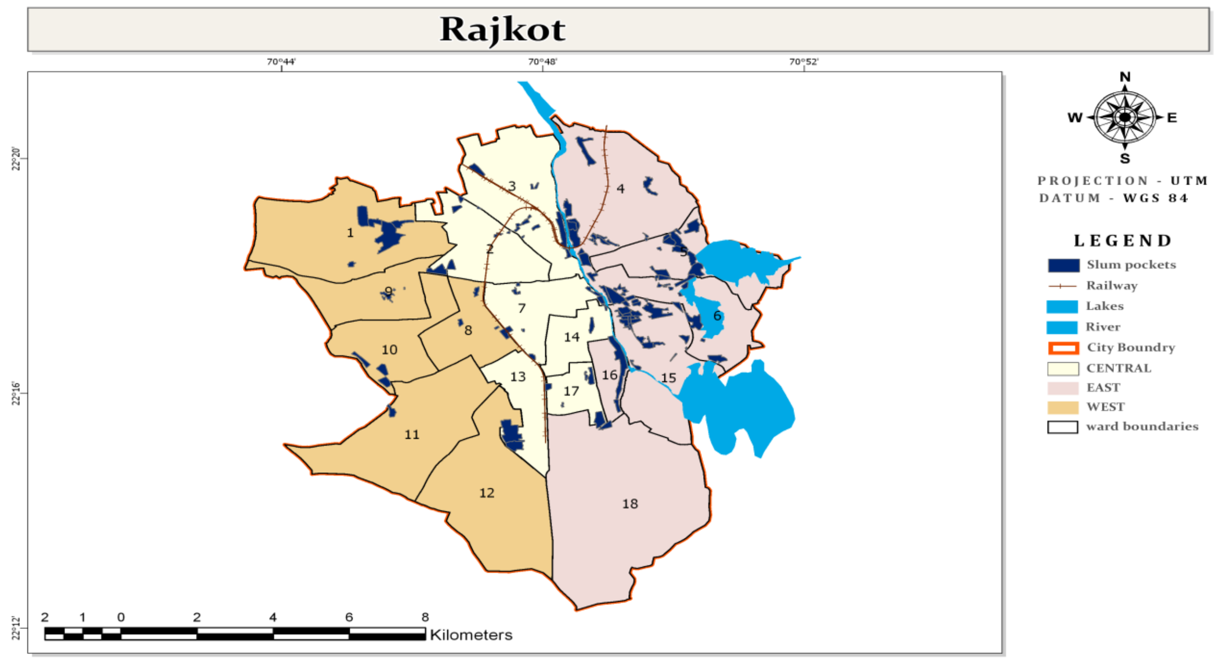

Fig. 1. Spatial distribution of slums across Rajkot Municipal Corporation, showing zonal distribution and concentration in the eastern sector.

III. DATA AND METHODOLOGY

The study integrates spatial and non-spatial datasets, including satellite imagery, municipal and ward boundaries, transport networks, river and lake layers, slum boundary data, and household-level survey attributes. The methodology follows a normalization-based multi-criteria evaluation framework implemented within a GIS environment.

A. Methodological Framework

The analytical workflow begins with the selection of parameters to be incorporated in the analysis, followed by the identification of the attributes associated with each parameter. For each attribute, percentage values are calculated and multiplied by the assigned score. The values are then aggregated to derive parameter-level scores. Weights are assigned on the basis of interdependency and relative planning importance. The weighted parameter values are summed to derive indicator-level values, and these indicator values are subsequently aggregated to compute the final Slum Severity Index (SSI). The final slum index is linked to planning and policy considerations to support redevelopment or relocation alternatives.

