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Research Article

Integrating Geospatial Analysis and Decision Support Systems for Effective Utility Planning in Kharkhoda, Haryana

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ABSTRACT

Equitable access to schools, parks, banks and community spaces is essential for strengthening rural development. Geographic Information Systems (GIS) provide an effective means to integrate planning norms with spatial realities, enabling both the identification of gaps and the selection of suitable land for new facilities. In Kharkhoda Block, Haryana, cluster-level assessment revealed persistent shortages, particularly in open spaces and community infrastructure. Panchayat land parcels were evaluated through weighted overlay analysis and the outcomes were operationalized in a web-based decision support system, creating a transparent, practical and replicable pathway for micro-level rural planning and effective governance.

Keywords: micro-level planning; rural utilities; land suitability; weighted overlay; Panchayat land; RADPFI; URDPFI; decision support; Kharkhoda; Haryana

Introduction

Balanced regional development depends on the equitable siting and delivery of everyday utilities-schools, parks, community halls, banks, post offices, police posts and reliable drinking water-at the scale where people actually live: the village and ward. International and Indian planning guidance converges on two ideas. First, micro-level planning at village/cluster scale is necessary to overcome aggregation bias and spatial inequity that often remain hidden in district-level averages (Dutta & Singh, 2007). Second, geographic information systems (GIS) and related spatial decision tools provide a rigorous way to integrate norms, population, distance and land availability into transparent, reproducible location decisions (Malczewski, 2004; Longley et al., 2015).
India's URDPFI (2015) and RADPFI (2017) guidelines specify service standards (e.g., 1 primary school per 5,000 people; 1 playground and park per 5,000; 1 bank per 10,000; 1 post office per 15,000; 1 police post per 50,000) and recommend cluster formation for planning in rural areas between 25,000–50,000 population. Combining those norms with geospatial analysis enables two complementary tasks: (i) quantify deficiencies by cluster; and (ii) identify suitable Panchayat land parcels that satisfy area and distance criteria so the right facilities can actually be built.

Study contributions are threefold:
(1) a norm-compliant, cluster-wise deficiency account for education and other basic infrastructure;
(2) a GIS-based land suitability framework that ties "what is missing" to "where it can go," using area and distance criteria at village scale; and
(3) a web DSS (Leaflet/HTML/CSS) that serves maps, tables and siting guidance for implementation.

Literature review

GIS-enabled siting and multi-criteria decision analysis (MCDA) are well established for public facility location. Malczewski (2004) provides a foundational review of GIS-based suitability analysis and weighted linear combination; the Analytic Hierarchy Process (AHP) introduced by Saaty (1980) remains a standard for criterion weighting in planning. In India, Dutta and Singh (2007) showed how spatial databases at micro scales sharpen planning judgements; Rao (2012) detailed village-level geoinformatics workflows that connect remote sensing, GIS and field data for rural development. Several studies demonstrate how MCDA and GIS translate

planning standards into implementable decisions. Jain and Subbaiah (2007) used GIS suitability to guide urban expansion; Jaybhaye, Mundhe and Dorik (2014) showed solid-waste site selection with sensitivity testing; Lallianthanga and Sailo (2013) applied geospatial planning to improve land use systems in a hilly district. In rural service delivery, Kaushik, Kandpal and Pandey (2017) and Bhandari, Panwar and Saklani (2016) documented Panchayat-scale web-GIS that improve visibility of resource gaps and facilitate e-governance. For sectoral infrastructure, studies have applied similar methods to petrol stations (Khahro & Memon, 2017; Njoku & Alagbe, 2015), agricultural land/water (Mohana, Velmurugan, & Santhanam, 2017) and transportation (Jain, Kushwaha, & Agarwal, 2017).

Indian planning guidance operationalizes these methods. URDPFI (2015) codifies population-based norms for education, open space, community facilities, safety and communications. RADPFI (2017) emphasizes rural clusters (25–50k) as the right spatial unit for planning norms and encourages spatial tools in Gram Panchayat Development Plans. Water service standards for rural areas have long followed the ARWSP/NRDWP "40 LPCD" minimum for basic needs (Ministry of Drinking Water and Sanitation, 2013), broken down by use category in ARWSP schedules. On the data side, Sentinel-2 and other EO products are widely used to create base layers and suitability inputs (Longley et al., 2015).

Two major gaps still recur. First, evidence often stops at deficiency mapping, without completing the chain to parcel-level siting on legally usable land. Second, micro-level analyses are seldom published as running DSS tools usable by block staff. The present study addresses both gaps for Kharkhoda: it (i) quantifies which clusters lack what and (ii) identifies which village-level Panchayat parcels can host missing facilities under URDPFI/RADPFI area–distance rules, then (iii) deploys a working, open web DSS.

Study area

Kharkhoda Block lies in southern Sonipat District, Haryana. The block spans 296.9 km² and comprises 44 villages and one urban local body (Kharkhoda Municipal Committee) (Census of India, 2011). It is bounded by Gohana, Rai and Sonipat blocks to the north/east; National Capital Territory of Delhi to the southeast; and Rohtak and Jhajjar districts to the west/southwest. Settlements are primarily agrarian with dispersed village morphology and a single town node (Kharkhoda MC). For micro-planning, the block was partitioned into six clusters (Barona, Farmana, Khanda, Kharkhoda Urban, Mandaura, Sisana), each 25,000–50,000 population, per RADPFI. Cluster populations used are the 2019 projections prepared from Census 2011 via Excel's exponential GROWTH function (see Table 1.1).

