GIS-BASED LANDFILL SITE SELECTION FOR SOLID WASTE MANAGEMENT IN GROWING URBAN AREAS: A CASE STUDY OF SRIPERUMBUDUR

A PROJECT REPORT

Submitted by

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ABSTRACT

Effective solid waste disposal is a major challenge for cities experiencing rapid population growth and increased waste generation due to residential, commercial, industrial, and infrastructure development. An important aspect of municipal solid waste management is the selection of suitable landfill sites, which has significant economic, ecological, and environmental health implications. This study aims to identify and evaluate potential landfill sites using GIS and decision criteria based on environmental and socioeconomic factors, including surface and groundwater quality, land elevation, land use, proximity to urban and sensitive areas, distance from roads, population density, and land value. The study focuses on Sriperumbudur district in Tamil Nadu, and utilizes urban maps from 2009 to 2020, as well as data on transportation, industries, elevation, and government policy to model urban growth and identify potential landfill sites. The results showed that the distance from residential area and sensitive places gained the highest weight of 0.01013 and 0.0652, respectively, out of a total of eight environmental sub-criteria. The final suitability map is generated through the integration of GIS layers overlayed, providing a valuable tool for urban planners and decision-makers in addressing the challenges of solid waste management in rapidly growing cities.

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ABBREVIATION	EXPLANATION
GIS	Geological Information System
MSWM	Municipal Solid Waste Management
MCDM	Multicriteria decision-making
IOT	Internet Of Things
WHO	World Health Organisation
SEZ	Special Economic Zone
GPS	Gobal Positioning System
QGIS	Quantum Geological Information System

CHAPTER 1

INTRODUCTION

1.1 OVERVIEW

Cities are expanding at an unprecedented pace, driven by population growth and migration fr rural areas.The unplanned urbanization that accompanies this expansion often results degradation of natural resources and a decline in the quality of life for residents . Solid wa management (SWM) techniques are essential for maintaining a healthy living environment cities, and the presence of a sanitary landfill is critical to these efforts .

Multi-criteria decision analysis (MCDA) with Geographic Information Systems (GIS) has emerged as a powerful tool for incorporating a diverse range of environmental parameters into the landfill site selection process . In this paper, we review several studies that have applied MCDA and GIS techniques to identify suitable landfill sites for waste management in different regions. The increasing popularity of applying environmental criteria in national planning and management has led to a proliferation of scientific approaches to determine the best location for hazardous waste landfills . For instance, one study focused on the hazardous waste produced in Qazin, Iran, and used GIS to evaluate the entire region based on certain evaluation criteria for the analysis of landfill site suitability.The appropriate site selection for waste disposal is a major challenge in waste management, and GIS has become an innovative tool in landfill siting processes. The methodology presented in these studies utilizes GIS to create a digital geo-database that provides a spatial clustering process for landfill siting.

The GIS-aided methodology evaluates the entire region based on certain evaluation criteria for the analysis of landfill site suitability.

In this project, the case of Sriperumbudur is taken into account, a rapidly growing urban area in India, the demand for solid waste disposal has increased significantly in recent years due to the population growth and industrial development in the region. However, the existing landfill sites in the region have reached their capacity, and the need for identifying new landfill sites has become crucial. The evaluation criteria were classified into four main categories: geological and tectonic, hydrological and hydrogeological, morphological, and social.

Overall, solid waste management is a critical issue in urban planning due to its enormous impact on the economy, ecology, and environmental health of the region. As cities continue to grow, larger quantities of waste are produced, making the problem of waste management increasingly urgent. Therefore, it is essential to develop effective and sustainable strategies for waste management, including the appropriate selection of landfill sites. The use of MCDA and GIS techniques provides a powerful and innovative approach for the selection of landfill sites, with the potential to optimize the management of solid waste and promote sustainable urban development.

Geospatial technology provides an efficient and effective means of identifying potential landfill sites. It enables the integration of different types of data, including environmental, social, and economic, to produce a comprehensive analysis of potential sites. Geospatial technology also provides a spatially explicit analysis of the site's suitability, which helps to reduce the potential environmental and social impacts associated with landfills. The objective of this project is to use geospatial technology to identify potential landfill sites in Sriperumbudur. The project will focus on producing a comprehensive analysis of potential sites using various geospatial tools, including remote sensing, GIS, and spatial analysis techniques. The project will also consider the environmental, social, and economic factors that influence the selection of a landfill site. The project's findings will provide useful insights into the landfill site selection process, which can help urban planners and policymakers to make informed decisions on waste management in rapidly growing urban areas. The project's outcomes will also contribute to the development of a sustainable and integrated solid waste management system in Sriperumbudur.