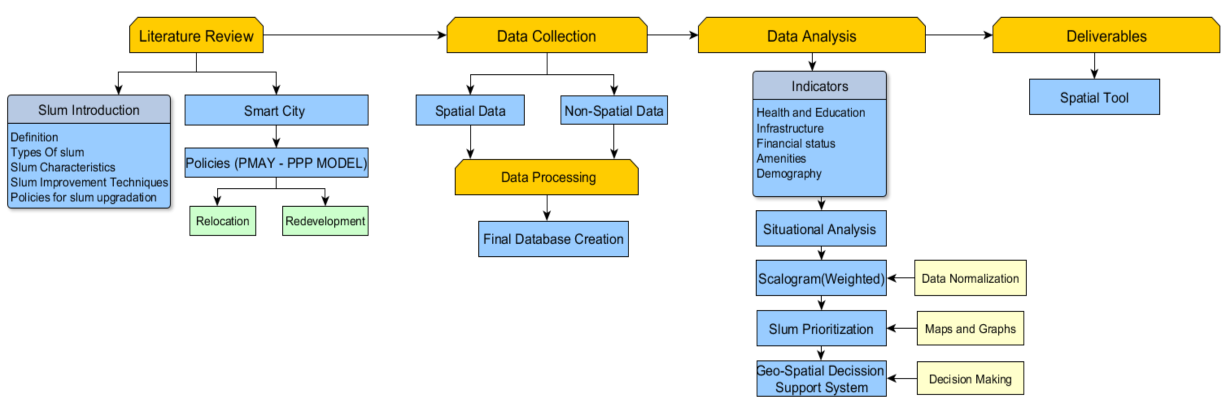

Fig. 2. Methodological flow used for parameter normalization, weight allocation, composite scoring, and decision support.

B. Indicator Groups and Weight Allocation

Five major indicator groups were used in the assessment: amenities, demographics, financial status, building materials, and health and education. Each group contains household-level parameters that reflect living conditions, economic capacity, social vulnerability, and the quality of the built environment. Attribute-level weights extracted from the original project framework are presented in Table I.

Table I. Indicator Groups, Parameters, And Attribute-Level Weights Used in The Ssi Framework

Indicator group	Parameter	Weight
Amenities	Cooking fuel	0.20
Amenities	Toilet facility	0.30
Amenities	Bathroom facility in house	0.20
Amenities	Light facility in house	0.30
Demographics	Number of persons in household	0.35
Demographics	Number of children	0.30
Demographics	Number of earning members	0.35
Financial status	Type of employment	0.15
Financial status	Yearly family income	0.20
Financial status	Yearly expenses of a family	0.10
Financial status	Legal status of land	0.15
Financial status	Social security	0.15
Financial status	Current occupation	0.25
Building materials	Type of construction	0.25
Building materials	Type of flooring	0.20
Building materials	Roof material	0.30
Building materials	Wall material	0.15
Building materials	Number of rooms	0.10
Health and education	Number of patients	0.30
Health and education	Number of children not going to school	0.30
Health and education	Monthly medical expenses	0.30
Health and education	Child vaccination	0.10

C. Composite Index and Decision Support System

The final SSI was computed as the aggregate of the weighted indicator values. Lower values reflect poorer living and infrastructure conditions, while higher values represent comparatively better conditions. A custom SSI calculator was used to automate the computation of indicator values and export the results to a structured database. A complementary relocation model was then applied to distinguish settlements that may require relocation on the basis of river proximity, railway proximity, and low-lying terrain conditions. The database used for the calculator was required to contain all mandatory fields, avoid invalid characters, follow a standard field naming convention, and maintain consistent slum names for spatial joining with the GIS shapefile.

