A Geospatial Approach to identify Landfill Sites as Alternatives to Unsuitable Dumping Areas

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Abstract
The rapid pace of urbanization, industrialization and population growth has significantly increased the volume and complexity of municipal solid waste (MSW), intensifying both environmental and public health concerns globally. Among the various MSW management strategies, the sanitary landfilling remains the most widely practiced method for final waste disposal, particularly in developing countries. The landfill site selection process is inherently complex and multifaceted. This study considered multiple environmental and socio-economic factors. The OSM shape file was downloaded from Geofabrik's Open Street Map Data extracts. All feature layers were clipped via the study area boundary layer with the 'Clip Multiple Layers' plugin in QGIS. Buffer analysis was performed via ArcGIS software. The results indicated that the existing Srinivasapuram dumping yard, Thanjavur, southern part of India is unsuitable for further expansion. The analysis also revealed that the western and southeastern zones within the proposed area offer suitable locations for landfill development.

The study focused towards the utilization of open-source OSM data and fundamental spatial techniques such as buffer analysis, overlay analysis and visualization. On the basis of multicriteria evaluation, the ten top-ranked candidate sites are shortlisted and the first three sites are ideal which are having the areas of 384.40 acres, 372.22 acres and 336.90 acres.

Keywords: Solid waste management, Landfill site selection, Geographic information system, Remote sensing, Thanjavur.

Introduction

The rapid pace of urbanization, industrialization and population growth has significantly increased the volume and complexity of municipal solid waste (MSW), heightening environmental and public health concerns worldwide[8,9]. Changing consumption patterns, driven by rising living standards and technological advancements, have drastically altered the composition of waste, shifting it from predominantly organic to increasingly inorganic and heterogeneous forms, thereby complicating traditional disposal methods[8]. Among various MSW management strategies, such as recycling, thermal treatment and biological processing, sanitary landfilling remains the most widely practiced method for final waste disposal particularly in developing countries due to its cost-effectiveness and operational simplicity[9,19].

However, improper site selection or inadequate management of landfill sites can lead to severe environmental degradation including soil and groundwater contamination and air pollution from uncontrolled gas emissions[9]. The landfill site selection process is inherently complex and multifaceted, requiring the integration of environmental, socioeconomic, technical and regulatory criteria[18]. This complexity is further exacerbated by challenges such as limited land availability, increasing population density and growing public opposition, often referred to as the not in my backyard (NIMBY) phenomenon[20].

To address the limitations of traditional siting methods, spatial analysis techniques particularly Geographic Information Systems (GIS) and Remote Sensing (RS) have become instrumental in evaluating suitability based on multiple constraints[12]. These tools facilitate the incorporation of both spatial and non-spatial data such as land use, slope, proximity to urban infrastructure and hydrogeological sensitivity into a structured, transparent decision-making process[12].

In India, several proximity-based constraints are commonly considered for landfill siting. These include a 500-meter buffer from roads[10], a 250-meter buffer from railways[5], a 5,000-meter buffer from airports[13], a 200-meter buffer from surface water bodies[14,15,21] and a 1,000-meter buffer from historical and religious sites[5]. Additionally, the Central Public Health and Environmental Engineering Organisation (CPHEEO) landfill site selection guidelines[3], as illustrated in figure 1a, also outline similar constraints.

In India, improper disposal practices remain a critical issue, particularly in rapidly urbanizing and developing regions. Cities such as Thanjavur, Tiruchirappalli and Coimbatore face escalating challenges in MSW management[7,17,22]. In Thanjavur Municipal Corporation (TMC), which has populations of 222,943 and 54,234 households, approximately 107 tons of waste are generated daily, with 100% collection and source segregation[6]. However, the existing system lacks scientific processing methods and relies primarily on uncontrolled dumping at sites such as Srinivasapuram, leading to significant environmental and public health hazards[22]. A study by Thayalnayaki and Jayanthi[24] at the Srinivasapuram dumpsite revealed elevated levels of total dissolved solids (TDS), iron and fluoride in groundwater samples, indicating severe leachate contamination. Similar issues were observed at Ariyamangalam, Tiruchirappalli, where groundwater near the dumpsite exhibited excessive concentrations of heavy metals such as lead, copper, cadmium and manganese[11].

Sadhasivam et al[17] applied a multicriteria evaluation (MCE) approach in Thiruverumbur taluk, utilizing 12 subcriteria across cultural, physical, demographic and environmental dimensions. Al-Fares[1] employed GIS and multicriteria decision analysis (MCDA) in Kuwait, identifying optimal landfill sites covering 2.8% of the land area, with an emphasis on low hydraulic conductivity and the long-term viability of the proposed sites.

Gautam et al[7] proposed a rank-based remote sensing model in Coimbatore, identifying 29% of the area as suitable for landfill expansion, with agricultural lands emerging as the most appropriate.

Nagarajan et al[16] conducted a hydrochemical assessment in Thanjavur, revealing that 34% of groundwater was unfit for drinking and that 20% was unsuitable for irrigation, primarily due to sodium and chloride dominance. The Cauvery River, a critical water source in Tamil Nadu, is increasingly polluted by industrial effluents, agricultural runoff and urban discharges, further underscoring the importance of sustainable waste disposal practices[4].

In this context, the present study evaluates the suitability of the Srinivasapuram dumpsite for landfill expansion and identifies alternative sites within the Thanjavur region using OpenStreetMap (OSM) data, buffer analysis and overlay analysis techniques. Previous studies have documented the characteristics of existing dumping yards and their groundwater conditions.

Study Region and Data Collection

Thanjavur Municipal Corporation is the study region. It is located in the Thanjavur district of Tamil Nadu State, India. The geographical coordinates are approximately 10°47' N latitude and 79°08' E longitude. Thanjavur is administered by a municipal corporation that covers an area of 36.33 sq km and has a population of 222,619 as per the 2011 Census. The corporation is divided into 51 wards. Figure 1b and figure 1c show the district and corporation boundaries including the ward divisions.

The OSM shapefile was downloaded from Geofabrik's OpenStreetMap Data Extracts. According to Brinkhoff[2], OpenStreetMap (OSM) is a freely available, up-to-date, vector-format dataset that provides user-contributed geographic information on a global scale. Although its primary focus is not land use or land cover, it can be effectively used to extract built-up and urban areas using features such as the "landuse" tag (e.g. residential, industrial, commercial), building footprints and certain road types (e.g. residential roads, living streets). The OSM data model consists of nodes, ways and relations, enriched with key-value tag pairs that allow for flexible and extensible data representation.

The data were obtained by selecting the appropriate extension links step by step. First, the subregion 'Asia' was selected, followed by 'India' and then the 'Southern Zone.' This process resulted in the downloading of a compressed (zipped) folder named southern-zone-latest-free.shp with a size of 1.04 GB. After extraction, the folder expanded to 3.66 GB and contained various file types including .cpg, .dbf, .prj, .shp and .shx. The dataset includes multiple feature classes, such as buildings, land use, natural features, places, places of worship (pofw), points of interest (pois), railways, roads, traffic, transport, water bodies and waterways.