Table 1.1: Details of Clusters in Kharkhoda Block (2019)

Cluster Name	Village name	Cluster Population	Cluster Name	Village name	Cluster Population
Farmana	Muzzam Nagar	31580	Barona	Barona	28245
	Nakloi			Nizampur Khurd	
	Bidhlan			Pahladpur	
	Nizampur Majra			Pai	
	Farmana			Gopalpur	
	Gorar			Rampur	
	Silana			Sahoti	
	Ridhau			Karhouli	
Khanda	Anandpur	30415		Khurampur	
	Nirthan			Kundal	
	Fatehpur		Mandaura	Ferozepur Bangar	29808
	Rohat			Pipli	
	Jharaut			Jataula	
	Jharauti			Saidpur	
	Kanwali			Thana Kalan	
	Sehri			Thana Khurd	
	Khanda			Mandaura	
	Kheri Dahiya			Turakpur	
Sisana	Ashrafpur Matindu	29290		Mandauri	
	Nasirpur Cholka		Kharkhoda Urban	Kharkhoda (MC)	29870
	Chhanauli				
	Garhi Sisana				
	Rohna				
	Sisana				

Source: Prepared by Researcher

Objectives of the research

1. Quantify cluster-wise status and deficiency of utilities (education, banks, parks, playgrounds, community centres, post offices, police posts, drinking water) against Government of India norms.
2. Identify Panchayat land parcels suitable for siting missing facilities using a GIS-based multi-criteria suitability framework that respects URDPFI/RADPFI area and distance standards.
3. Operationalize the analysis in a web Decision Support System for Kharkhoda Block to support planning, transparency and phasing.

5. Data and analytical framework

5.1 Data sources

(1) Primary field survey (2019): GPS locations (Geo Tracker), facility inventories and service attributes across 44 villages + Kharkhoda MC (education, banks, community centres, parks, playgrounds, post offices, police posts, boosting stations, tube wells).
(2) Population base: Census of India 2011 village/town data; 2019 projections used for norm calculations, derived via Excel GROWTH.
(3) Standards: URDPFI (2015) and RADPFI (2017) for facilities; NRDWP/ARWSP for drinking water (40 LPCD basic need).
(4) Geospatial layers: Sentinel-2A (2019) for land cover; high-resolution imagery in Google Earth Pro for parcel-scale digitization; village boundaries from District Census Handbook (Census of India, 2011).

5.2 Cluster formation

Villages were grouped into six contiguous clusters (25–50k population) following RADPFI/SPMRM practice (RADPFI, 2017). Final clusters: Barona, Farmana, Khanda, Kharkhoda Urban, Mandaura, Sisana.

5.3 Deficiency analysis against norms

For each cluster and utility category, Required (R) was computed from population and the relevant norm; Existing (E) was taken from field inventory; Deficiency (D) and Surplus (S) were derived as D = max(0, R–E) and S = max(0, E–R). Norms used are summarized in Table 1.3 and the results in Tables 1.2–1.4, 1.5, 1.6.

5.4 Vacant land identification and suitability modeling

Vacant Panchayat land was identified through village consultations and GPS logging, delineated in Google Earth Pro and validated against Sentinel-2 imagery. Suitability analysis used a weighted overlay (WLC) in GIS:
(1) Criteria (Table 1.8): parcel area thresholds and distance to settlement/habitation per URDPFI/RADPFI (e.g., primary school 0.4–0.6 ha within 500 m; park/open space approx. 1 ha within 500 m; high school approx. 1 ha within 1 km; banks/post offices/veterinary 0.5–1.0 ha within 5 km).
(2) Standardization: Boolean masks for area and distance requirements by facility type; parcels graded "suitable" if both area and distance tests passed.
(3) Weighting: Because siting rules are constraint-dominant (must meet both), equal weighting was used in the base case; sensitivity checks ±20% did not change feasibility status of the identified parcels.
(4) Outputs: Cluster-wise suitability layers and parcel lists by facility type. Figures 1.1-1.9 show suitability maps.

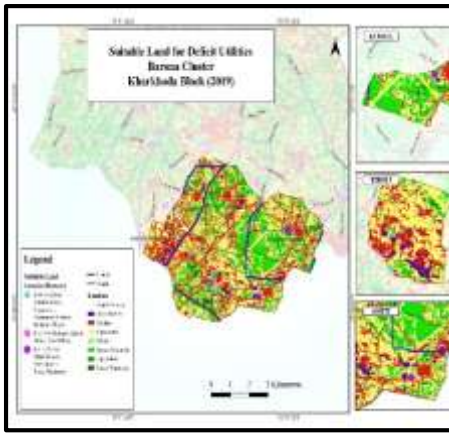
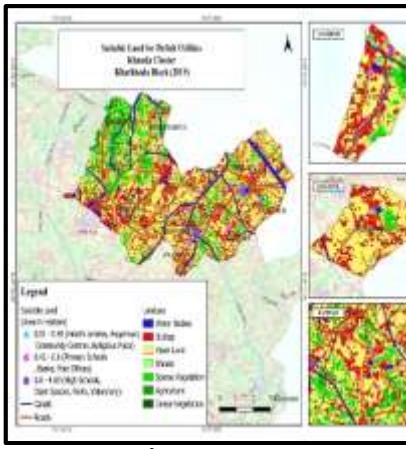