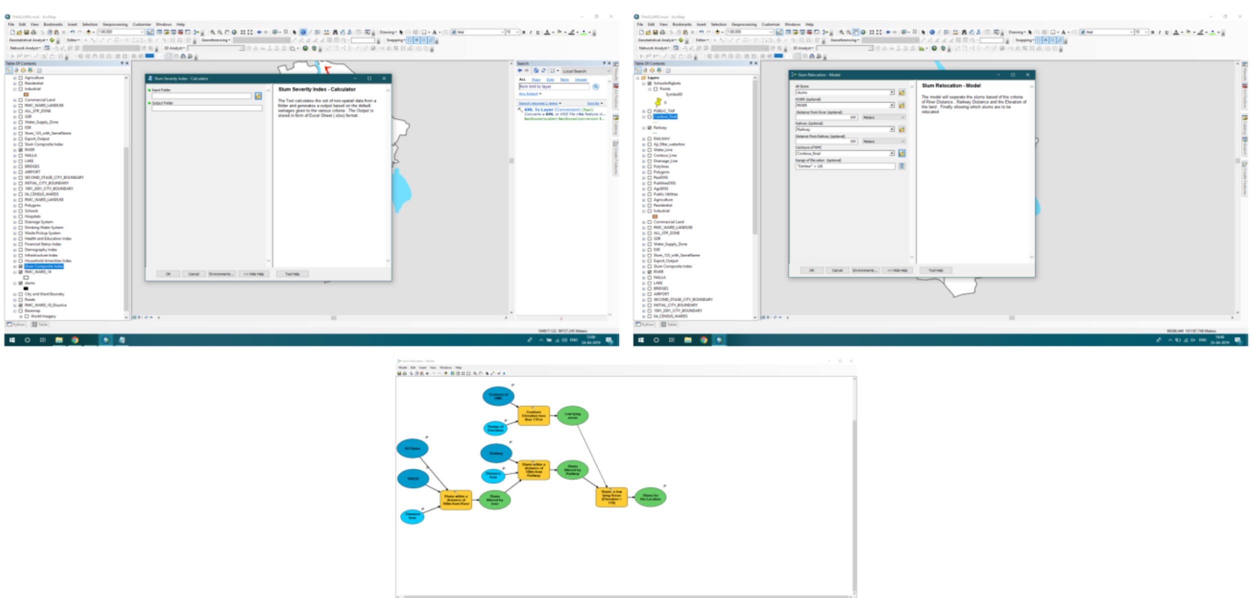

Fig. 3. Decision support system components, including the custom SSI calculator, relocation model interface, and relocation rule graph.

IV. RESULTS AND ANALYSIS

A. Slum Level Service Availability

The slum level analysis compared the availability of five key services: schools, waste pickup, drainage, drinking water, and hospital access. The mapped results reveal clear spatial disparities across the municipal zones. The eastern zone contains the highest concentration of slums and consequently bears the greatest infrastructure pressure. Drainage appears to be the most deficient service category, whereas school, waste pickup, and hospital availability are relatively better represented in mapped slum locations.