Criteria for Identifying Suitable Land for Sanitary Landfill Sites

S.NO	PLACE	MINIMUM SITING DISTANCE
1	Coastal regulation, wetland, critical habitat areas, sensitive eco-fragile areas, and flood plains as recorded for the last 100 years	Sanitary landfill site not permitted within these identified areas
2	Rivers	100 metres (m) away from the flood plain
3	Pond, lakes, water bodies	200 m
4	Non-meandering water channel (canal, drainage, etc.)	30 m
5	Highway or railway line, water supply wells	500 m from center line
6	Habitation	All landfill facility: 500
7	Earthquake zone	500m from fault line fracture*
8	Flood prone area	Sanitary landfill site not permitted
9	Water table (highest level)	The bottom liner of the landfill should be above 2m from the highest water table
10	Airport	20 km**

* The urban local bodies (ULBs) located in seismic zone 4 and zone 5 should consult the seismic fault map before finalising the site for the sanitary landfill. They should also ensure that when the sanitary landfill is designed, the seismic factors are taken into consideration in determining the stability of the landfill structure.
** In a special case, a landfill site may be set up within 10–20 km away from the airport or airbase if there is no objection certificate from the civil aviation authority or air force as the case may be.

Figure 1a: CPHEEO Landfill Site Selection Guidelines[3]

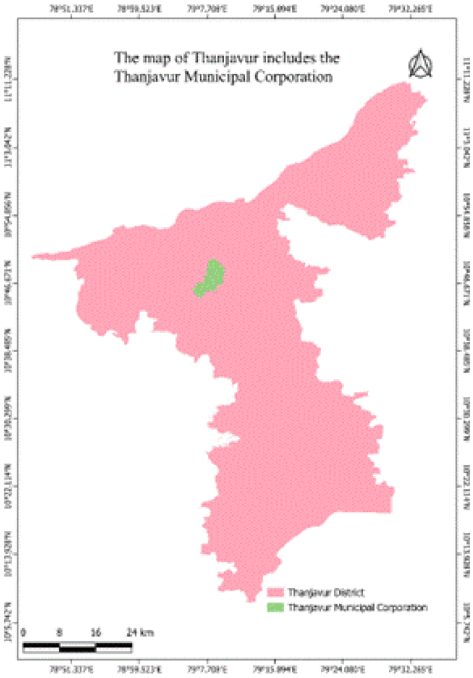

Figure 1b: The map of Thanjavur District and Municipal Corporation

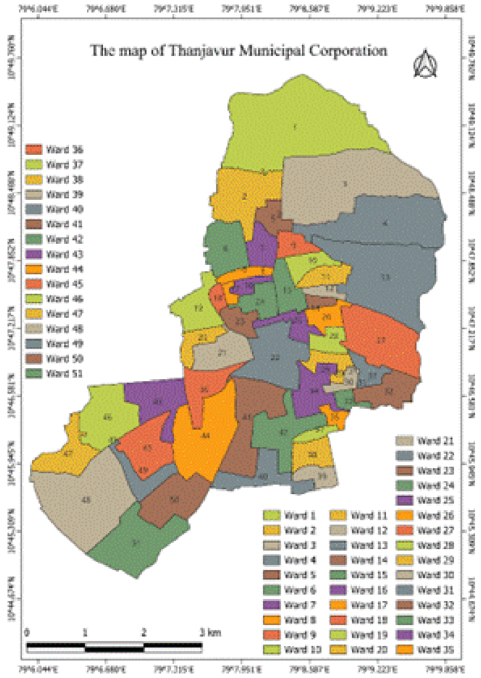

Figure 1c: The map of Thanjavur Municipal corporation

A soil map shapefile was also utilized from an existing dataset stored on my laptop, specifically the 'DSMW' dataset accessed from the Food and Agriculture Organization (FAO) of the United Nations. The administrative boundaries were downloaded from the Survey of India portal whereas the municipal corporation boundaries were obtained from the Ministry of Housing and Urban Affairs, Government of India portal. The file used was named Corporation_Wards_Thanjavur_30-06-2020. QGIS Desktop 3.34.10 and ArcMap 10.7.1 were used for the analysis.

Data Processing Procedure

Study Area Creation: The center point was created via a vector point feature. In the horizontal panel of the QGIS software, the Layer menu was accessed, followed by selecting the Create Layer and then the New Shapefile Layer. The point feature type was selected and the layer was named the center point. After the Center Point layer is created, a right-clicking operation on the layer enables the Toggle Editing Mode. The Add Point Feature tool was then used to place the point approximately at the Big Temple flight.

Next, the study area boundary was created using a vector polygon feature, following a similar procedure as the center point layer but instead selecting the polygon feature type. After the study area, boundary layer was created, the toggle editing mode was enabled. The add polygon feature tool was used and the digitized segment tool was selected. The boundary was then delineated by selecting multiple district edge points around the center point, ensuring that the boundary accurately followed the curved edges.

Study area extraction: After the study area boundary was created, all feature layers were clipped to the study area boundary layer with the 'Clip Multiple Layers' plugin in QGIS. However, instead of clipping all the layers at once, three layers were clipped frequently to avoid overhanging issues on the laptop.

Buffer analysis: Buffer analysis was performed via ArcGIS software with the following buffer distances: 10,000 m (10 km) for airports, 500 m for railways and highways, 100 m for other roads, 1,000 m for places of worship, 250 m for points of interest, 200 m for water bodies, 100 m for waterways and 100 m for transport bus stops (Figure 2). After the buffer analysis, all the layers were clipped to the study area boundary via the 'Clip Multiple Layer' plugin in QGIS.

Results and Discussion

The methodology incorporates proximity-based criteria including distances from airports, railways, highways, roads, waterways, water bodies, places of worship, public amenities and soil types, using a GIS-based buffer and union analysis approach as shown in figure 2. This streamlined spatial overlay technique supports environmentally sound and data-informed landfill siting decisions.

Airport: The airport is located alongside the Thanjavur–Pudukkottai National Highway and functions as an Air Force Station that is currently owned and operated by the Indian Air Force. Figure 3a shows the location of the airport whereas figure 3b illustrates the constraint zone around the airport. According to CPHEEO guidelines, landfill sites should not be located within 20 km of an airport. However, in special cases, landfills may be considered within a 10–20 km range. In this study, a 10 km buffer around the airport is considered a constraint zone for landfill suitability whereas areas beyond 10 km are deemed suitable. Figure 3b depicts the 10 km proximity/buffer from the airport.

Railways: Railways also traverse the study area, connecting various districts and States. The Thanjavur Railway Junction connects the city to nearby districts including Trichy, Nagapattinam, Thiruvarur and Mayiladuthurai. Figure 4a shows the railway tracks within the study area and figure 4b indicates the constraint zone around the railway lines. In accordance with CPHEEO guidelines, landfill sites should be located at least 500 meters away from railway tracks. Accordingly, a 500-meter buffer is considered a constraint zone for landfill site selection. Figure 4b presents the 500-meter proximity/buffer from the railways.

Highways: The study area is traversed by several highways that connect Thanjavur with various districts and states. Major roads include the Vikravandi–Kumbakonam–Thanjavur Road, Trichy–Thanjavur Road, Thanjavur Ring Road, Thanjavur–Pattukkottai–Aranthangi–Karaikudi–Paramakudi–Sayalkudi Road, Thanjavur–Mannargudi–Thiruthuraipoondi Vedaranyam–Koiyakarai Road, Saliamangalam Outer Road, Ramanathan Circle, Pudukottai Main Road, Poondi Bypass, Perambalur–Manamadurai Road, Odathurai Street, New Bus Stand Road, Nagapattinam–Gudalur–Mysore Road (Old National Highway), Nagapattinam–Coimbatore–Gundlupet Highway, Moopanar Road, Medical College Road, Kumbakonam–Thanjavur New National Highway, Grand Anaicut–Kaveripattinam Road, Gandhiji Road, East Main Street and several unnamed highways.

