

Spatial Analysis of Open Space Waste Dumping (OSWD) in Lakshmangarh Municipality (Rajasthan) Using Geospatial Technology

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ABSTRACT

The study investigates the spatial distribution and extent of open space dumping sites (OSDS) in Lakshmangarh Municipality (Sikar district, Rajasthan), where residents routinely throw household trash in open fields. A total 161 open dumping sites (ODS) were identified in the 40 municipal wards through a geospatial inventory and field-based survey. The results show that there is a significant geographic variation in the level of open dumping and classified in four categories (high, moderate, low and no open dumping). The ward no 9, 28 and 39 are identified as high-dumping wards, which together accounting for 56 dumping sites (34.78%). The 10 wards identified under the moderate category which consist of 64 sites (39.75%), while 20 wards classified as low-dumping

wards with 41 sites (25.47%). The high rate of open dumping, especially in vacant spaces, suggests a lack of waste collection, waste disposal facilities and public waste management. These unsupervised disposal methods can lead to land degradation, soil and groundwater contamination, undesirable environmental conditions, and a higher risk for environmental and public health. The study emphasizes the importance of establishing an effective and sustainable MSW management system by optimizing waste collection and transport, source separation, recycling and resource recovery, scientific disposal of waste, periodic tracking of hot spots of waste disposal, and increasing awareness and involvement of the public in the process. The results serve as a spatial basis for prioritizing interventions in waste management and in improving environmental quality and public health in the study area.

Keywords Municipal waste management, Open dumping waste, Environmental pollution, Swachh Bharat mission, Lakshmangarh.

INTRODUCTION

Waste management is currently one of the most critical environmental issues worldwide, and mishandled waste can also significantly impact environmental health (Ferronato and Torretta 2019). The mounting waste volumes, particularly in urban and peri-urban areas have put pressure on current waste management systems and resulted in the disposal of domestic waste in open spaces (Kumar *et al.* 2024). Worldwide, the mismanagement of solid waste is a significant con-

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tributor to soil pollution, water pollution and disease transmission. (Abubakar *et al.* 2022). The World Bank estimates that more than 2 billion tons of waste are produced around the world each year and that a lot of it is poorly managed (Valavanidis 2023). In many developing countries, such mismanagement often takes the form of the very basic practice of open dumping, which is defined as the unscientific and unorganized disposal of refuse in unregulated dumpsites (Ferro-nato and Torretta 2019 ; Gunarathne *et al.* 2024). This common practice presents serious public health and environmental risks, as many open dump areas become breeding grounds for disease vectors and hazardous substances often percolate into soil, water sources and the environment (Mahajan 2023, Ziraba *et al.* 2016). Waste degradation releases particulate matter and the toxicity of the leaching liquids into the groundwater, all of which further exacerbate the risk of chronic respiratory diseases and long-term health issues for surrounding communities (Siddiqua *et al.* 2022, Gupta *et al.* 2024, Njewa *et al.* 2025). Municipal solid waste that is dumped unconventionally can adversely affect soil, irrigation water and groundwater quality. There is a correlation between the distance from the open dump site and the amount of contamination in the soils, with pH, EC, and heavy metal (Zn, Cr, Pb, Cu, Cd) concentrations increasing also near the open dump site (Jilani and Rashid 2020 ; Azeez *et al.* 2011). The bioaccumulation of heavy metals in crops cultivated on these soils and those irrigated with leachate-contaminated water exceed the permissible levels, which creates food safety concerns (Nwaogu *et al.* 2017, Rani 2016). Leachate percolation also increases the TDS, nitrate, chloride, and heavy metals in the groundwater, making it unsuitable for human consumption and other uses (Mohan and Gandhimathi 2009 ; Raina *et al.* 2019). In India, waste management (WM) is a critical issue, as the socio-economic and environmental consequences of waste disposal practices require a careful examination of waste management paradigms (WMP) (Joseph 2024). The problem of municipal solid waste (MSW) in India is gigantic and > 90% of the collected waste is still dumped in untreated open sites (Paul *et al.* 2019). Although India has launched several schemes like Swachh Bharat Abhiyan (Clean India Mission) to promote sanitation and waste management, but it is still considered as a major problem in urban and

rural areas (Kumari 2024). Several studies (Gupta *et al.* 1998 ; Narayana 2009 ; Kalyani and Pandey 2014 ; Kumar *et al.* 2017 ; Karthikeyan *et al.* 2018 ; Meena *et al.* 2023 ; Mahadevan *et al.* 2026 ; Sen and Yadav 2026) have been done in different regions of the country to evaluate the ecological and health burdens of these disposal practices. However, no study is reported from the region, therefore the present study intends to find out the location of the waste dumping open spaces, prepare an inventory and discuss its impact on the livelihood of the study area.