Figure 1.1



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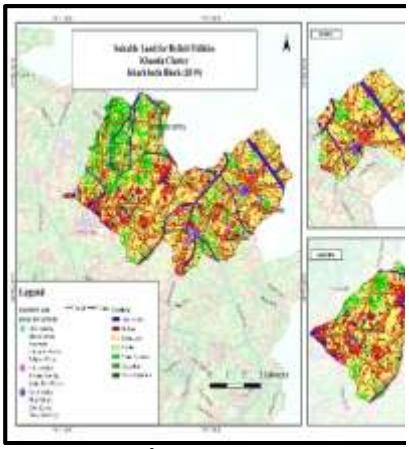

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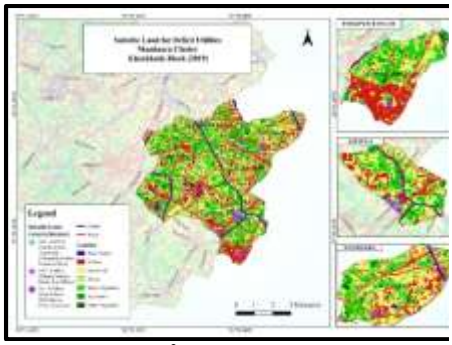

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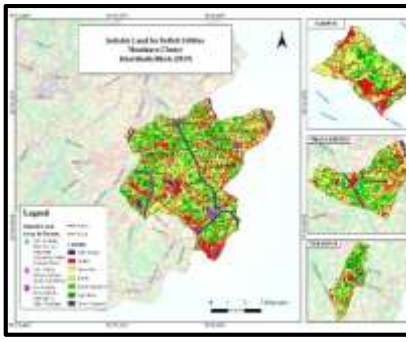

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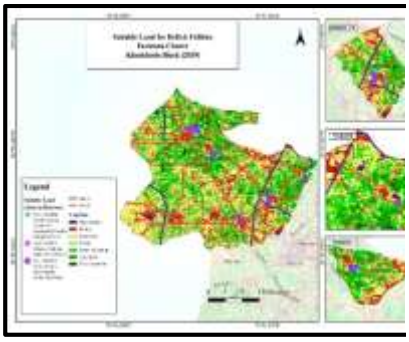

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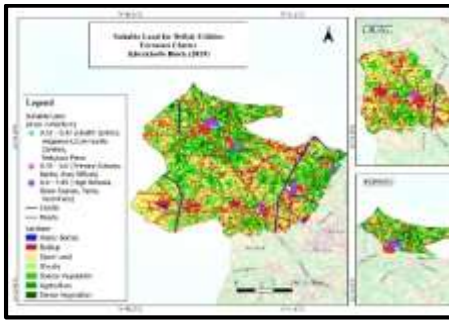

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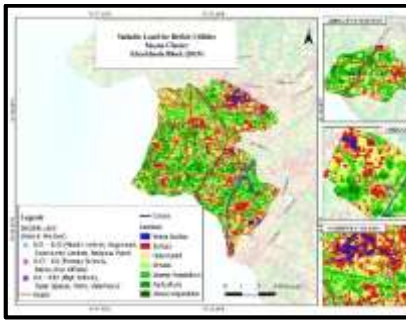

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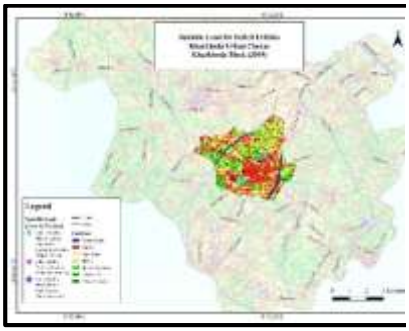


Figure 1.9

5.5 Decision Support System (DSS)

An open-web DSS hosts base maps and thematic outputs: Study Area Maps, Utility Services Maps and Site Suitability Maps by cluster. Built with HTML/CSS and Leaflet, the interface exposes layer toggles, pop-ups and map images. (URL: https://khararwebgis.in). The navigation and content structure are shown in Figures 1.10-1.18 (map gallery, service menus and cluster-level siting).

Figure 1.10

Figure 1.11

Figure 1.12

Figure 1.13

Figure 1.14

Figure 1.15

Figure 1.16

Figure 1.17

Figure 1.18

6. Results

6.1 Norms for education and other utilities

Table 1.2 : Norms for Educational Services, (URDPFI, 2015; RADPFI, 2017)

Service	Standard (population served per unit)
Primary school	1 per 5,000
High school (IX–X)	1 per 15,000
College	1 per 1,000,000

Table 1.3 : Norms for Other Basic Infrastructure Services, (URDPFI, 2015; RADPFI, 2017)

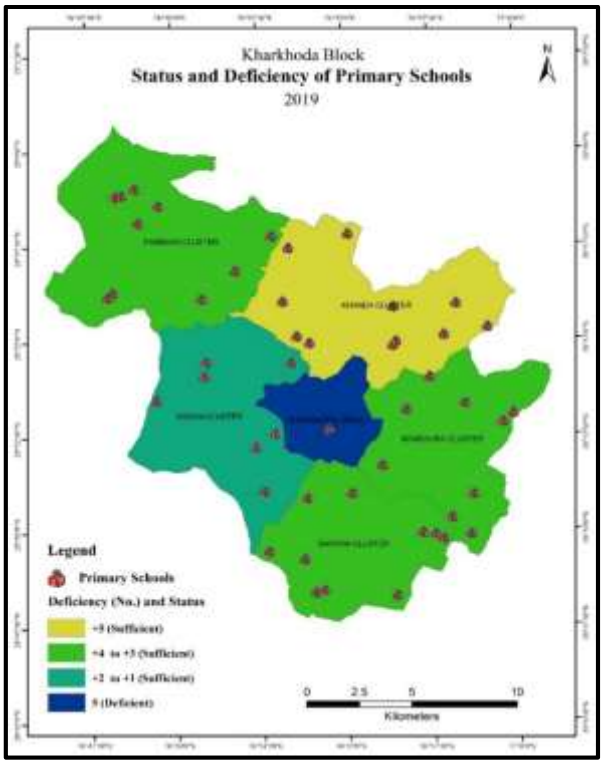
Category	Standard (population served per unit)
Banks	1 per 10,000
Parks	1 per 5,000
Playgrounds	1 per 5,000
Community centres	1 per 5,000
Post offices	1 per 15,000
Police posts	1 per 50,000