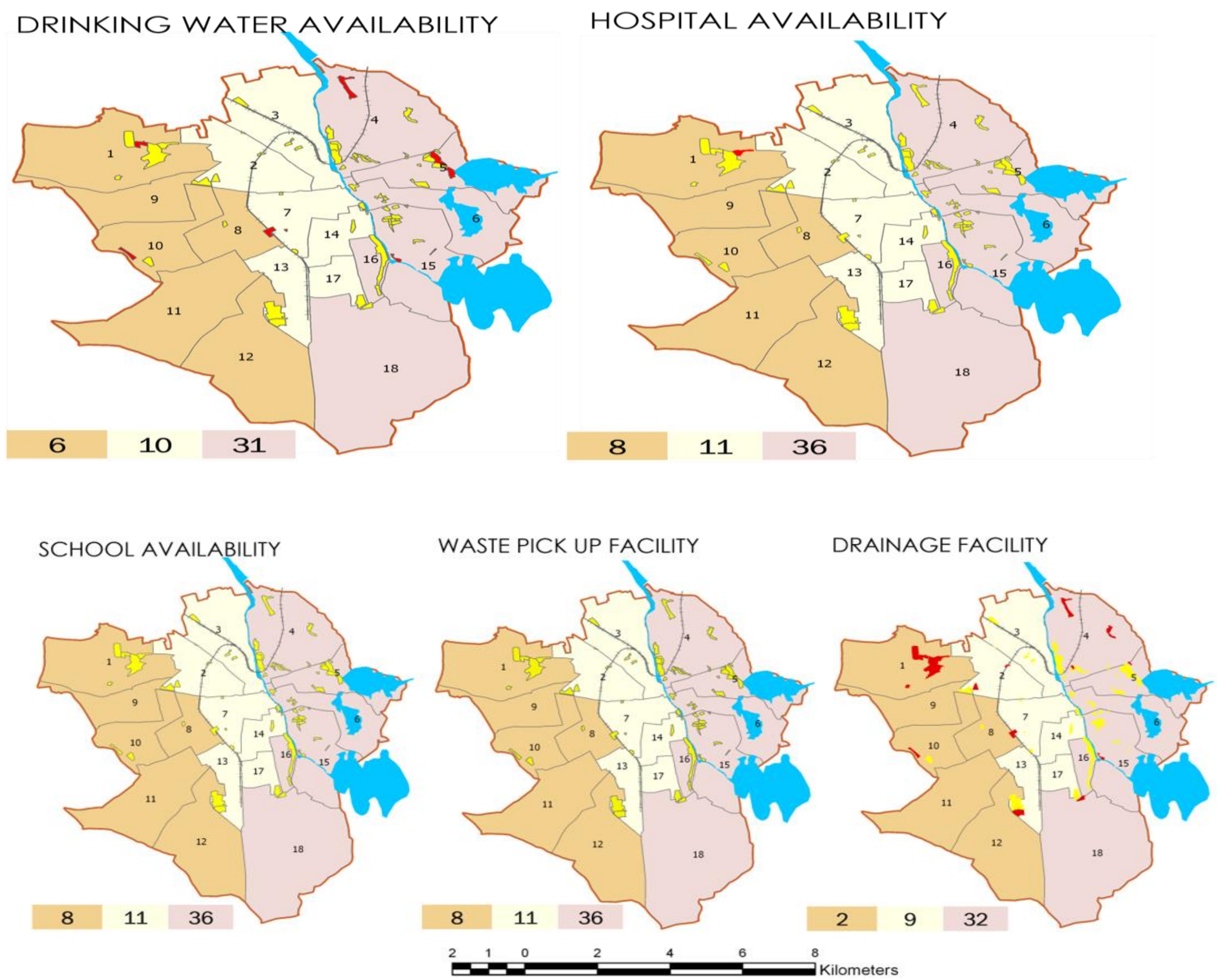

Fig. 4. Slum-level service availability maps for schools, waste pickup, drainage, drinking water, and hospitals.

Table II Zonal Comparison of Mapped Service Availability Across Slum Areas

Category	West Zone	Central Zone	East Zone
Total slums	8	11	36
School availability	8	11	36
Waste pickup	8	11	36
Drainage facility	2	9	32
Drinking water facility	6	10	31
Hospital availability	8	11	36

B. Indicator-Based Analysis and Prioritisation

Indicator maps were prepared for infrastructure, demography, health and education, household amenities, and financial status. These maps reveal not only the city-wide distribution of severity but also the location of particularly weak settlements under each thematic dimension. Together, they support a multi-dimensional understanding of slum deprivation and help explain why some slums emerge as higher priorities for intervention.