MATERIALS AND METHODS

Study Area

The study area is located in the Northeastern (semi-arid region) of Rajasthan and lies between 27°48' N to 27°50' N latitude and 75°01' E to 75°03' E longitude (Fig. 1). It is close to various major cities such as Sikar (30 km), Jhunjhunu (50 km), Alwar (100 km) and Jaipur (150 km). Administratively, the municipality (urban area) is divided into 40 municipal wards (MW) with a total area of 16.26 km² and 53,392 persons population (Census of India 2011, Survey of India 2026). The climatic conditions of the area are extreme with very hot summers (< 45°C) and cold winters (5°C). The monsoon season lasts from July to September, during which most of the rainfall occurs.

Data Sources and Methodology

The study utilizes primary as well as secondary data to fulfil the requirement of the present work. The secondary data were collected from Lakshmangarh Municipality, Rajasthan municipal, census of India, 2011 (Table 1). On the other hand, the primary data were collected through comprehensive field visits

Table 1. Data collection and their sources from the study area.

Sl. No.	Data	Source
1	Open space dumping & dustbins locations	Field Observation, GPS, GPS Camera & Google Earth Pro
2	Ward wise populations	Lakshmangarh Municipality & Survey of India
3	Municipal waste record and ward boundary map of Lakshmangarh	Lakshmangarh Municipality

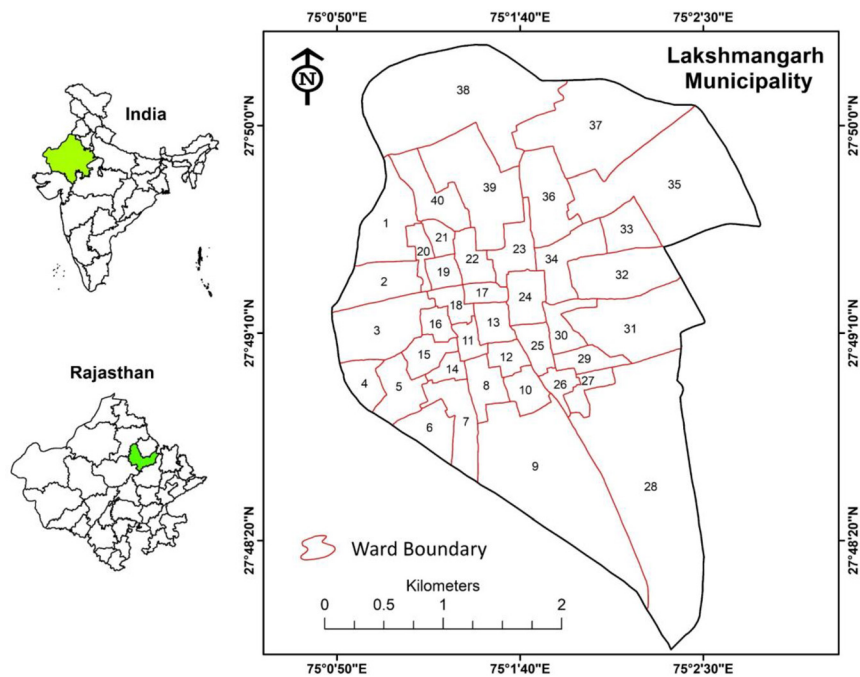


Fig. 1. Location of the Lakshmangarh municipality (Sikar), Rajasthan.