6.2 Cluster-wise status and deficiencies-Education

Table 1.4 : Cluster-wise Status and Deficiency of Education Services (2019)

Service	Norm (pop/unit)	Kharkhoda Urban (TP = 29,870) - R/E/D/S	Barona (28,245) - R/E/D/S	Mandaura (29,808) - R/E/D/S	Farmana (31,580) - R/E/D/S	Sisana (29,290) - R/E/D/S	Khanda (30,415) - R/E/D/S
Primary school	5,000	5/2/3/0	5/9/0/4	5/10/0/5	5/7/0/2	6/10/0/4	6/11/0/5
High school	15,000	2/2/0/0	2/18/0/16	2/18/0/16	2/13/0/11	2/16/0/14	2/19/0/17
College	1,000,000	1/2/0/1	0/1/0/1	0/1/0/1	0/1/0/1	0/1/0/1	1/5/0/4

Education infrastructure is highly uneven. Primary schools show a deficit of 3 in Kharkhoda Urban, while all rural clusters show surpluses. High schools are over-provided in rural clusters relative to norms, while the town meets its target exactly. At the college level, all clusters meet or exceed needs (no deficits). These patterns indicate that near-town settlements require more foundational facilities, while rural areas accumulated more secondary schools than required by the 15,000 norm-consistent with legacy siting and catchment overlaps.



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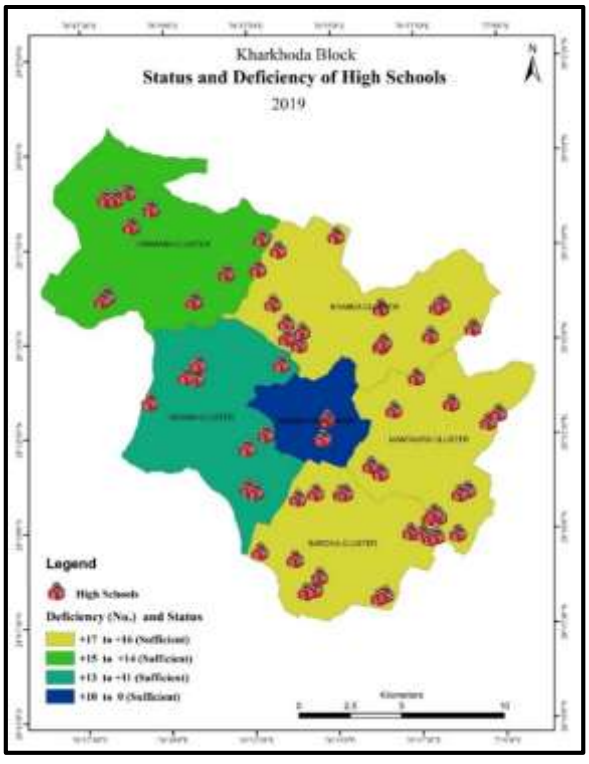