Figure 5a illustrates the highway network in Thanjavur including National Highways NH 136, NH 36 and NH 83 and State Highways SH 22, SH 27, SH 29, SH 63, SH 8, SH 99A, SHU 61 and SHU 89. Figure 5b depicts the constraint zones around these highways. According to CPHEEO guidelines, landfill sites should be located at least 500 meters away from highways. In this study, a 500-meter buffer zone surrounding highways is considered a constraint for landfill site suitability. Figure 5b shows the 500-meter proximity/buffer from the highway network.

Roads: The study area includes an extensive network of roads, both major and minor, that connect various villages, districts and States.

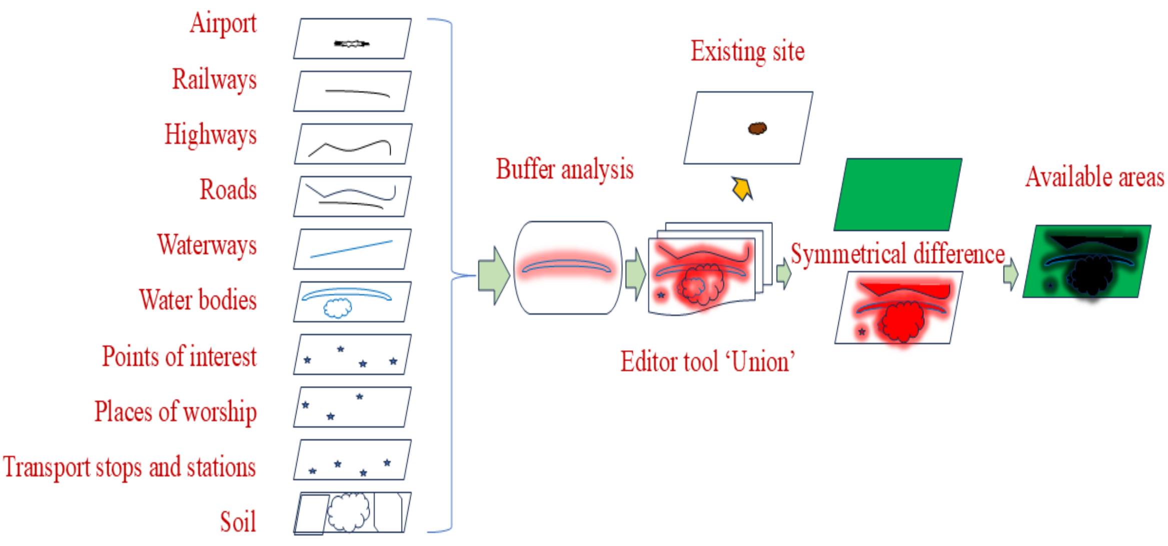