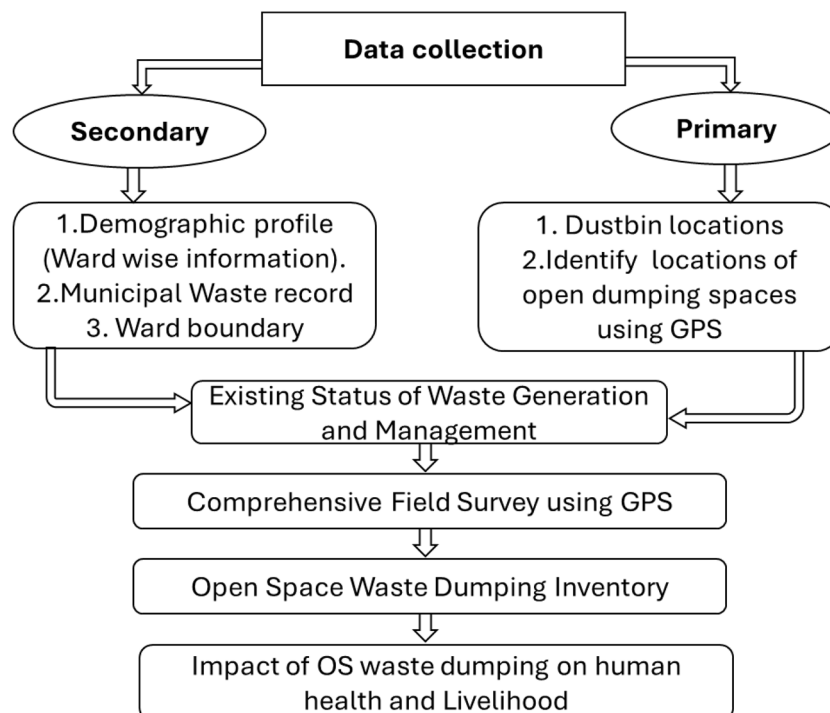


Fig. 2. Methodological framework of the study.

to identify the open space dumping, roadside waste and conditions of dustbins in the area. (Table 1). From the field observations, the data was collected through Garmin GPS (point data) and GPS Camera (Android App used for geotagged photographs) (Fig. 2). Afterward the point data was updated in Google Earth Pro Software for ward-wise distribution and open space dumping inventory preparation (Fig. 2).

RESULTS

Existing Status of Waste Generation and Management

The study area has 11,543 residential households and about 2,301 commercial establishments such as shops, hotels, hospitals, educational institutions and other service units that add to the municipal waste stream. It produces around 22.77 tons of Municipal solid waste (MSW) daily. The estimated per capita waste generation ranges between 0.41 kg/day to 0.45 kg/day, which aligns with the observed waste generation for a day. Street cleaning and waste management is the responsibility of municipal sanitation services for the road network of about 30 km. Based on municipal records, almost 60% of roads are swept daily and the remaining 40% are swept alternatively every day. Municipal records indicate that there are 100 community

waste bins throughout the municipality (each with a capacity of 1.1 m³), for the collection of temporary waste. But the frequency of emptying the bins is not constant. In all, 30 bins are emptied every day, 25 on alternative days, 20 every second day, 20 every week and 5 occasionally. Such variations in the rate of collection lead to accumulation of waste temporarily, especially in densely populated and highly industrialized zones, and increase the chances of secondary waste dumping at collection points (Plate 1). During the current study, field verification was carried out, and the functional waste bins were found to be 43 in total, and their locations were plotted on a map with the help of GPS and geospatial techniques (Fig. 3).

The observed differences between the recorded and actual situations suggest poor waste storage facilities and emphasize the need for field-oriented assessment to analyze the actual situation of MSW management. Further field investigation also showed that there is variation in waste collection frequency between the different wards. There are around 50% of the waste collection sites that are serviced on a daily basis, 40% are serviced every other day, and 10% are collected twice weekly (Table 2).

The irregular collection schedule can lead to temporary storage of waste at collection sites, such

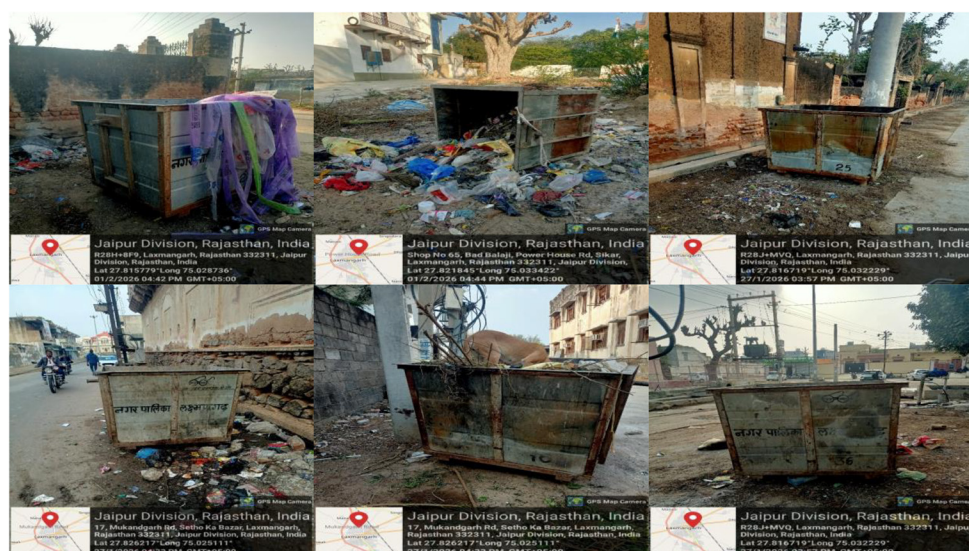


Plate 1. Showing the condition of dustbins in the study area.