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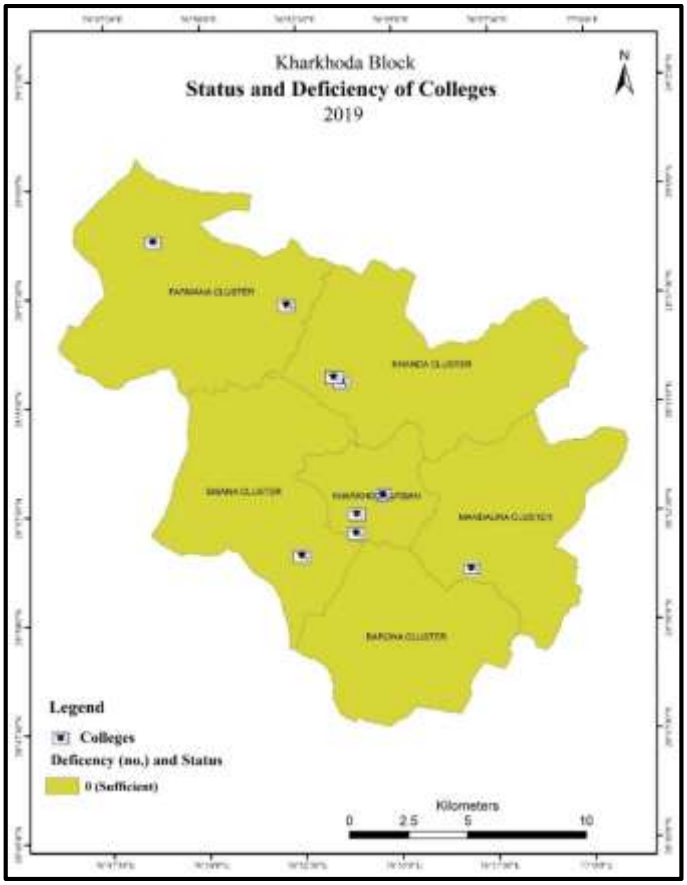
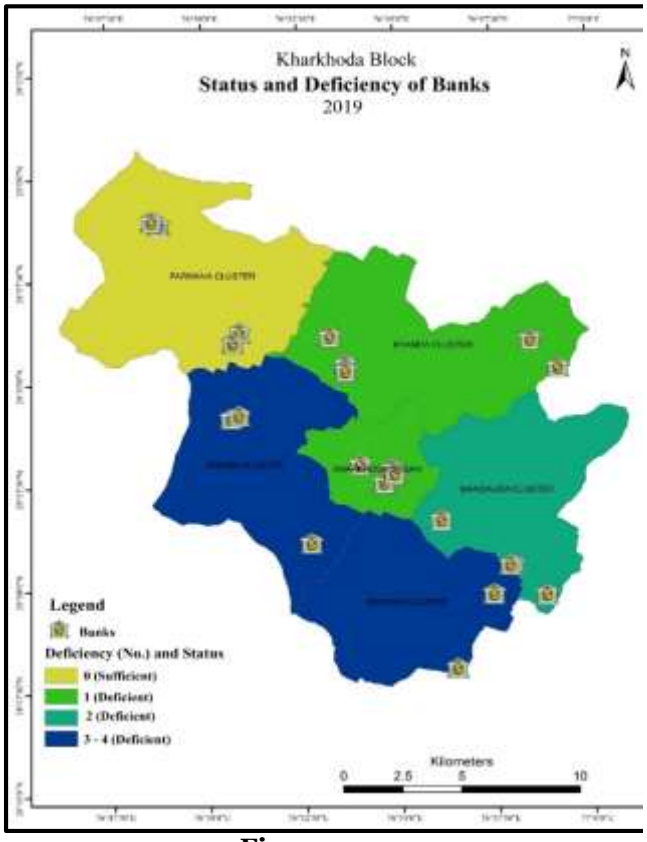


Figure 1.21

***Figures 1.19-1.21 illustrate the spatial status/deficiency of schools and colleges;**

6.3 Cluster-wise status and deficiencies-Other basic infrastructure



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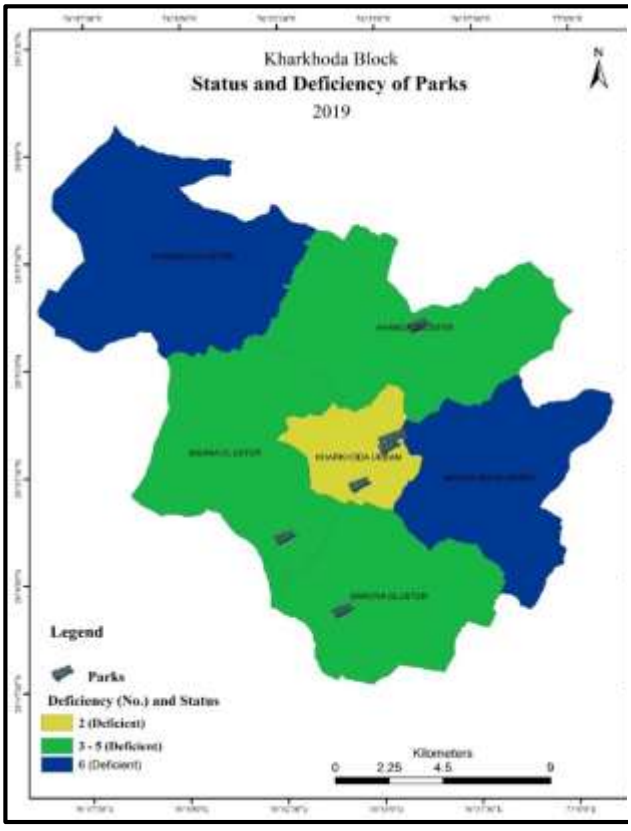

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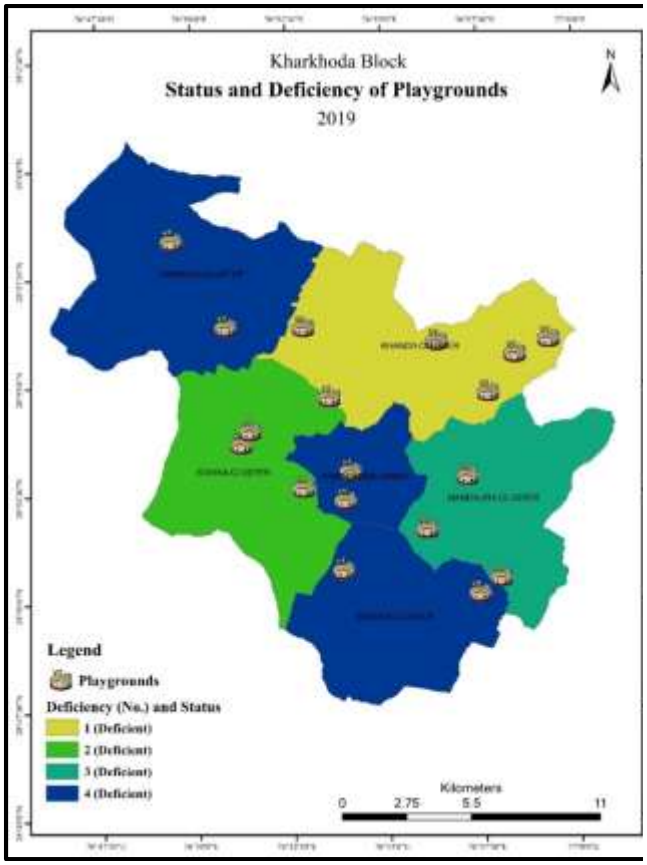