Figure 2: Methodology Flow Chart

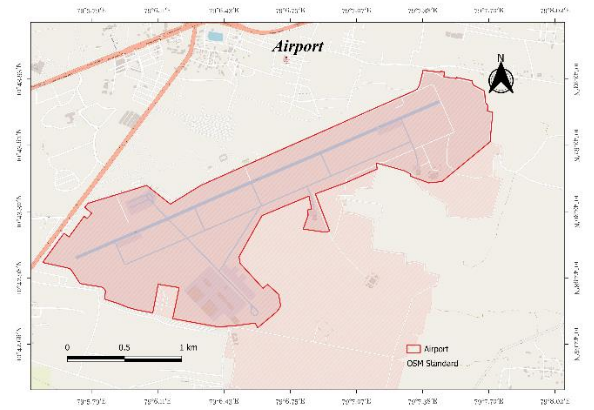

Figure 3a: Airport

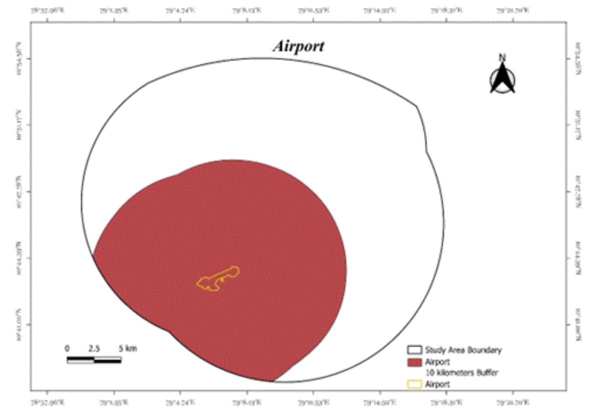

Figure 3b: Airport

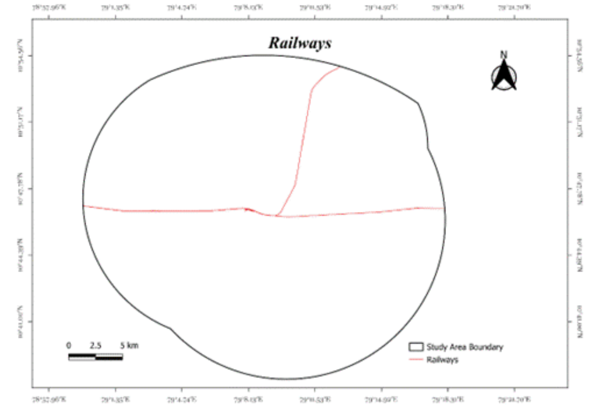

Figure 4a: Railways

Figure 4b: Railways

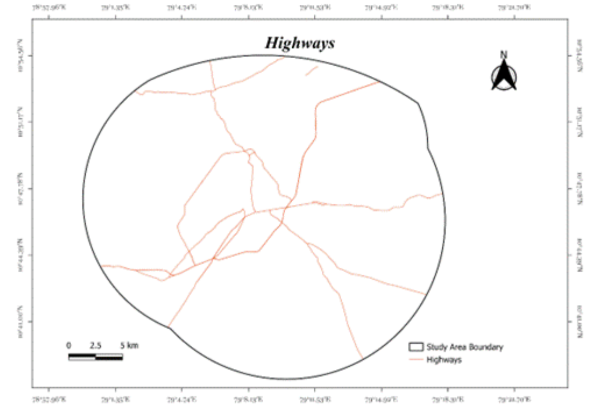

Figure 5a: Highways

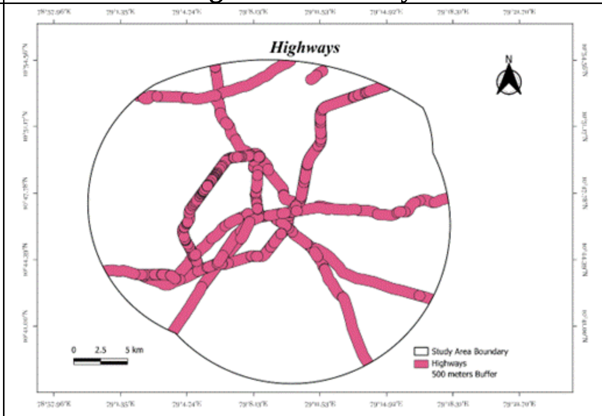

Figure 5b: Highways

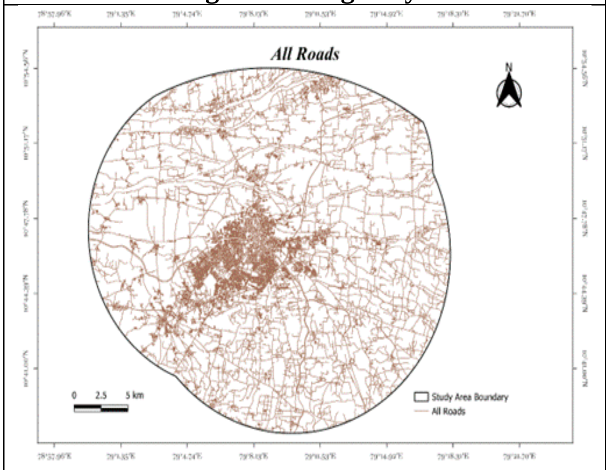

Figure 6a: All Roads

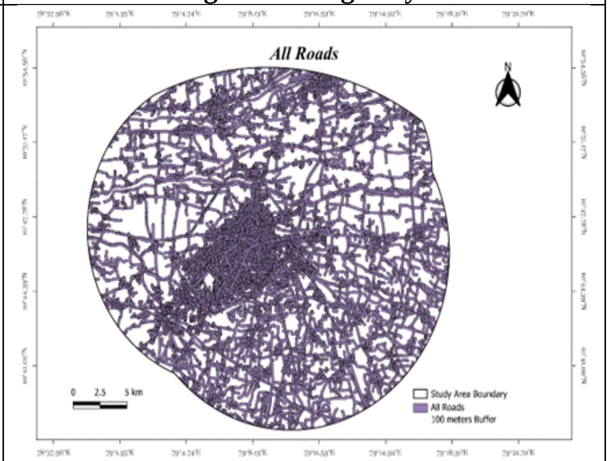

Figure 6b: All Roads

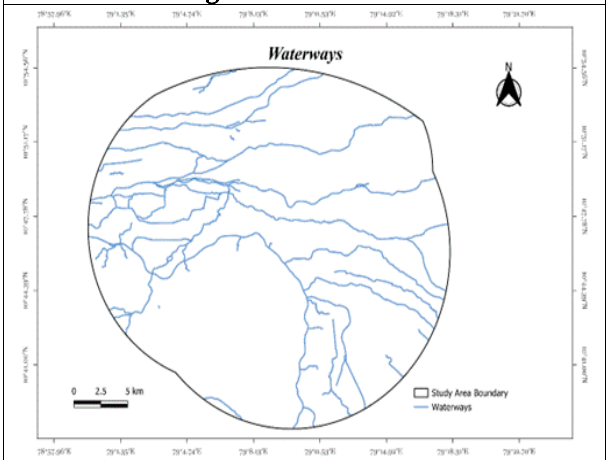

Figure 7a: Waterways

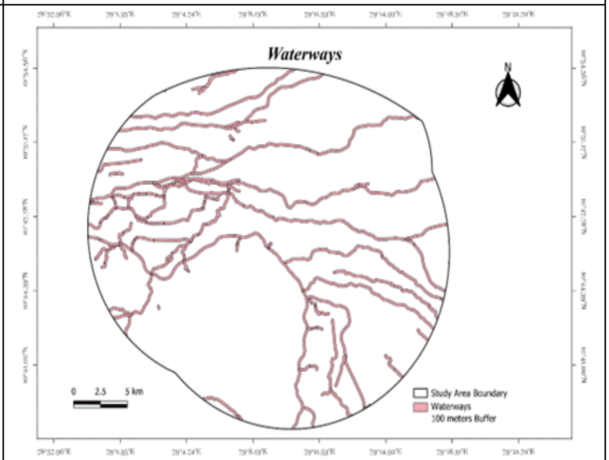

Figure 7b: Waterways

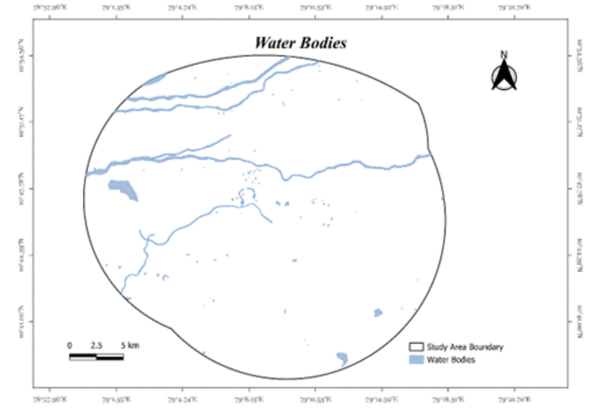

Figure 8a: Water Bodies

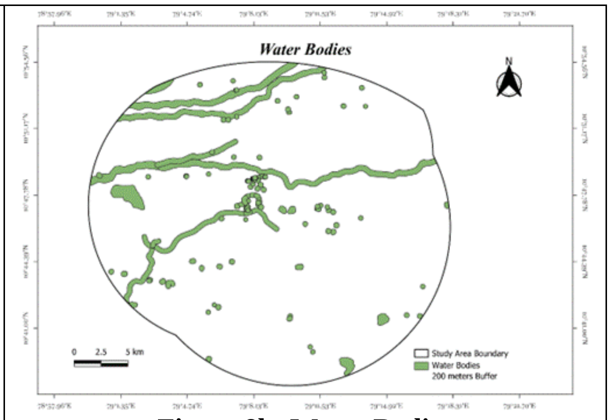