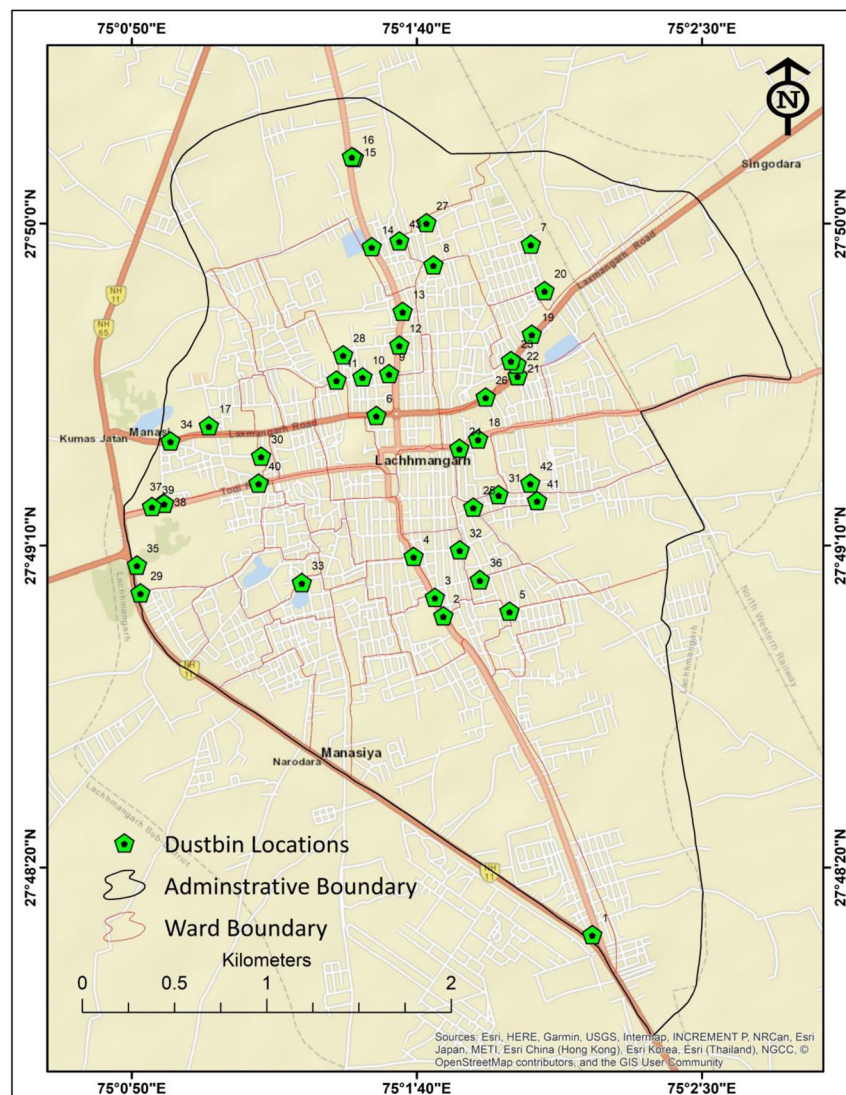


Fig. 3. Location and number of dustbins in the study area (Source: Field survey 2026).

as in high-density residential and commercial areas, which can raise the risk of secondary dumping and

associated environmental and public health risks (Plate 1). The animal-drawn carts and tractors are

Table 2. Frequency of waste transport as per Lakshmangarh municipality 2026.

Frequency	Percentage of Waste transport
Daily	50%
Alternate day	40%
Twice a week	10%

Source: Lakshmangarh municipality, 2026.

Table 3. Means of waste transport (per day) as per Lakshmangarh municipality 2026.

Type	No.	Trimade	Waste transport
Animal cart	7	4	12.5 tonnes
Tractors	16	3	10
Other	2	—	—

Source: Lakshmangarh municipality, 2026.

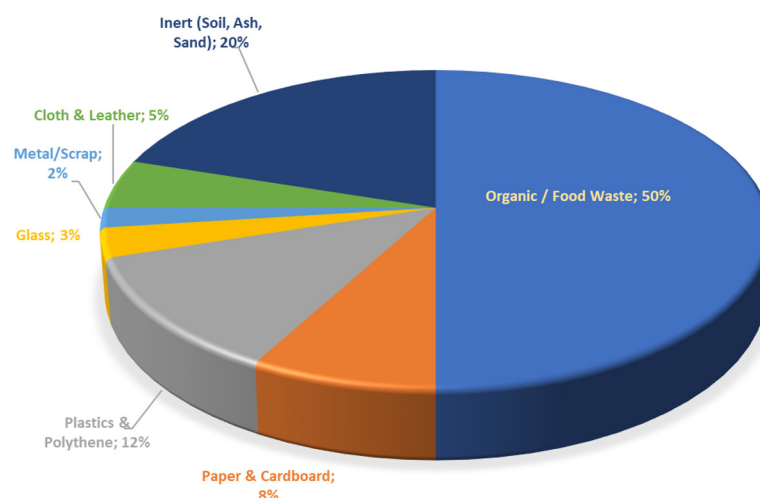


Fig. 4. Showing the composition of waste generation in the study area (Source: Lakshmangarh Municipality 2026).