In the following sections, we will review the methodologies, criteria, and results of several studies that have used MCDA and GIS techniques for landfill site selection, highlighting the benefits and limitations of these approaches. The use of geospatial technology in identifying potential landfill sites is a crucial step towards developing a sustainable and integrated solid waste management system in rapidly growing urban areas. This project aims to provide useful insights into the landfill site selection process and contribute to the development of a sustainable waste management system in Sriperumbudur.

1.2 OBJECTIVES

- To evaluate the potential landfill sites in rapidly growing urban areas using geospatial technology.

- To identify the suitable criteria for selecting landfill sites based on environmental, social, and economic factors.

- To assess the existing landfill sites in Sriperumbudur and suggest ways to improve their performance.

- To propose new potential landfill sites in Sriperumbudur based on geospatial analysis.

1.3 SCOPE OF THE PROJECT

- The study will focus on Sriperumbudur, a rapidly growing urban area in India.

- Geospatial technology will be used to analyze various factors such as land use, topography, soil type, proximity to residential areas, and water resources.

- The study will identify suitable criteria for selecting landfill sites and apply them to the Sriperumbudur region.

- The existing landfill sites in Sriperumbudur will be evaluated, and recommendations will be made to improve their performance.

- New potential landfill sites will be proposed based on the geospatial analysis conducted in the study.

- The study will contribute to the development of sustainable landfill management practices in Sriperumbudur and other rapidly growing urban areas.

CHAPTER 2

LITERATURE SURVEY

2.1 REVIEW ON SOLID WASTE MANAGEMENT

The management of solid waste is becoming increasingly important due to rapid urbanization and its associated negative impacts on the environment. There is a growing concern about the increase in solid waste generated from various sources, including domestic, industrial and construction waste. This has led to a lack of knowledge of the key elements that are crucial to solid waste management.Researchers have conducted various studies on solid waste management to develop sustainable solid waste management systems. Successful solid waste management practices have been established in developed countries, but developing countries still lag behind . Recycling has been suggested as a solution to minimizing the quantity of solid waste dumped in landfills and reducing the burden placed on quarries to produce natural materials, as well as increasing the lifespan of landfills.

A waste management hierarchy based on the 3R principle of reducing, reusing, and recycling has been established to reduce the amount of solid waste produced on landfill sites.Improper handling of solid waste leads to a significant amount of air and water pollution . Descriptive statistics have been used to characterize the potential for reuse and recycling of solid waste. Successful solid waste management practices have been shown to validate structures and have a genuine influence on natural systems. The primary pillar of solid waste management is the notion of sustainability .

A combined Geographic Information System and Life Cycle Assessment model has been used to better understand how solid waste might aid in the transition to a sustainable supply mix of resources . Remote sensing and vector data have been used in combination to evaluate the potential of existing landfill sites and their area of effect for growth .

2.2 REVIEW ON APPLYING GIS TECHNOLOGY IN SWM

The rapid growth of urban areas around the world has resulted in an increased demand for land for various purposes. One of the critical issues faced by urban planners and policymakers is the selection of appropriate sites for waste disposal. Landfills are essential infrastructure for managing the solid waste generated by urban areas, and it is crucial to locate them appropriately to minimize the potential environmental impact and health hazards.

Several studies have used geospatial technology to identify and evaluate potential landfill sites. These studies have shown that geospatial technology is a valuable tool in identifying and evaluating potential landfill sites. Geospatial technology includes various techniques such as geographic information systems (GIS), remote sensing, and global positioning systems (GPS).

A study conducted by in the Delhi region of India used a GIS-based approach to identify potential landfill sites. The study identified several factors such as land use, slope, and distance from water bodies that could influence the selection of a landfill site. The study concluded that a GIS-based approach could be an effective tool for identifying potential landfill sites. Another study by used a multi-criteria decision-making (MCDM) approach to evaluate potential landfill sites in a rapidly growing urban area of China. The study used various criteria such as distance from residential areas, slope, land use, and geological factors to identify potential landfill sites. The study concluded that the MCDM approach could provide a comprehensive and objective evaluation of potential landfill sites.