Figure 8b: Water Bodies

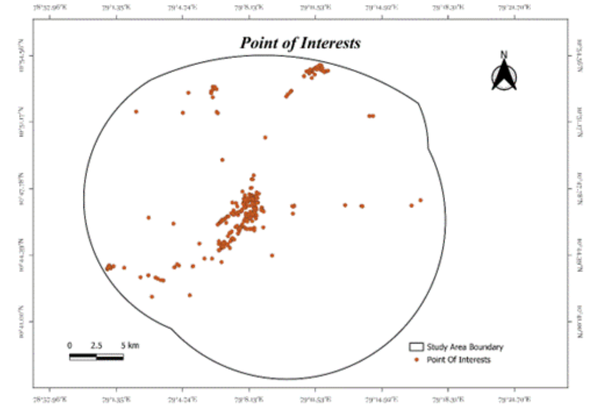

Figure 9a: Point of Interest

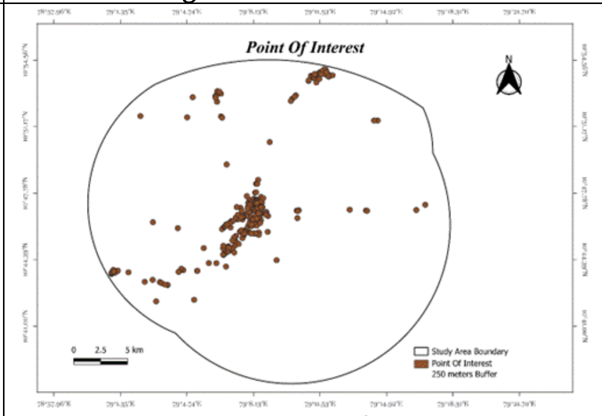

Figure 9b: Point of Interest

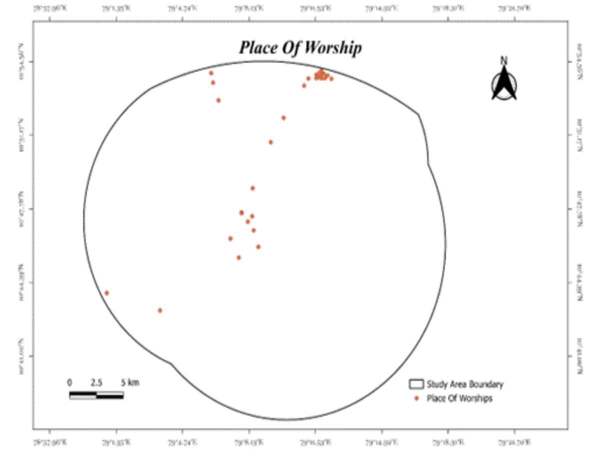

Figure 10a: Place of Worship

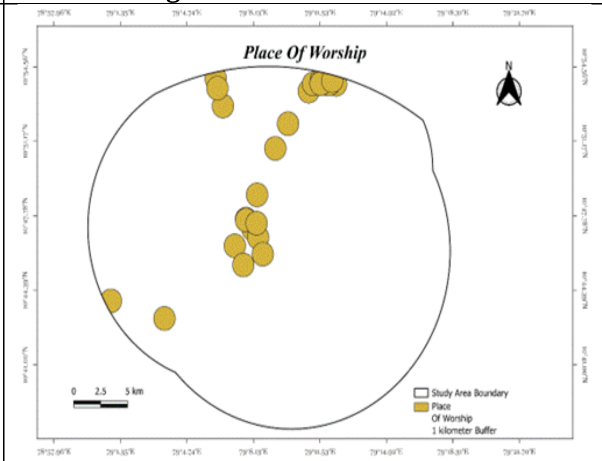

Figure 10b: Place of Worship

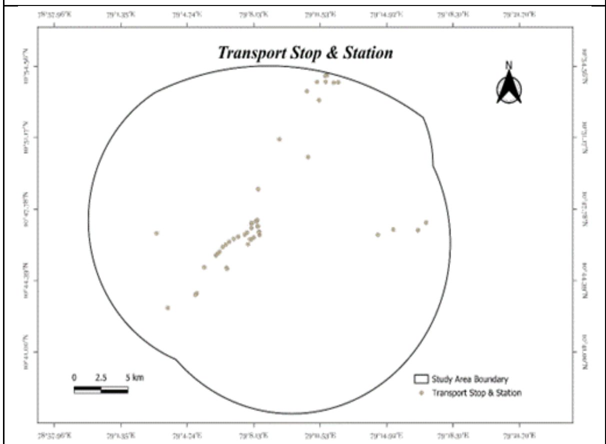

Figure 11a: Transport Stop and Station

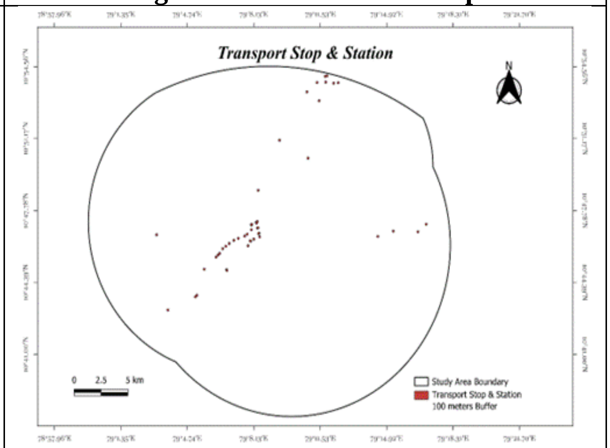

Figure 11b: Transport Stop and Station

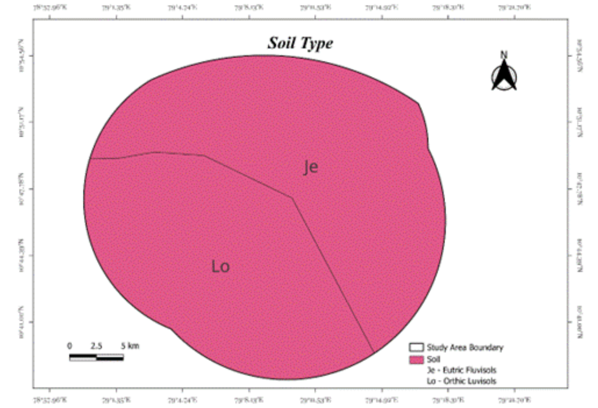

Figure 12a: Soil Types

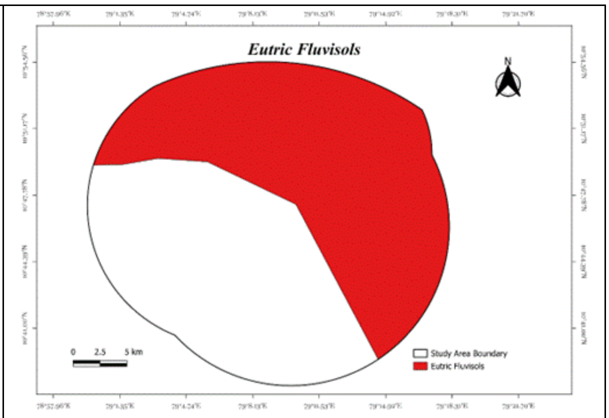

Figure 12b: Soil Type (Eutric Fluvisols)

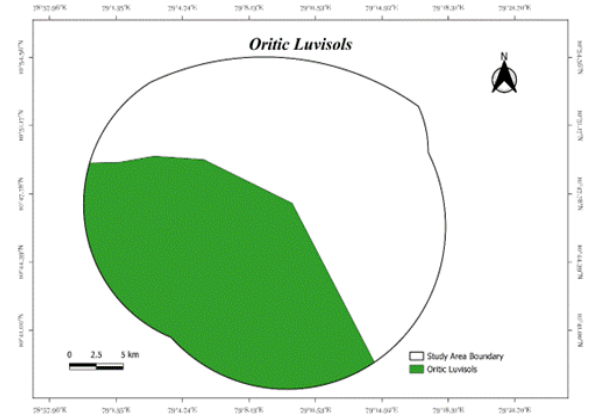

Figure 12c: Soil Type (Oritic Luvisols)