used for waste transportation. The municipality has seven animal carts, which are used on an average of four trips per day, removing an average of 12.5 tonnes of waste every day. Also, each day, 16 tractors make an average of 3 trips to pick up almost 10 tonnes of waste at the processing and disposal site (Table 3). The municipality also has some mechanized equipment, such as a JCB and a loader, to manage bulk waste and site operations.

The current transportation network is able to

Table 4. Composition-based classification of MAW in Lakshmangarh municipality.

Sl. No.	Category	Description	Source
1	Biodegradable	Food waste, garden waste, vegetables waste	Household, hotels, markets
2	Recyclable	Paper, plastic, metal, glass	Shops, household
3	Inert/debris	Soil, bricks, construction debris	Constructions sites
4	Domestic hazardous	Paint, batteries, chemicals, bulbs	Household, workshop
5	Biomedical	Bandages, disposables	Clinics, dispensaries
6	E-waste	Electronic devices, chargers	Household, offices

Source: Lakshmangarh municipality 2026.

address the daily waste being produced, but increased collection efficiency and storage facilities must be implemented to reduce the amount of waste at collection sites. The municipal solid waste is conveyed to a designated municipal waste treatment and reuse plant (which occupies a land area of about 6 ha) for treatment and resource recovery. It has a semi-automatic trommel, baler, shredder, screening machine and a composting machine for handling biodegradable waste. However, in the field, there is evidence that the efficiency of these facilities is limited because most of the waste arrives at the processing plant in a mixed state and as a result recovery potential for recyclables and compostable organic wastes are reduced. The mu-

Table 5. Category wise waste, their estimated share (in %) and their sources in the study area.

Waste Category	Estimated Share (%)	Primary Sources
Organic / Food waste	50%	Households, Markets, Hotels
Paper & Card board	08%	Offices, Shops
Plastics & Polythene	12%	Households, Markets
Glass	03%	Households, Restaurants
Metal / Scrap	02%	Industries, Households
Cloth & Leather	05%	Households
Inert (Soil, Ash, Sand)	20%	Construction, Roads, Households

Source: Lakshmangarh municipality 2026.

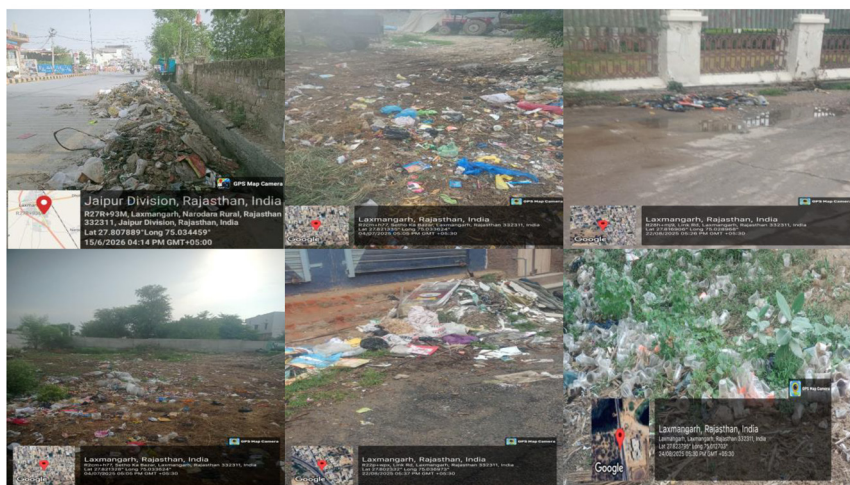


Plate 2. Showing roadside dumping of waste in the study area.

nicipality has 122 sanitation workers, 35 contract sanitation workers and 10 staff members working in the landfill and processing sites. The number of workers available is adequate for routine waste management operations, but field observations indicate that better deployment, monitoring of operation and supervisory structures are needed to improve the efficiency of the services and achieved uniform waste collection in all municipal wards.