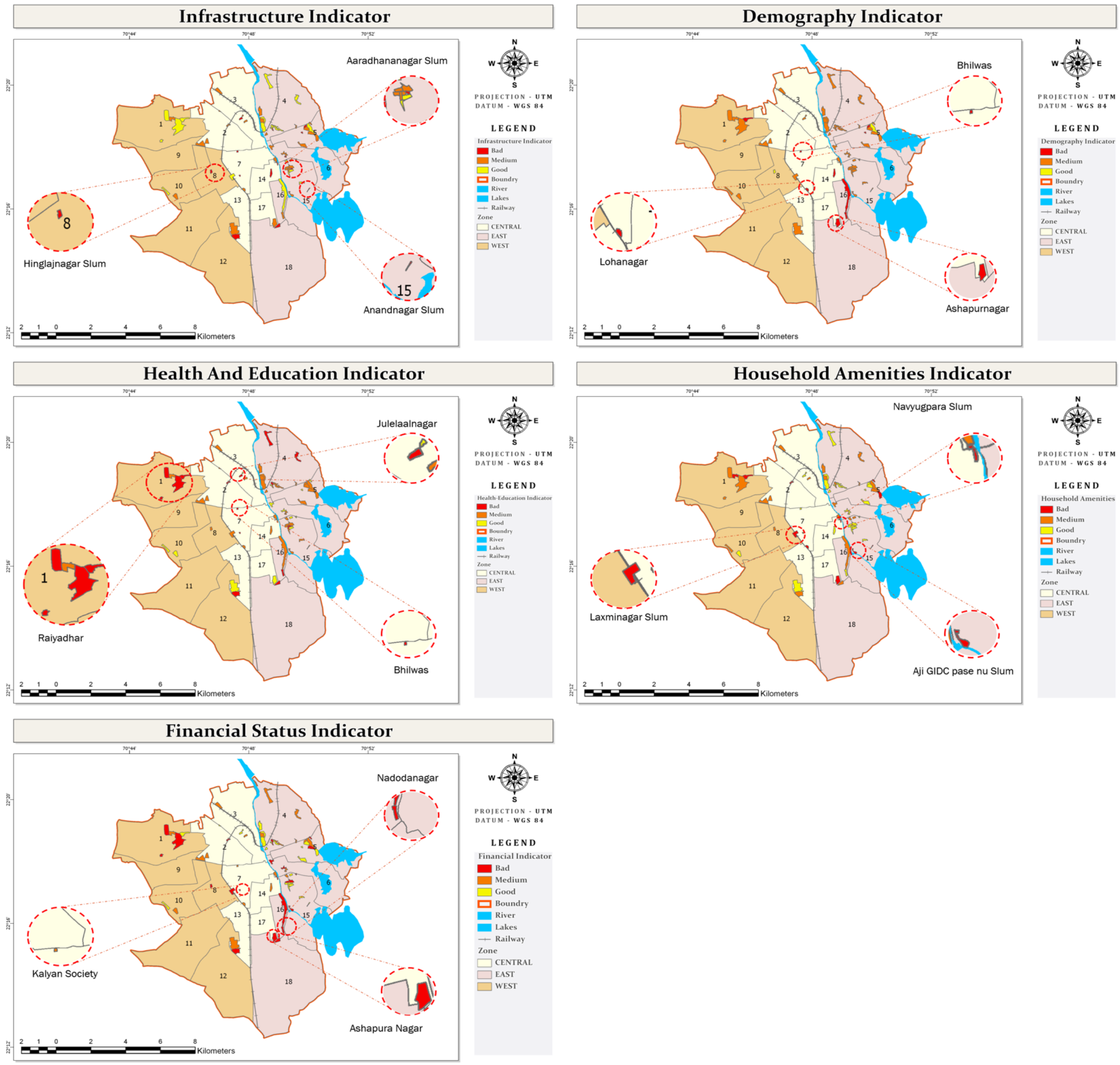

Fig. 5. Indicator maps used to interpret slum conditions across infrastructure, demography, health and education, household amenities, and financial status.

Table III Selected Slums Identified in the Indicator Analysis

Slum name	Indicator value	Ward number
Shastrinagar	4.14	1
Laxminagar	4.92	7 & 8
Raiyadhar	5.34	10

Among the analysed settlements, Shastrinagar emerges as the most sensitive slum, followed by Laxminagar and Raiyadhar. The indicator maps show that poor-performing slums are typically associated with weak amenity provision, fragile housing materials, poor financial security, and higher health-related vulnerability. The SSI framework therefore supports not only slum ranking but also thematic diagnosis of the type of intervention needed.

C. Per-Slum Analysis: Kitipara

A detailed dwelling-level analysis was carried out for Kitipara to understand intra-slum variation in infrastructure conditions. The indicator map ranks each dwelling unit according to the selected parameters associated with the respective household. Dwelling units with better conditions are rated higher, while units with poorer conditions receive lower scores. After normalization, the dwelling-level indicator is derived by aggregating the rating values assigned to each unit. The resulting map shows that conditions are not uniform within the slum boundary and that micro-level pockets of deprivation remain visible even within a single settlement.