Similarly, a study by used a GIS-based approach to evaluate potential landfill sites in the Istanbul metropolitan area of Turkey. The study used various criteria such as distance from residential areas, land use, and geological factors to identify potential landfill sites. The study concluded that a GIS-based approach could be an effective tool for identifying potential landfill sites in a rapidly growing urban area. Several studies have used geospatial technology to identify and evaluate potential landfill sites in rapidly growing urban areas. These studies have shown that geospatial technology is a valuable tool in identifying and evaluating potential landfill sites.

2.3 REVIEW ON SUITABLE SITE SELECTION FOR SWM

Site selection for solid waste management is a critical task for municipal authorities. The selection process requires a systematic approach that considers several factors, including environmental, social, and economic impacts. In this review, will discuss suitable site selection analysis for the management of solid waste dumping and provide relevant references.

One of the most important considerations in site selection is the proximity to the source of waste. The closer the site is to the source, the lower the transportation costs and associated greenhouse gas emissions. However, proximity to residential areas and sensitive environmental features, such as wetlands and water bodies, should also be considered. A comprehensive site selection process should also evaluate factors such as land use, soil type, geology, and hydrogeology to ensure that the site can withstand the environmental impact of waste disposal.

Several methods and tools are available for site selection analysis, including geographic information systems (GIS), multicriteria decision analysis (MCDA), and expert systems. The use of these tools can help decision-makers to evaluate and compare potential sites based on a range of criteria, such as land use suitability, environmental impact, public health and safety, and social acceptance. A combination of these tools and methods is often used to provide a comprehensive and systematic approach to site selection.

There are several case studies and research papers that demonstrate the effectiveness of using site selection analysis for solid waste management. For example, a study conducted in the municipality of San Nicolas, Mexico, used GIS and MCDA to identify suitable sites for a new landfill facility.The study considered criteria such as distance to the nearest settlement, land use, and environmental sensitivity. The study concluded that the selected site met all the criteria and was suitable for a new landfill facility .

Another example is a study conducted in the city of Izmir, Turkey, which used a GIS-based approach to identify potential landfill sites. The study considered factors such as slope, distance to water resources, distance to residential areas, and distance to protected areas. The study concluded that the selected sites were suitable for solid waste management and had minimal environmental impact . Site selection analysis is crucial for effective solid waste management. It helps decision-makers to identify suitable sites that minimize environmental impact, are cost-effective, and meet the needs of the community. The use of GIS, MCDA, and expert systems can provide a comprehensive and systematic approach to site selection. Municipal authorities should consider using these tools and methods in their site selection process to ensure sustainable waste management practices.

CHAPTER 3

MATERIALS & METHODS

3.1 OVERVIEW

The methodology starts with the identification of potential sites for solid waste dumping in the study area. The relevant maps from the municipality office of Sriperumbudur and estimated the amount of municipal solid waste generated in the area. The criteria selection process is then carried out, which is one of the most critical steps in the site selection process. The criteria selection process depends on the availability of data and nature of the study area from political, geological, and environmental perspectives. The authors collected all the required data for this process. In this study, several criteria were considered for site selection, including urban centres, nature reserves, electrical power plants, well sites, power lines, railways, roads, slope, main rivers, historical sites, and religious sites. A database was developed for each of the criteria used, and each criterion was standardized with regards to the suitability for locating a landfill site. After selecting the criteria, all were weighted. The selection criteria are identified and weighted, and the collected data is also analyzed, accelerating the process of decision making. The hierarchy was deconstructed into a pair of comparison matrices. This pairwise comparison was used to determine the relative importance of each alternative in terms of each criterion to be identified according to its importance in the site selection process. Finally, the weighted overlay technique by GIS was used to generate the suitability map and show the potential sites for landfilling. The detailed description of the waste generated amount and volume and the estimated number of inhabitants for the study period. They utilized GIS software and weighted overlay method to perform the process of landfill site selection. There were many process steps used in GIS to reach the final required suitability index map in this study. Decision rules for analysis on the landfill site selection data in weighted overlay were established using GIS.