Composition and sources of MSW

The municipal waste (MW) in the study area is a mixture of biodegradable, recyclable, inert, hazardous, biomedical and electronic wastes from residential, commercial, institutional and public activities (Table 4). Organic waste is found to be the biggest component (50%) mainly from the domestic sector, vegetable markets, hotels and restaurants, as per municipal data and field observations. The proportion of recyclable materials (12% plastics, 8% paper and cardboard, 5% cloth and leather, 3% glass, 2% metals) is small, and inert materials (20% soil, ash, construction, road sweepings) make up a large portion of the waste stream (Fig. 4 & Table 5). In addition to municipal waste, the municipality produces construction and demolition waste, domestic hazardous waste (such as batteries, paints and chemicals) and biomedical waste from healthcare institutions, as

well as e-waste from households and commercial entities. These waste streams present substantial environmental and public health hazards if they are not handled and disposed of properly, especially if they are contaminated with other municipal solid waste. The primary generators of municipal solid waste are residential households, commercial establishments, educational institutions, healthcare facilities, street sweeping operations, markets, hotels, restaurants, and other bulk waste generators. The waste stream has a high proportion of materials that can be recycled and biodegraded but field investigations indicated that the waste is collected on the whole without being segregated. The lack of source segregation substantially reduces the efficiency of recycling and composting operations, resulting in the disposal of valuable recoverable materials along with mixed municipal waste.

Open Space Waste Dumping (OSWD) Inventory

To identify and document unauthorized dumping of solid waste sites in the study area, a systematic field survey was carried out. The field visit was performed to each dump site and georeferencing of each site was accomplished with a handheld GPS enabled unit (Table 6). The geographic coordinates (latitude and longitude) were collected for each identifiable dumping location to create a complete geographic database that could be analyzed using GIS mapping



Plate 3. Open space dumping of waste in the study area.

software. A total of 161 open dumping sites (Table 6) were identified in the study area; this suggests that indiscriminate waste disposal is common in the study area. The coordinates recorded reveal spatial distribution of dumping locations throughout the town which indicate the prevalence of informal solid waste disposal. In the field investigation, it was noted that most of the dumping areas were found in abandoned plots, open spaces close to residential areas, road margins and agricultural fields adjacent to residential

settlements. The sites were already receiving municipal solid waste generated by households and had no engineered containment or environmental protection measures (Plate 2). The information resulting from the inventory was entered into an ArcGIS to create a spatial distribution map of the dumping sites (Fig. 2). Field observations indicated that dumping sites differed significantly in size and waste deposition, but most were comprised of a combination of municipal solid waste produced by adjacent families.

Table 6. Field based open space waste dumping inventory of Lakshmangarh Municipality, (Sikar), Rajasthan.

Site No.	Latitude	Longitude	Ward	Site No	Latitude	Longitude	Ward
1	27.8026	75.0364	9	82	27.8261	75.0288	36
2	27.8037	75.0367	9	83	27.826	75.0284	23
3	27.8043	75.0348	9	84	27.826	75.0279	23
4	27.8039	75.0359	9	85	27.8267	75.0276	23
5	27.8044	75.0369	28	86	27.8267	75.0279	23
6	27.8052	75.0358	9	87	27.8279	75.0282	23
7	27.8059	75.0355	9	88	27.8269	75.0245	39
8	27.8062	75.0348	9	89	27.8285	75.0275	39
9	27.8066	75.0348	9	90	27.8245	75.0369	32
10	27.8017	75.0376	28	91	27.8235	75.0357	32
11	27.8016	75.038	28	92	27.8232	75.0334	32
12	27.8024	75.0392	28	93	27.8234	75.0374	32
13	27.8025	75.0368	9	94	27.8218	75.0381	31
14	27.8027	75.0368	9	95	27.822	75.0388	31
15	27.8056	75.0361	9	96	27.8218	75.0393	31
16	27.8034	75.0374	28	97	27.8224	75.0389	31
17	27.804	75.0365	9	98	27.8239	75.0379	32
18	27.8046	75.0361	9	99	27.8224	75.0335	32
19	27.8045	75.036	9	100	27.8222	75.0339	32
20	27.8049	75.0359	9	101	27.8284	75.0309	36
21	27.8079	75.0343	9	102	27.8308	75.0268	38
22	27.8054	75.0358	9	103	27.8165	75.0213	14
23	27.8028	75.0377	28	104	27.8156	75.0182	5
24	27.8059	75.0338	9	105	27.8155	75.019	5
25	27.8034	75.0377	28	106	27.8163	75.0193	5
26	27.8108	75.0338	28	107	27.8148	75.0193	5
27	27.8141	75.0304	9	108	27.815	75.0204	5
28	27.8138	75.0287	9	109	27.8151	75.0202	5
29	27.8135	75.0292	9	110	27.8146	75.0206	7
30	27.8147	75.0313	27	111	27.8143	75.0199	5
31	27.8146	75.0315	27	112	27.8146	75.0198	5
32	27.8135	75.0316	9	113	27.8136	75.02	6
33	27.8119	75.0321	9	114	27.8146	75.0165	4
34	27.8123	75.0318	9	115	27.813	75.0191	6
35	27.8118	75.0336	28	116	27.8133	75.0193	6
36	27.8123	75.0361	28	117	27.8128	75.0197	6
37	27.8194	75.0277	25	118	27.813	75.021	6
38	27.8193	75.027	13	119	27.8128	75.0207	6
39	27.8191	75.026	13	120	27.8132	75.0202	6
40	27.8192	75.0293	25	121	27.8209	75.0217	16
41	27.8138	75.033	28	122	27.8199	75.0225	16
42	27.817	75.0337	27	123	27.8216	75.0211	3
43	27.817	75.0341	27	124	27.8221	75.0218	18
44	27.8178	75.0347	29	125	27.8202	75.0223	16
45	27.8188	75.0337	31	126	27.8171	75.0169	5
46	27.8198	75.0351	31	127	27.8174	75.0144	4
47	27.8164	75.0261	8	128	27.8182	75.0244	11
48	27.8167	75.0261	8	129	27.8182	75.023	14
49	27.8171	75.0264	12	130	27.8168	75.0242	8
50	27.8127	75.0229	7	131	27.8178	75.0252	8
51	27.8126	75.0238	7	132	27.8253	75.0187	1
52	27.8127	75.0241	7	133	27.8255	75.0181	1
53	27.8128	75.0247	9	134	27.8254	75.0182	1
54	27.815	75.0228	7	135	27.8252	75.0179	1
55	27.8207	75.0302	30	136	27.8177	75.0287	25
56	27.8205	75.0307	30	137	27.8269	75.0318	36