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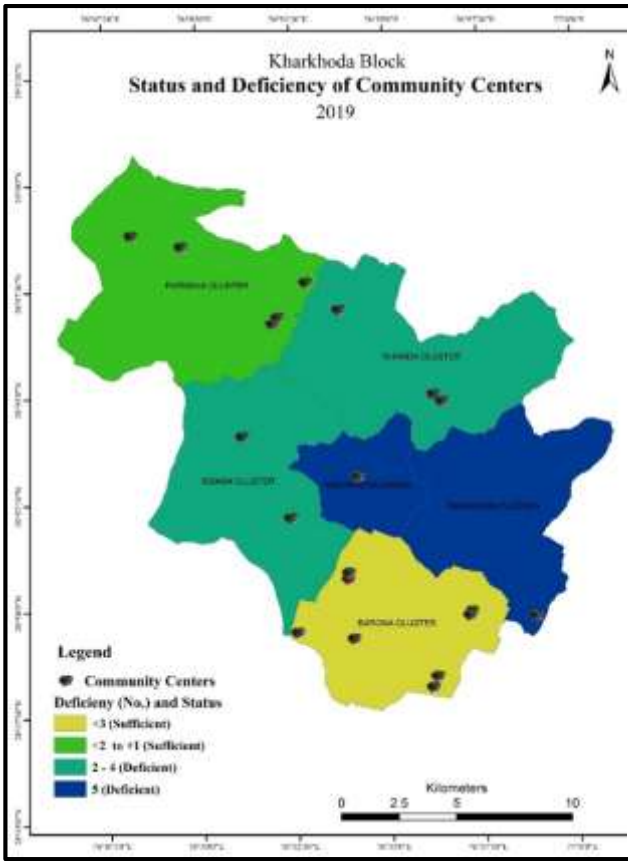

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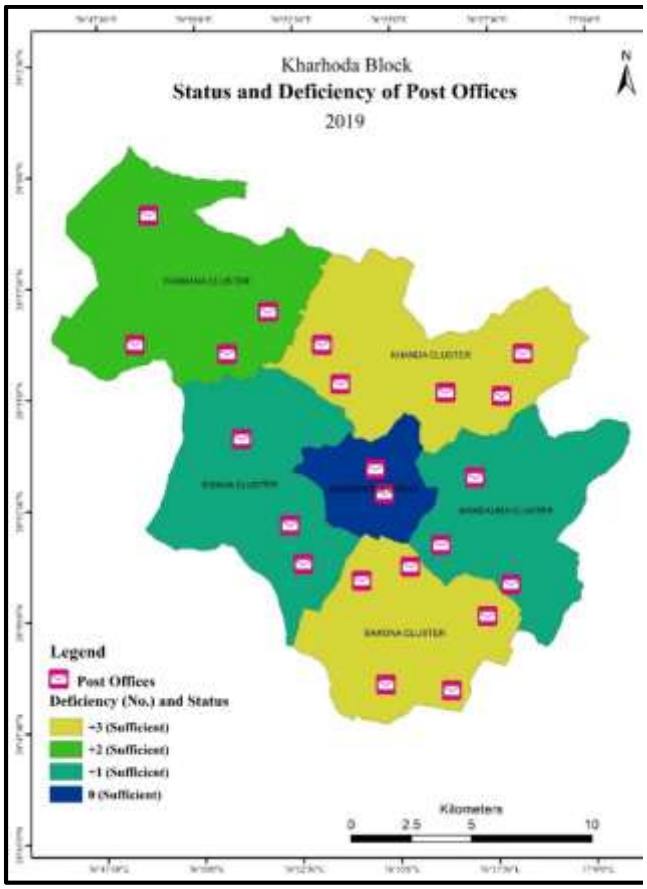

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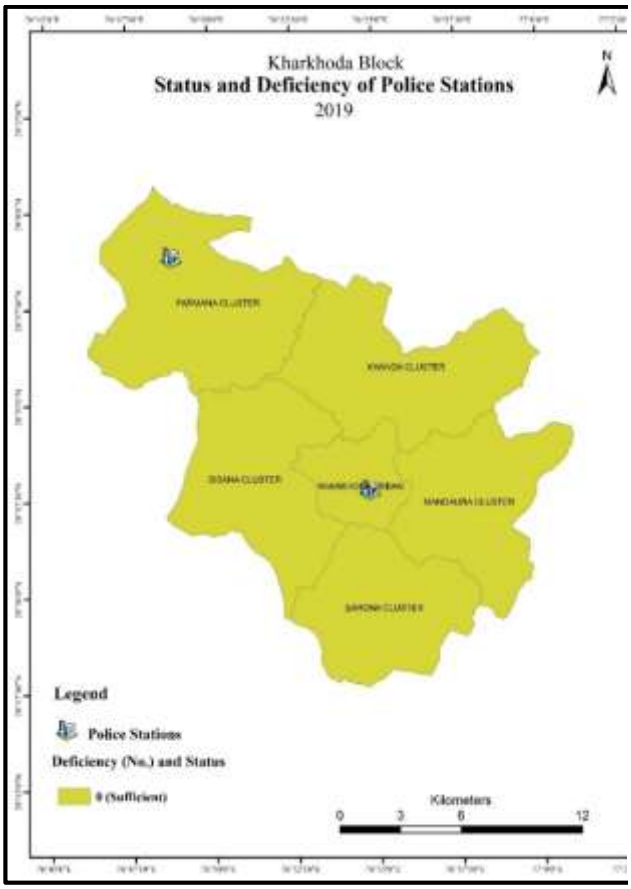