GIS software was used for imaging and analysis of the required data. In order to evaluate the site selection criteria, GIS was used to measure the relative importance weights for the evaluation criteria. Weighted overlay divides problems into smaller understandable parts, analyzed each part separately, and then integrated the parts in a logical manner. This paper utilized geospatial technology to identify suitable landfill sites in a rapidly growing urban area. Their methodology provides a systematic and comprehensive approach to site selection that considers various factors, including environmental impact and cost-effectiveness. The use of GIS and MCDA provides decision-makers with a powerful tool for evaluating potential sites and selecting the most suitable one. The methodology presented in this paper provides a valuable contribution to the field of solid waste management. The use of geospatial technology, particularly GIS and MCDA, provides a powerful tool for decision-makers in identifying suitable landfill sites. This methodology can be utilized by municipal authorities in other rapidly growing urban areas to ensure sustainable waste management practices.

3.2 CRITERIA WEIGHTS

Criteria weights are an essential aspect of the methodology used for landfill site selection. The weights represent the relative importance of each criterion compared to others under consideration. There are four different techniques for assigning weights, including ranking, rating, pairwise comparison, and trade-off analysis. In this study, the method of pairwise comparison was used to calculate the weights for each criterion. The comparison matrix was used to determine the relative importance of each criterion compared to others. The weights were assigned based on the decision of which criterion was more important in each comparison. Constraint criteria, such as fault, sensitive habitats, and airport, were considered alongside factor criteria, including slope, soil permeability, surface water, groundwater, land use, road network, and residential areas. The analytic hierarchy process was used in the decision-making process concept. Surface water, groundwater, and residential areas were also considered as constraint criteria. Overall, the weights of the criteria were used to generate a suitability map that highlighted the potential sites for landfilling in the study area.

3.3 DIGITAL ENVIRONMENTAL MAPS USING QGIS

In this study, QGIS, a free and open-source GIS software, was used for creating digital environmental maps for suitable landfill site selection. The software was used to analyze, visualize, and manage geospatial data and to represent the spatial variation. The study also used the special extension tool 'buffer' to create buffer zones around important sites or specific geographic features in each criterion. Each criterion was classified into classes and given a rank value according to importance in the study area based on expert opinions and literature reviews. QGIS was also used for optimizing the routing of collection trucks from dumping sites to recycling units. The user-friendly interface, cross-platform compatibility, extensive range of plugins and tools, and cost-effectiveness make QGIS an excellent tool for analyzing geospatial data and optimizing waste management systems.

3.4 IDENTIFICATION OF OPTIMUM SITE FOR LANDFILL

Landfill site selection for solid waste management is a crucial task as it involves identifying and evaluating potential locations for the disposal of solid waste in a manner that minimizes negative impacts on human health and the environment. Here are some key factors to consider when identifying a suitable landfill site:

Geographical factors: The landfill site should be located in an area that is away from residential areas, water bodies, and other sensitive land uses. The site should be accessible by transportation for both solid waste delivery and monitoring activities.

Geotechnical factors: The landfill site should be located on stable ground, which is not prone to natural disasters such as earthquakes, flooding, and landslides. The soil and rock conditions should be able to support the landfill structure and withstand the load of the waste.

Environmental factors: The landfill site should not negatively impact the surrounding environment, including air quality, water quality, and natural habitats. Proper measures should be taken to control potential hazards, such as leachate and gas emissions.

Regulatory factors: The site should comply with local and national regulations and laws governing the operation of landfills, including zoning, waste disposal, and environmental protection.

Social factors: The landfill site should be located in a community that is willing to accept the facility, with minimal impact on the quality of life for nearby residents.

To identify suitable landfill sites, various site selection methods such as Geographic Information System (GIS) analysis, and Multi-Criteria Decision Analysis (MCDA) can be used. These methods involve evaluating potential sites based on multiple criteria, including those listed above, to identify the best location for a landfill site. It is essential to involve stakeholders in the site selection process to ensure that the selected site is acceptable to the community and meets their needs.

3.5 STUDY AREA DETAILS

The study area is located in Sriperumbudur, a town Panchayat in Tamil Nadu, India, situated 40 kilometers southwest of Chennai on the national highway 4. The area covers 3.79 sq.km and is situated between the latitudes of 12o 0' 0''N to 13o 50' 0''N and the longitudes of 79o 0' 0" E to 80o 30' 0" E. Sriperumbudur is part of Kancheepuram district, which consists of eight taluks covering a total area of 4432 sq.km.