Table 6. Continued.

Site No.	Latitude	Longitude	Ward	Site No	Latitude	Longitude	Ward
57	27.8233	75.032	32	138	27.8266	75.0335	34
58	27.8266	75.0294	36	139	27.8264	75.0337	34
59	27.8136	75.0276	9	140	27.8297	75.0213	39
60	27.8137	75.0279	9	141	27.8189	75.02	15
61	27.8134	75.0251	9	142	27.8264	75.0216	21
62	27.8149	75.0309	26	143	27.8282	75.0212	40
63	27.8219	75.0295	24	144	27.8278	75.0204	40
64	27.819	75.0203	15	145	27.817	75.0243	8
65	27.8162	75.0209	7	146	27.8175	75.024	8
66	27.8275	75.025	39	147	27.8304	75.026	39
67	27.8278	75.0243	39	148	27.8299	75.0261	39
68	27.8276	75.0247	39	149	27.8159	75.0342	27
69	27.8265	75.0259	39	150	27.826	75.0198	20
70	27.8262	75.0256	39	151	27.8254	75.02	20
71	27.8266	75.0238	40	152	27.8222	75.0201	2
72	27.8177	75.0223	14	153	27.8253	75.0188	1
73	27.8177	75.0197	15	154	27.8042	75.038	28
74	27.8181	75.0254	12	155	27.8059	75.035	9
75	27.8183	75.0251	11	156	27.8065	75.0361	28
76	27.8188	75.025	13	157	27.8065	75.0359	28
77	27.8238	75.0315	32	158	27.8337	75.0229	38
78	27.825	75.0313	34	159	27.8032	75.0353	9
79	27.8246	75.031	34	160	27.8031	75.0356	9
80	27.8251	75.0305	34	161	27.803	75.0358	9
81	27.8261	75.0283	23				

Source: Primary Survey, 2026.

Unsegregated waste was often dumped directly on top of bare ground, creating waste heaps that were exposed to rain, wind, domestic animals and human activities. These disposal methods can lead to soil contamination, create leachate, foul odours, breeding grounds for pests and disease, and degradation in the environment especially near residential areas. The spatial inventory is one of the main outputs of the field investigation and constitutes a reliable geospatial database that is used to identify environmentally sensitive locations that need priority intervention. Moreover, the inventory can help municipal officials

to plan waste collection infrastructure, choose the appropriate waste storage sites, and develop scientifically sound solid waste management strategies.

The data showed a significant spatial variation in the distribution of open dumping sites throughout the municipality (Table 7). There were 40 municipal wards, of which 33 wards had at least one open dumping site and seven wards (W10, W17, W19, W22, W33, W35 and W37) had none of these open dumping sites during the survey period. For ease of interpretation, the wards were divided into four

Table 7. Categories of open space dumping sites in the study area.