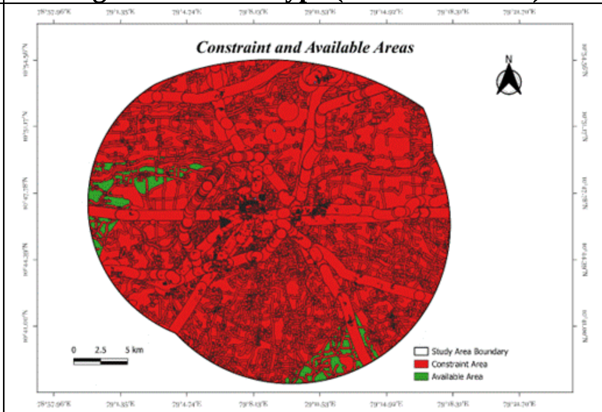

Figure 13: Constrain Areas and Available Areas

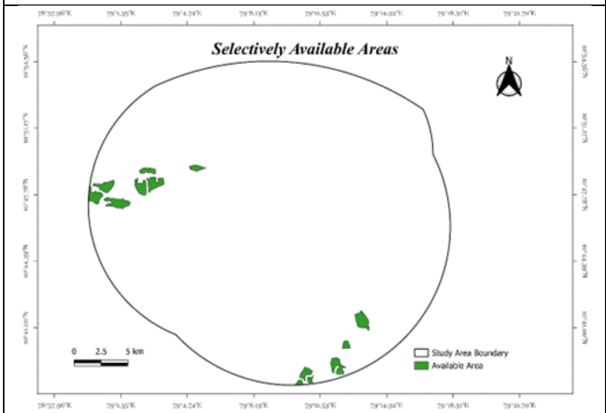

Figure 14: Selectively Available Areas

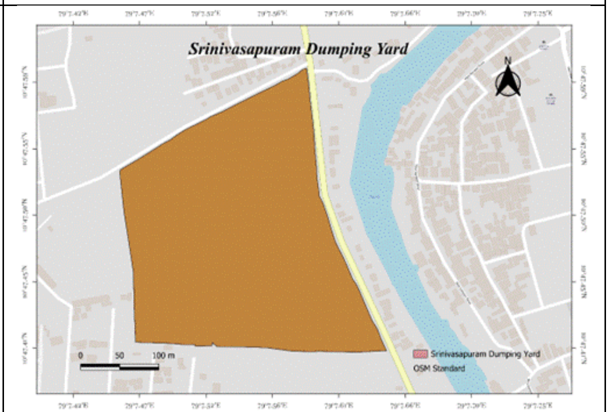

Figure 15a: Srinivasapuram Dumping Yard

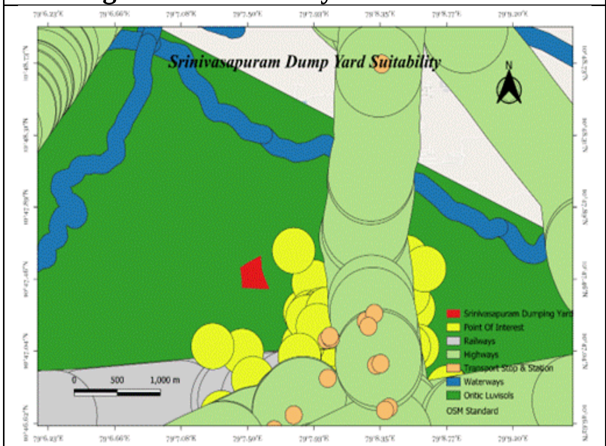

Figure 15b: Srinivasapuram Dump Yard Suitability

Figure 15c: Srinivasapuram Dump Yard Unsuitable

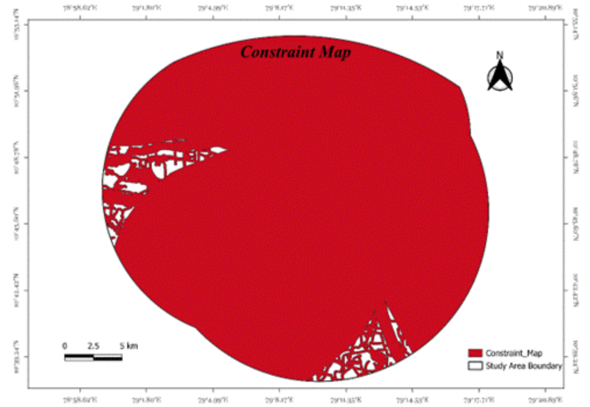

Figure 16a: Constraint Map (By Union Tool)

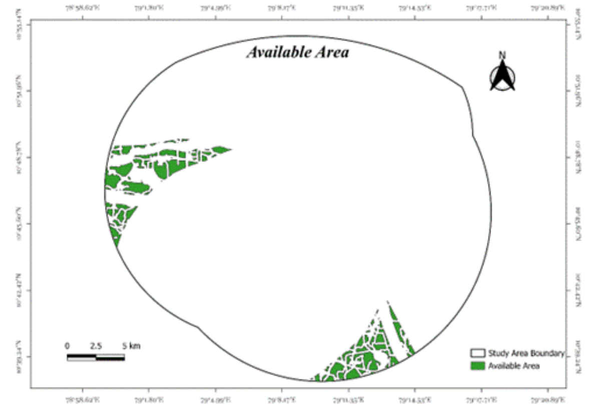

Figure 16b: Available Area (By Symmetrical Difference Tool)

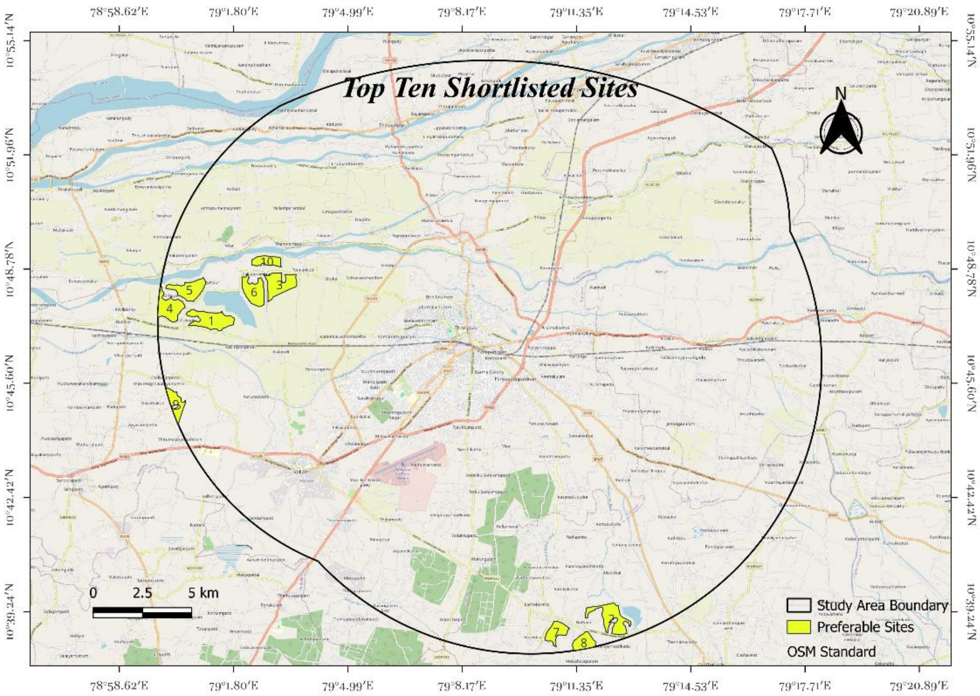

Figure 17: Top Ten Shortlisted Sites

The notable roads within the study area include Yagappa Nagar Road, West Street, West Rampart Street, West Nain Street, Vallalar Street, Veerasingam Pettai Road, Vanuvali Roads, Vaniyan Street, Valuthoor Road, Vadakku Mada Valagam, Vaalan Adham Nagar, Uppan Kuttai Lane, Umar Street, Tamil University Road, Sundram Nagar, Srinivasan Pillai Street, Sri Lakshmi Nagar Road, SPJ Nagar, South Rampart Street, South Main Street, Soolamangalam–Purasakkudi Road, Sivan Kovil Street, Sevvai Kilamai Padithurai, Reddipalayam Road, Rajan Road, Railway Station Road, Pushyamandapa Street, Pookollai Street, Poo Kaara Street, Periya Kovil Road, Paambatti Theru, Paaku Thoppu, Overhead Crosswalk, Old Rameswaram Road, Old Kumbakonam Road, New Cauvery Nagar, Nattani Road and more.