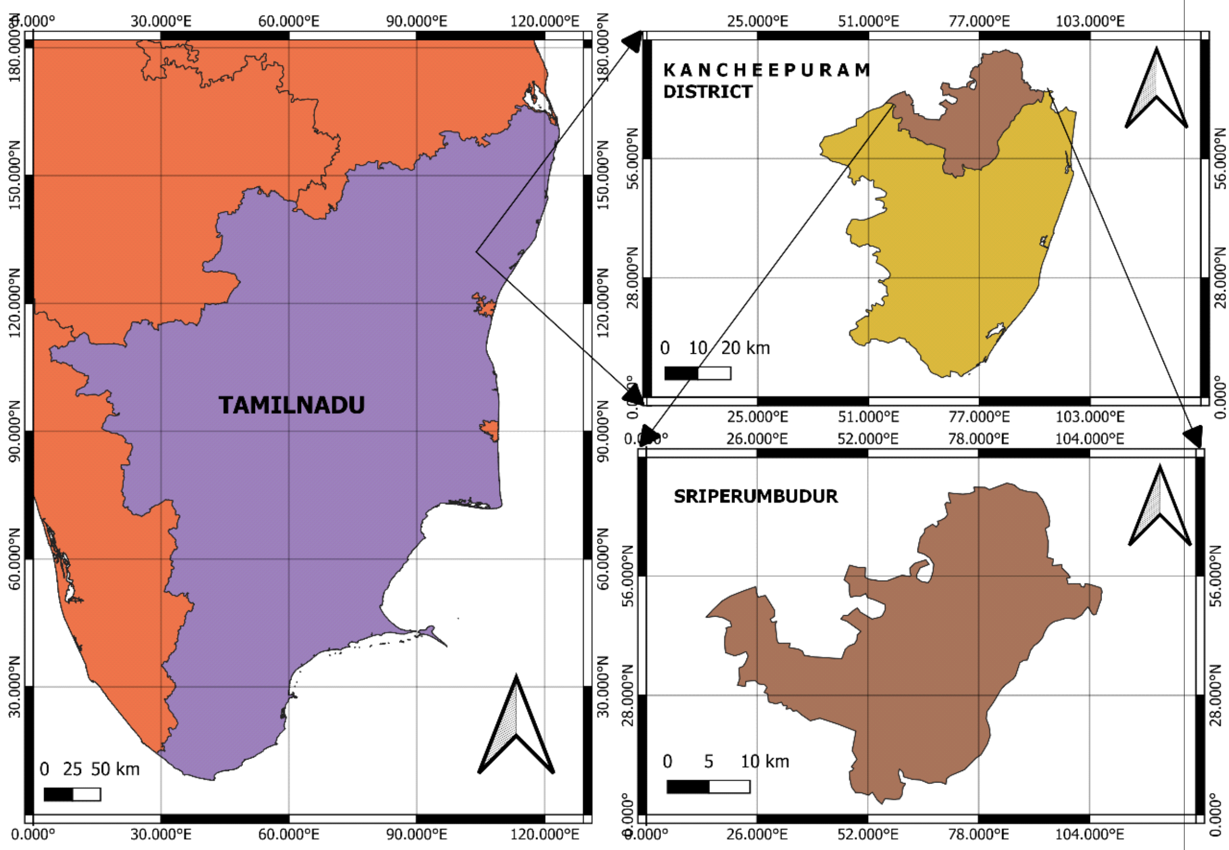

Figure 1 Study Area Identification

The district is primarily agricultural, with an abundance of rainfall and water resources such as tanks, tube wells, and bore wells. However, recent developments such as the Special Economic Zone (SEZ) have led to the conversion of agricultural lands into residential plots and industrial areas, particularly in taluks like Sriperumbudur, Tambaram, Kancheepuram, and Cheyyur, covering an area of 48.21 sq.km. Agriculture is the main occupation of the people in the district.

3.6 METHODOLOGY FLOW CHART

The decision process for landfill site selection is structured in three stages, as shown in Figure 2. The first stage involves setting the objective and selecting decision criteria. The objective of the decision hierarchy is to select the most suitable site for landfill. The decision criteria are the factors that will be used to evaluate the potential sites.