Figure 1.27

***Figures 1.22–1.27 visualize banks, parks, playgrounds, community centres, post offices and police;**

Table 1.5 : Cluster-wise Status and Deficiency of Other Basic Infrastructure Services (2019)

Category	Norm	Kharkhoda Urban R/E/D/S	Barona R/E/D/S	Mandaura R/E/D/S	Farmana R/E/D/S	Sisana R/E/D/S	Khanda R/E/D/S
Banks	10,000	6/5/1/0	6/4/2/0	6/4/2/0	6/6/0/0	6/3/3/0	6/5/1/0
Parks	5,000	6/4/2/0	6/1/5/0	6/0/6/0	6/0/6/0	6/1/5/0	6/1/5/0
Playgrounds	5,000	6/2/4/0	6/2/4/0	6/3/3/0	6/2/4/0	6/4/2/0	6/5/1/0
Community centres	5,000	6/1/5/0	6/9/0/3	6/1/5/0	6/5/1/0	6/2/4/0	6/3/3/0
Post offices	15,000	2/2/0/0	2/5/0/3	2/3/0/1	2/4/0/2	2/3/0/1*	2/5/0/3
Police posts	50,000	1/2/0/1	1/0/1/0	1/1/0/0	1/1/0/0	1/0/1/0	1/0/1/0

*Field synthesis and the narrative results indicate no deficits in post offices block-wide; several clusters hold surpluses.

The most consistent shortfalls are parks and playgrounds across all clusters; community centres are deficient except in Barona (surplus). Sisana shows the largest banking shortfall (3), while Kharkhoda Urban carries the heaviest multi-category gaps-banks (1), parks (2), playgrounds (4) and community centres (5). Police posts are under-provided in Barona, Sisana and Khanda. Post offices are adequate or surplus.

6.4 Drinking water adequacy by cluster

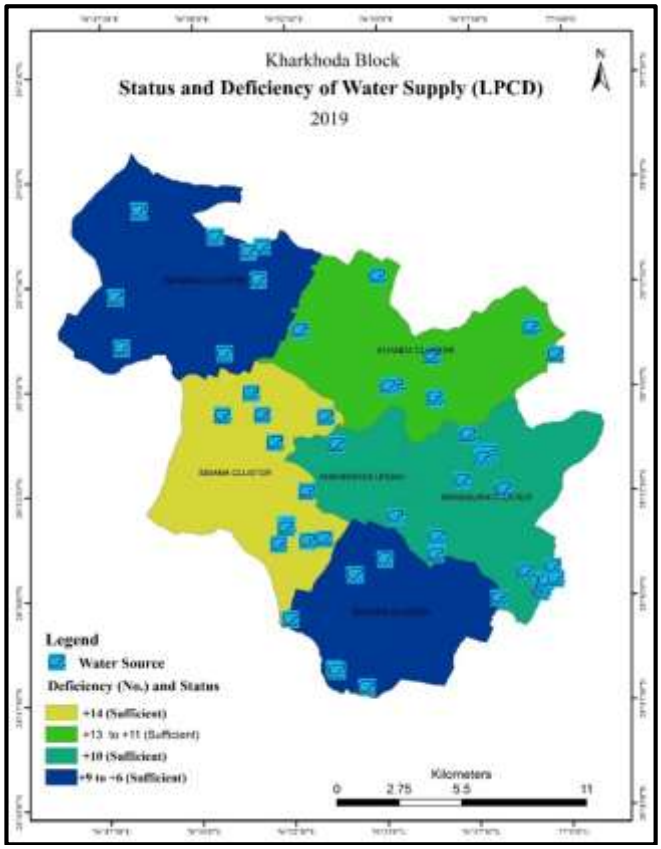

Figure 1.28 : LPCD status (Kharkhoda Block)

Table 1.6 : Cluster-wise Status of Drinking Water (LPCD) (2019)

Cluster	Required (NRDWP/ARWSP)	Existing (LPCD)	Deficit	Surplus
Kharkhoda Urban	40	50	0	+10
Barona	40	46	0	+6
Mandaura	40	50	0	+10
Farmana	40	47	0	+7
Sisana	40	54	0	+14
Khanda	40	51	0	+11

All clusters meet/exceed the 40 LPCD threshold, with Sisana highest (54) and Barona lowest (46). The issue for water is not adequacy but intra-cluster distribution and reliability, addressed via tubewell/booster mapping in the DSS.

6.5 Summary-aggregate deficits

Table **S1** aggregates deficits across education + other infrastructure, using Tables 1.4 and 1.5

Table S1 : Aggregate Deficits by Cluster (Education + Other Utilities), (drinking water excluded as all meet 40 LPCD)

Cluster	Primary school deficits	High school deficits	Bank	Park	Playground	Community centre	Post office	Police post	Total
Kharkhoda Urban	**3**	0	1	2	4	5	0	0	15
Barona	0	0	2	5	4	0	0	1	12
Mandaura	0	0	2	6	3	5	0	0	16
Farmana	0	0	0	6	4	1	0	0	11
Sisana	0	0	3	5	2	4	0	1	15
Khanda	0	0	1	5	1	3	0	1	11

Mandaura (16), Kharkhoda Urban (15) and Sisana (15) carry the heaviest loads. Across the board, parks/playgrounds dominate the gap profile.