Figure 6a presents the spatial distribution of these roads within the study area. According to CPHEEO guidelines and general best practices, landfill sites should not be located in close proximity to public roads to minimize nuisance and health hazards. In this study, a 100-meter buffer around all roads is considered a constraint zone for landfill site suitability. Figure 6b illustrates the 100-meter proximity/buffer from all identified roads.

Waterways: Waterways serve as the primary source of water for agricultural activities in the study area. Major water bodies include the Vettar River, Vennar River, Vallam River, Nasuvunni River, Kudamuruti River, Kollidam River and Cauvery River, along with the Grand Anaicut Canal and several unnamed streams, canals and drainage channels. Figure 7a shows the distributions of all canals, drains, rivers and streams within the study area. In accordance with environmental guidelines and best practices, landfill sites should be located at safe distances from water bodies to prevent contamination of water resources. In this study, a 100-meter buffer around all waterways is considered a constraint zone for landfill site selection. Areas located more

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than 100 m from these water bodies are deemed suitable for landfill siting. Figure 7b shows the 100-meter proximity/buffer from all waterways.

Water Bodies: Water bodies play crucial roles in supporting agricultural and fishing activities within the study area. The key water bodies identified include Agali, Aiyankulam, Karupattiya, Kollidam, Palli Agraharam Pond, Pillayarpattai Lake, Poonga Swimming Pool, Ribas Pond, Shivan Temple Pond, Singaperumal Kulam, Sivagangai Tank, Swimming Pool, Temple Pond, Water Park and several other unnamed ponds, lakes and reservoirs.

Figure 8a shows the spatial distributions of all identified water bodies, reservoirs, riverbanks and wetlands within the study area. In line with environmental protection guidelines, landfill sites should be located at safe distances from water bodies to avoid contamination of surface and groundwater resources. In this study, a 200-meter buffer around all water bodies is considered a constraint zone for landfill site suitability. Areas located more than 200 m from these water sources are considered suitable for landfill siting. Figure 8b depicts the 200-meter proximity/buffer zone from all water bodies.

Points of interest: Points of interest (POIs) represent public places that provide essential services such as domestic supplies, food, healthcare, education, banking and other community needs. The key POIs identified within the study area include A.K.C. Nursing Home, A.S.K. Residency, Aasai Maligai, Abayam Hospital, Abi and Abi College, Abraham Pandithar Siddha Clinic, Adaikalamatha Institute of Management, AGR Beauty Parlor, Aiyangar Bakery, AJ Clinic, Ajma Seafood, Anandham Silks, Anjuman Marriage Hall, Anu Multispeciality Hospital, Apex Heart Hospital, Arasu Jewels, Arul Cinema, Ayyampettai Police Station, Canara Bank, Shrist College, City Union Bank, Devar Mess, Dheerka Sumangali Mahal, Government Elementary School, Government Eye Hospital, Government Hospital, Government School for the Blind, Hotel Gnanam, Hotel Ramnath, Hotel Sangam, ICICI Bank, Indian Bank, Indian Overseas Bank, IOB Regional Office, Janaki Nursing Home, Jupiter Theatre, Kalyan Jewellers, Kalyanasundaram Higher Secondary School, Lakshmi Silks, Lotus Tiles and more.

Figure 9a shows the spatial distributions of various POI categories including ATMs, artworks, bakeries, banks, beauty shops, beverage shops, bicycle shops, bookstores, cafés, cinemas, clinics, clothing stores, colleges, community centers, computer shops, dental clinics, department stores, fast food outlets, fountains, furniture shops, gift shops, guest houses, hospitals, hostels, hotels, jewellers, marketplaces, mobile phone shops, parks, pharmacies, police stations, post offices, restaurants, schools, shoe shops, sports centers, supermarkets, public toilets, universities and even water towers. In terms of best practices in urban planning and environmental safety, landfill sites should not be situated close to these sensitive and public-use areas. In this study, a 250-meter buffer around all the POIs is considered a constraint zone for landfill site suitability. Areas beyond 250 meters from public places are deemed suitable for landfill siting. Figure 9b shows the 250-meter proximity/buffer zone from all identified POIs.

Places of worship: Places of worship are vital for cultural development, traditional preservation and religious practices within a community. Several significant religious sites have been identified in the study area including Kodi Amman Kovil, Vinayagar Kovil, Anjaneya Temple, Thyagaraja Samathy Anjaneya Temple, Shiva Temple, Masjid, Shri Ooradichi Narayani Amman Temple, Shri Devanayaki Ambal Sametha Sri Chakkaravakesavarar Thirukovil, Railady Mosque, Manakkaadu Mosque, Vaaniya Street Mosque, Jaamiya Masjid, St. Antony's Church, Anjaneyar Temple, Anjuman Mosque, East Street Mosque, Shivan Temple, Maelapettai Mosque, Modern Mosque, Punitha Anthoniyar Church and many other unnamed places of worship.

Figure 10a displays the spatial distribution of all identified places of worship including Christian churches, Hindu temples and Muslim mosques, across the study area. In accordance with CPHEEO guidelines and social sensitivity, landfill sites should not be located near religious sites to respect community sentiment and maintain environmental hygiene. For this study, a 1000-meter buffer around all places of worship was considered a constraint zone for landfill site selection. Areas beyond 1000 m from these sites are considered suitable for landfill siting. Figure 10b shows the 1000-meter proximity/buffer zone from all worship places.

Transport stops and stations: Transport stops and stations play crucial roles in public mobility, providing designated points for vehicle halts and passenger transit. In the study area, several key transportation hubs, including the KSRTC Bus Stop, Old Bus Stand, Thiruvaiyaru Bus Stand, Vallam Main Bus Station, Ayyampet Bus Stop, Balaji Nagar, Chakkarapalli, Easwari Nagar, Kodi Amman Kovil Stop, Koviladi Bus Stop, Lakshmi Seeval Stop, Mangalapuram Bus Stop, Medical College gate 1, 2 and 3 Bus Stops, Membalam Bus Stop, Municipal Colony Bus Stop, Nedaar, Pasupathikovil, Ramanathan, Solan Silai, Tamil University Stop, Vaaniya Street Bus Stop, Kudikadu Railway Halt, Alakkudi Station, Ayyampet Station, Pasupathikovil Station, Saliyamangalam Station, Thanjavur Railway Junction, Titte Station, Rahath Cabs, Thanjavur Taxi Stand and several other unnamed transport stops and stations, have been identified.

Figure 11a shows the spatial distributions of all identified bus stations, bus stops, railway halts, railway stations and taxi stands within the study area. As per planning considerations and CPHEEO guidelines, landfill sites should be located at a safe distance from transport hubs to avoid public health risks and operational disruptions. In this study, a 100-meter buffer zone around all transport stops and stations is considered a constraint for landfill site selection. Areas located more than 100 m from these transport hubs are deemed suitable. Figure 11b shows the 100-meter proximity/buffer from all stops and stations.