The second stage involves creating a GIS database and identifying suitable candidate sites. The GIS database will include information on the potential sites, such as their location, size, and environmental characteristics. The candidate sites will be evaluated based on environmental and economic factors. Environmental factors may include the risk of contamination and potential health problems associated with proximity to the landfill, while economic factors may include land value, transportation costs, and operational costs.

The surveys will include observations, measurements, and interviews with stakeholders involved in the waste management process. The data collected will be used to create a GIS-based model to optimize transportation routes and streamline the waste management process. Sampling will also be conducted to collect data on air and water quality near the dumping sites and recycling units using sensors for air quality and sample collection for water quality. The water samples will be analyzed in a laboratory to determine the concentration of pollutants and their impact on the environment. This data will be used to evaluate the environmental impact of construction demolition waste on water quality. The third stage involves utilizing fuzzy multicriteria decision-making to identify the most suitable site. Fuzzy multicriteria decision-making is a method that can handle the uncertainty and imprecision that often exists in decision-making processes. It allows decision-makers to consider multiple criteria simultaneously and to assign weights to each criterion based on its importance.

Overall, the decision process for landfill site selection is a complex and multi-faceted process that requires careful consideration of a range of environmental and economic factors. The use of fuzzy multicriteria decision-making can help to ensure that the most suitable site is selected based on a comprehensive evaluation of all relevant criteria.

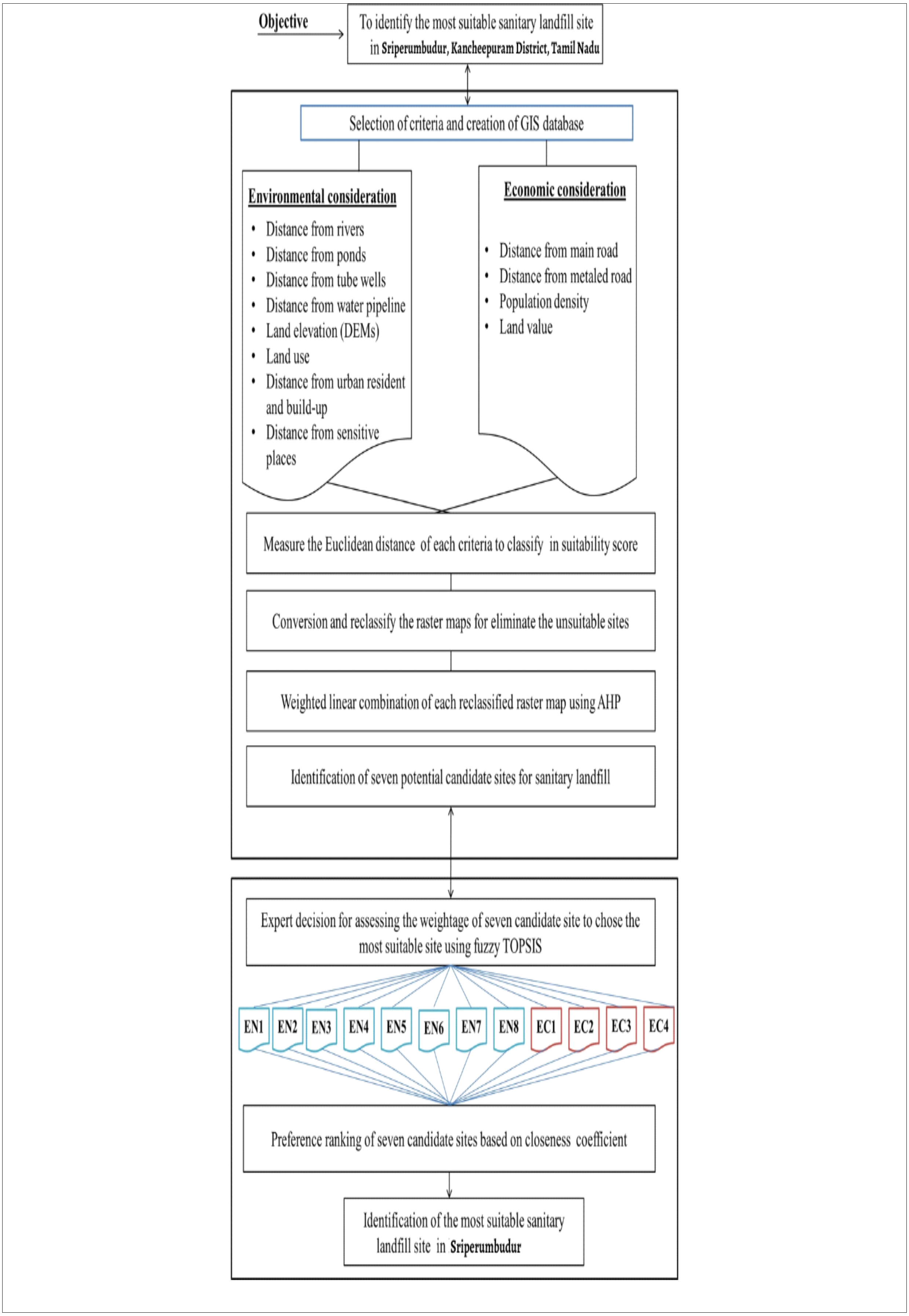
Objective
To identify the most suitable sanitary landfill site in Sriperumbudur, Kancheepuram District, Tamil Nadu
Selection of criteria and creation of GIS database
Environmental consideration
Distance from rivers
Distance from ponds
Distance from tube wells
Distance from water pipeline
Land elevation (DEMs)
Land use
Distance from urban resident and build-up
Distance from sensitive places
Economic consideration
Distance from main road
Distance from metaled road
Population density
Land value
Measure the Euclidean distance of each criteria to classify in suitability score
Conversion and reclassify the raster maps for eliminate the unsuitable sites
Weighted linear combination of each reclassified raster map using AHP
Identification of seven potential candidate sites for sanitary landfill
Expert decision for assessing the weightage of seven candidate site to chose the most suitable site using fuzzy TOPSIS
EN1
EN2
EN3
EN4
EN5
EN6
EN7
EN8
EC1
EC2
EC3
EC4
Preference ranking of seven candidate sites based on closeness coefficient
Identification of the most suitable sanitary landfill site in Sriperumbudur