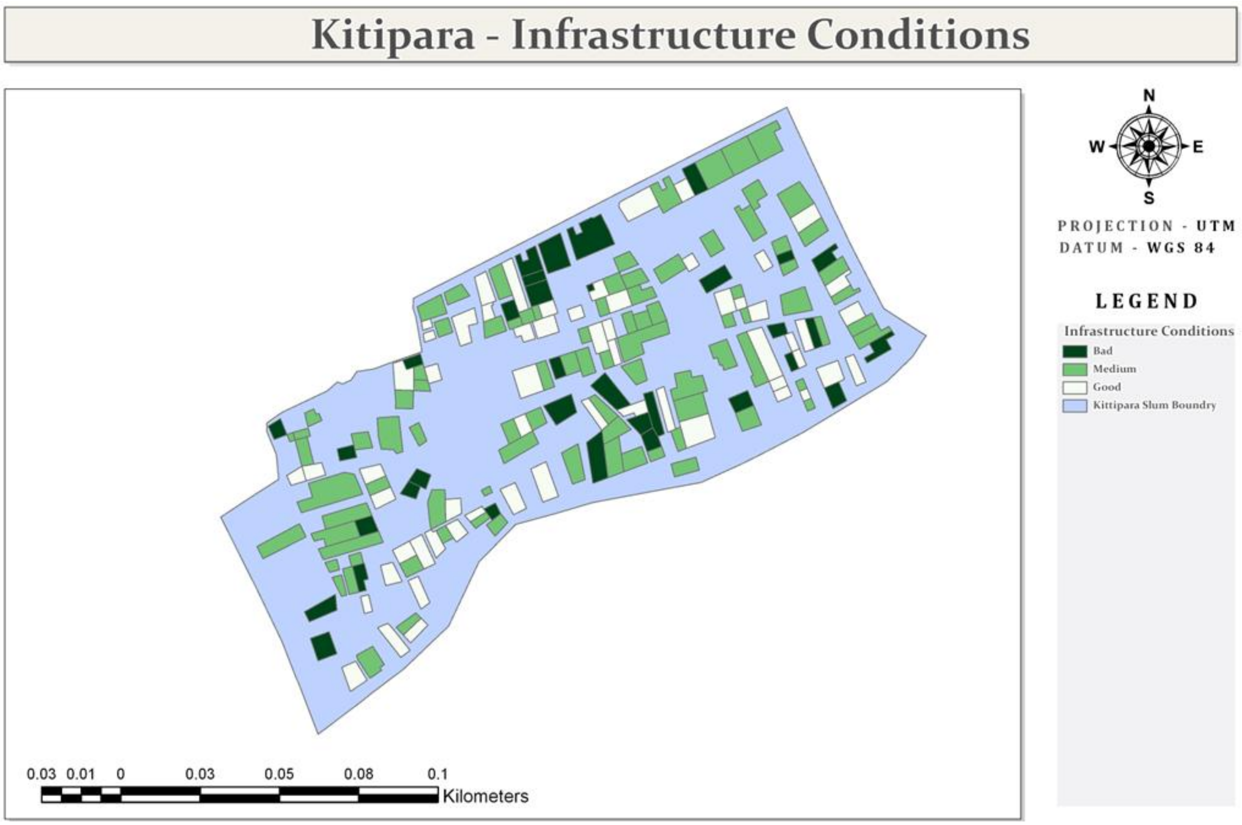

Fig. 6. Dwelling-level infrastructure condition assessment for Kitipara slum.

D. Relocation and Redevelopment Implications

The relocation model extends the analysis beyond prioritisation by identifying slums exposed to locational risk. Settlements located near rivers, railway tracks, and low-lying areas were treated as candidates for relocation or special policy attention under PMAY and RAY-type guidelines. The project findings indicate that a substantial number of slums in the RMC boundary fall within these sensitive spatial conditions. This demonstrates the usefulness of combining SSI-based social severity with spatial risk screening.

V. DISCUSSION

The Rajkot case demonstrates that informal settlements are not randomly distributed; they are concentrated in zones shaped by employment access, industrial land use, transport corridors, and environmentally vulnerable land. The eastern zone contains the highest share of slums and carries the greatest service burden. At the same time, the results show that deprivation is not uniform even within individual slums. This has important implications for urban planning: broad zone-level policy is necessary, but household- and cluster-level interventions are equally important for meaningful upgrading. A major contribution of the study is the integration of indicator-based severity analysis with a spatial decision support tool. The custom SSI calculator improves analytical consistency and reduces manual computation effort, while the relocation model translates spatial risk conditions into policy-relevant outputs. Together, they create a practical framework for redevelopment, relocation, and service improvement.

VI. CONCLUSION

This paper presented a GIS-based methodology for mapping, analysing, and prioritising slums in Rajkot Municipal Corporation. By integrating infrastructure, demography, amenities, financial status, and health and education variables into a normalized and weighted composite index, the study developed a Slum Severity Index that supports evidence-based intervention planning. The results show that Rajkot's slums are strongly concentrated in the eastern zone, that drainage and drinking water remain critical service gaps, and that selected slums such as Shastrinagar require priority attention. The Kitipara case further confirms the value of dwelling-level analysis for identifying internal pockets of deprivation. Overall, the study demonstrates that GIS can function not only as a mapping tool but also as a decision support platform for slum redevelopment, relocation, and upgrading.

REFERENCES

[1] Census of India, "Primary Census Abstract for Slum," Government of India, 2011.
[2] Rajkot Municipal Corporation, municipal slum records and base mapping inputs used in the project.
[3] Government of India, *Pradhan Mantri Awas Yojana (PMAY) Guidelines*.
[4] SMARTNET, smart city project framework and core service components.
[5] UN-Habitat, *The Challenge of Slums*.
[6] Relevant literature on GIS-based slum mapping, indicator analysis, and urban decision support systems.