6.6 Land suitability for siting on Panchayat land

Table 1.8 : Area and Distance Criteria for Siting

Utility	Area (ha)	Distance from settlement/habitation
Primary school	0.4–0.6	within 500 m
High school	approx. 1.0	within 1 km
Health centre / Dispensary / Anganwadi	≥0.05	within 500 m
Community centre	≥0.05	within 500 m
Open space / Parks	approx. 1.0	within 500 m
Religious places	0.04–0.6	within 500 m
Banks / Post office / Veterinary	0.5–1.0	within 5 km

Cluster findings (Figures 1.1–1.9).

(1)Barona: Suitable Panchayat parcels in Kundal, Kiroli, Sohti. Available size classes cover 0.01–0.42 ha and 0.6–4.83 ha but not 0.42–0.6 ha. This configuration is ideal for parks/open space (1 ha), playgrounds and small facilities (community centres, Anganwadi) but mid-size plots for banks/post offices are scarce. Given deficits (parks 5; playgrounds 4; banks 2; police post 1), the big parcels can absorb parks/playgrounds immediately; small plots suit community centres (even though present surplus here, CC land can serve multi-purpose halls or libraries).

(2) Khanda: Suitable land in Anandpur, Fatehpur, Kanwali, Khanda, Rohat across all three size classes. Deficits (parks 5; CC 3; banks 1; police post 1; playground 1) can be met with 1 ha parks and distributed community halls within 500 m of habitations; a police post can be co-located on a 0.5–1.0 ha administrative site.

(3) Mandaura: Parcels in Ferozepur Bangar, Mandaura, Jataula, Saidpur, Thana Khurd, Turakpur across all three classes. The largest burden (total 16) is here, especially parks (6) and community centres (5). Identified 1 ha tracts on the settlement edge (within 500 m) can host parks; ≥0.05 ha inner-village parcels can host community centres.

(4) Farmana: Parcels in Bidhlan, Farmana, Silana, Ridhau, Nakloi across all three classes. With parks (6) and playgrounds (4) the main gaps, the 0.6–4.83 ha parcels enable park siting; school sites (no deficits) can be retained for future expansion.

(5) Sisana: Parcels in Ashrafpur Matindu, Nasirpur Cholka, Chhanauli across all three classes. Deficits: banks (3), parks (5), CC (4), police post (1). 0.5–1 ha parcels close to the village road network can accommodate banks/combined service centers; 1 ha parcels for parks; 0.05 ha for community centres within habitations.

(6) Kharkhoda Urban: City-fringe parcels exist in all three classes. Deficits: primary schools (3), parks (2), playgrounds (4), banks (1), community centres (5). The 0.4–0.6 ha parcels within 500 m of dense wards are prime candidates for new primary schools and community centres; 1 ha urban-edge parcels suit parks/playgrounds.

6.7 Decision Support System (DSS)

The Kharkhoda DSS (https://khararwebgis.in) renders (i) Study Area Maps (administrative boundaries, drainage/canals, physiography, population), (ii) Utility Services Maps (education, water, transport, other infrastructure) and (iii) Site Suitability Maps by cluster. The navigation bar and layer menus are shown in Figures 1.10–1.18. Users can pan/zoom, switch layers and open pop-ups for facility attributes and parcel IDs, enabling block officials to match deficits to parcels and plan sequencing by budget year.

7. Discussion

Three main implementation insights stand out -:
First, parks and playgrounds are the binding constraint. Across all six clusters, open-space deficits dominate totals (Table S1). This aligns with long-standing under-provision of public open space in rural settlements, where common land has contracted over time. The suitability analysis helps by pinning down ≥1 ha parcels within 500 m of habitations, which meet URDPFI access guidance and can double as flood storage/green commons where drainage permits.
Second, "right-size the right facility" matters as much as totals. Barona's missing 0.42–0.6 ha class implies that certain mid-size facilities (banks, post offices, veterinary) may require land pooling or re-parcelling, even though large and small sites are available. Conversely, Kharkhoda Urban shows abundant small parcels but pressure on 1 ha tracts for parks/playgrounds.
Third, the cluster lens avoids "stranded compliance." Rural clusters display large high-school surpluses relative to norms, while primary schools fall short only in the urban node. Without the cluster perspective, a block-level average would mask these opposite needs. The cluster approach embedded in RADPFI clarifies where foundational access (primary schools, CCs) must be expanded and where existing institutions should be strengthened rather than multiplied.
The DSS matters. Publishing suitability and deficits as a running web tool closes the loop between analysis and action, improves transparency and reduces transaction cost for Gram Panchayats seeking administrative approvals. Similar DSS deployments have measurably improved evidence use in rural planning elsewhere (Bhandari et al., 2016; Kaushik et al., 2017).

8. Conclusion

Kharkhoda Block already meets 40 LPCD drinking water norms and shows ample provision of high schools and post offices but remains under-served in primary schools (town only), parks, playgrounds, community centres, banks (selected clusters) and police posts (Barona, Sisana, Khanda). The GIS-based suitability analysis demonstrates that legal, viable Panchayat parcels exist in each cluster to absorb these gaps, guided by URDPFI/RADPFI area and distance criteria. Deploying the findings in a web-based DSS equips local governments to prioritize parks/playgrounds and community centres first, while targeting primary schools within Kharkhoda Urban and banks/police posts in Sisana/Barona/Khanda. The approach of linking norms, deficits and parcels offers a replicable blueprint for micro-level rural planning.

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