Category	Wards (W)	No. of Dumping Sites	% of OSD
High (>10)	9, 28, 39	32+14+10 = 56	34.78
Moderate (5-9)	1, 5, 6, 7, 8, 23, 27, 31, 32, 34	5+9+7+6+6+6+5+6+9+5 = 64	39.75
Low (1-4)	2, 3, 4, 11, 12, 13, 14, 15, 16, 18, 20, 21, 24, 25, 26, 29, 30, 36, 38, 40	1+1+2+2+2+3+3+3+3+1+2 +1+1+3+1+1+2+4+2+3 =41	25.47
No Open Dumping	10, 17, 19, 22, 33, 35, 37	—	—
Total	40 Wards	161	100%

groups according to number of identified dumping sites such as high (≥ 10), moderate (5-9), low (1-4) and no open dumping site (Table 7). The high category consisted of three wards (W9, W28 and W39) which in total represented 56 dumping sites (34.78%) of the total inventory. The W9 had the highest density with 32 dumping sites followed by W28 with 14 and W39 with 10 dumping sites, making these wards the main hotspots for open waste disposal in the study area. The moderate category included 10 wards (W1, W5, W6, W7, W8, W23, W27, W31, W32 and W34), representing 64 dumping sites (39.75%). A total of 41 (25.5%) dumping sites were found in the low category, with the remaining 7 wards having no dumping sites.

The classification shows that open dumping is an issue that affects a small number of wards, but is geographically widespread (Plate 2 & 3). The identified dumping sites were found to be concentrated in the High and Moderate categories, with almost 75% of all identified sites (120 out of 161) falling under these two categories, which gives a clear indication that the waste disposal issues are particularly alarming in these areas. This spatial pattern represents the need for a spatially differentiated approach to solid waste management, with priority interventions being given to the high-density dumping wards, such as improvements in waste collection, installing appropriate waste storage infrastructure, monitoring and the implementation of community awareness programmes. The inventory of waste generated at the ward level developed in this study can be useful as a spatial database to prioritize resource allocation and to guide evidence-based municipal solid waste management planning.

Impact of OSD on human health

In the study area, OSD sites are dominant in the vicinity of houses and are a major hazard to the health and well-being of the local inhabitants. The field observations indicated numerous dumping sites near residential houses, along roads/streets and in vacant plots often used by neighbors for waste storage. These practices foster breeding of disease vectors including mosquitoes, flies, rodents, and stray animals and thus contribute to the risk of transmission of vector-borne

and food-borne diseases. Degradation of biodegradable waste materials produces foul smells and gases that degrade the air quality of the local area, which is uncomfortable for local residents. Persistent exposure can cause respiratory irritation, headaches, nausea and allergic reactions, especially in children, the elderly, and those with preexisting respiratory diseases. A few dumping sites (W8, W9, W23, W27, W28 & W39) during the field survey were noted to have sanitary waste products and decomposing organic matter, which can carry pathogenic microorganisms and may lead to infectious diseases via direct or indirect contact with humans. The open dumping (OD) also has indirect health effects due to contamination in the environment. Dispersal of plastic waste by wind may contaminate surrounding soil and surface waters, and rainwater that has percolated through mixed waste can lead to the contamination of soil and surface runoff within the vicinity. These conditions have a negative effect on the environment and also raise the risk of human exposure to harmful substances. In addition, the construction waste, broken glass, metal debris, and discarded sharp items found at several of the dump-off locations pose physical hazards to residents, especially to children that frequently play in open areas adjacent to these dump-off sites. The clustering of open dumping sites in certain wards suggests that there is a significant proportion of the local population who are likely to be routinely exposed to these environmental health risks. The study did not conduct epidemiological investigations to generate evidence of a direct association between adverse public health outcomes and waste disposal in open dumps, but the conditions as observed in the present study do suggest a high risk for adverse public health outcomes from waste disposal in open dumps. The outcomes highlight the importance of strengthening the management of MSWs, regular waste collection, source separation and public awareness campaigns to reduce the health risks and improve the environmental quality of residential neighborhoods.

CONCLUSION

The study created a detailed GIS-based inventory of open solid waste disposal sites from a field survey and GPS mapping of 161 sites, which indicated that indiscriminate solid waste disposal is a common

environmental problem in the study area. The spatial analysis identified priority areas to be targeted for interventions, as there were some wards with more open dumping sites compared to others. During the field observations, it was also found that the dumping sites were predominantly comprised of mixed MSW dumped in unused land, unoccupied roads, and agricultural land near residential areas, which could impact the environment and people's health. The integration of field observations and GIS was successful in mapping, monitoring and identifying open dumping hotspots. The findings highlight the urgent need to improve source separation, door-to-door waste collection, waste storage and rules to combat illegal waste dumping. The geospatial database created in the course of this research can be used as a useful decision support tool for municipalities and can aid the planning of rapidly urbanizing areas for sustainable solid waste management by providing evidence-based planning.

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