Soil: Soil types play a significant role in cultivation, agricultural activities, construction practices, rainwater infiltration and the support of soil-based organisms. According to the available geospatial data, Eutric Fluvisols and Orthic Luvisols are the major soil types identified within the study area (Figure 12a).

i) Eutric Fluvisols: Fluvisols are soils developed from recent alluvial deposits and are typically found in river floodplains, alluvial fans and deltas[23]. These soils exhibit stratification due to varying depositional layers and are usually young with minimal horizon development.

- Eutric Fluvisols, a subtype of Fluvisols, are chemically rich in base cations (hence the term “eutric”) and present near-neutral pH levels.
- They are commonly found in inland fluvial and lacustrine environments, marine settings and coastal marshes.
- These soils are generally fertile and well suited for agriculture, particularly rice cultivation in humid tropical regions.
- However, constraints such as flooding, high water tables and in some coastal areas, salinity or acidity (e.g. Thionic Fluvisols) can impose significant limitations on land use.

ii) Orthic Luvisols: Luvisols are well-developed soils typically found in subhumid forested and grassland regions[23]. They are characterized by an argic horizon, a subsoil layer enriched with clay due to illuviation (the downward translocation of clay particles).

- Orthic Luvisols are the standard or “typical” form of Luvisols, displaying the most representative features of this soil group without notable deviations.
- These soils are fertile, exhibit good structure and have moderate to high base saturation. They are commonly used for agricultural production, especially for crops such as wheat and barley.
- Orthic Luvisols are typically found in regions with moderate rainfall and are often derived from loess or other fine-textured parent materials, frequently occurring in Europe and other temperate zones.

Figure 12a shows the spatial distributions of the soil types in the study area. Figure 12b highlights the areas covered by Eutric Fluvisols, whereas figure 12c represents the distribution of Orthic Luvisols. In this study, Eutric Fluvisols (Figure 12b) are considered unsuitable or constrained for landfill siting because of their proximity to water bodies and susceptibility to flooding. In contrast, Orthic Luvisols (Figure 12c) are deemed suitable for landfill siting because of their favorable physical and chemical characteristics.

Unsuitable and Suitable Locations: A simple visualization of all the constraint layers derived from the buffer zones was prepared, with all the constraint layers represented in red (Figure 13). The orthic luvisol layer, which is considered suitable, is highlighted in green. After these layers were visualized, the remaining visible green areas classified as medium and large in size were identified as potentially suitable sites for landfill location. Figure 14 illustrates the remaining suitable areas, while all other regions are deemed unsuitable. Notably, existing or currently practiced dumpsites are located within a constraint zone.

Srinivasapuram Dumping Yard: The existing dumping site at Srinivasapuram is located within the limits of Thanjavur Municipal Corporation (Figure 15a). The dump yard is situated more than 250 m away from the following sensitive establishments: Shri Venkateshwara Matric Higher Secondary School, Oriental Higher Secondary School, Kalyanasundaram Higher Secondary School, Raja Rajan Nursing Home, Dr. V. Marimuthu Hospital, Venkatesan Psychotic Hospital and Shri Lakshmi Scans and Clinic. Additionally, it is located more than 500 meters away from the Thanjavur Railway Station and railway track.

The dump yard also maintains a buffer of more than 500 m from major roads such as Ramanathan Circle, Pudukottai Main Road, Perambalur to Manamadurai Road, New Bus Stand Road, Nagapattinam–Gudalur–Mysore Road, Moopanar Road, Medical College Road, Gandhiji Road and East Main Street. It is also more than 100 meters away from the Cholan Silai and Membalam bus stops, as well as from the Grand Anaicut canal. The site lies above a soil type classified as Oritic Luvisols. On the basis of these factors and as per the considered siting criteria, the location initially appears to be suitable for landfill development (Figure 15b) as it does not fall within the defined constraint zones.

However, several critical factors suggest that the site is not suitable for landfill siting. The Srinivasapuram dump yard lies within 10 km of an airport, which poses potential risks to air traffic due to bird activity. Moreover, it is located within 200 meters of Agali and two other unnamed water bodies and within 100 meters of residential roads, secondary roads and service roads. The site is also located within 1,000 meters of religious worship places including Vinayagar Temple, Anjaneyar Temple and Kamatchi Amman Temple (Figure 15c). Considering these proximity constraints, it can be concluded that the Srinivasapuram dump yard falls within a restricted or constrained zone and is therefore unsuitable for landfill siting.

Identification by overlay analysis: After performing buffer analysis, all the clipped buffer layers including those for airports, railways, highways, roads, waterways, water bodies, points of interest, places of worship, transport stops and stations and unsuitable soil, were merged into a single constraint map via the 'Union' tool from the vector overlay analysis ‘Editor’ toolbox (Figure 16a). The available area was subsequently extracted via the 'Symmetrical Difference' tool between the study area layer and the constraint map in ArcMap GIS software (Figure 16b). The resulting available sites were then divided into individual polygons via the 'Feature to Polygon' tool from the Data Management toolbox. Finally, the 'Add Geometry Attributes' tool was used to create and calculate various fields, including areas (acres) and perimeters (meters), from the 'Feature' extension of the Data Management tools in ArcGIS.

Identified Sites: In the landfill site suitability analysis, a total of 113 potential sites were initially identified and subsequently subjected to detailed evaluation. Among these sites, ten were shortlisted on the basis of their comparatively larger available land area (Figure 17). The areas of the top ten shortlisted sites are as follows: Site 1 – 384.40 acres, site 2 – 372.22 acres, site 3 – 336.90 acres, site 4 – 312.40 acres, site 5 – 297.72 acres, site 6 – 296.37 acres, site 7 – 190.15 acres, site 8 – 180.37 acres, site 9 – 177.24 acres and site 10 – 155.73 acres. The final selection will depend primarily on the ownership status of the land, with a preference given to sites that are Government owned or under Government control.

Conclusion

This study employs a combination of vector datasets to delineate the zone of influence around potential landfill sites and to evaluate spatial constraints for landfill siting within proposed region. The results of this analysis provide a data-driven, pre/postprocessing tool to support informed decision-making by municipal authorities. The application of geospatial techniques enabled the systematic assessment of landfill site suitability within proposed region. Using buffer and overlay analyses, multiple spatial parameters were evaluated including proximity to airports, railways, highways, roads, water bodies, waterways, points of interest, places of worship, transport hubs and soil types.

The spatial analysis revealed several zones that meet the standard proximity constraints for landfill development. Furthermore, the existing dumping site at Srinivasapuram was critically evaluated. The findings indicate that while it satisfies some basic locational criteria, its continued use poses environmental concerns due to its proximity to sensitive receptors and existing evidence of groundwater contamination. These results underscore the need for identifying alternative, environmentally sustainable landfill sites using geospatial decision-support tools.

The data-driven methodology enhances transparency and reduces reliance on subjective judgment; however, its reliance on open-source OSM data and basic GIS techniques such as buffer and overlay analysis presents limitations. Future research will incorporate hydrogeological criteria to increase the robustness of site selection. Ultimately, the final decision for landfill development is influenced by land ownership, with preferences given to Government-owned or publicly controlled parcels.

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