Figure 2 Hierarchical structure of the decision process in landfill site selection

3.7 DATA COLLECTION METHODOLOGY

The collection of data is a crucial aspect of any research project, and for this particular study, the objective is to evaluate the environmental impact of construction demolition waste on air and water quality while optimizing the routes from dumping sites to recycling units. The chosen methodology for this study combines both primary and secondary data collection methods. Primary data will be gathered through field surveys and sampling, while secondary data will be sourced from various relevant published reports, scientific journals, and online databases. These sources were selected based on their relevance to the research topic and the quality of data they provide. The secondary data will be utilized to complement the primary data and to gain additional insights into the environmental impact of construction demolition waste on air and water quality. The online databases will be used to gather information on air and water quality, waste management, and GIS technologies. The scientific journals on environmental science and engineering will be utilized, alongside published reports on waste management practices and policies.

3.8 DATA ANALYSIS

3.8.1 Landfill site selection factors and evaluation criteria

When selecting a landfill site, it is important to consider both environmental and socioeconomic factors to avoid long-term negative impacts on components such as groundwater, surface water, and soil. The significance of criteria can vary depending on the geographical location. In this particular study, the selection criteria for landfill sites were determined based on local environmental and economic factors, following guidelines from the Pollution Control Board of the Government of India. A total of twelve decision criteria were assessed, with eight criteria considered from an environmental perspective and four from an economic perspective.

Table 1 Environmental Factors: Landfill site suitability criteria, sub criteria, alternatives, scores, and their weight

Criteria	Sub criteria	Alternative	Score	Weight
Environmental	Distance from river and canal (m)	< 200	1	0.0253
		200–400	3	
		400–600	4	
		600–800	6	
		> 800	9	
	Distance from waterbodies (m)	< 200	1	0.0158
		200–400	2	
		400–600	4	
		600–800	7	
		> 800	9	
	Distance from tube well (m)	< 100	1	0.0298
		100–200	3	
		200–300	5	
		300–400	7	
		> 400	9	
	Distance from pipeline (m)	< 100	1	0.0326
		100–200	3	
		200–300	4	
		300–400	6	
		> 400	9	
	Land elevation (m)	10 to 19	1	0.0454
		19 to 22	3	
		22 to 25	7	
		25 to 28	9	

		28 to 46	5	
	Land use land cover	Waterbodies	2	0.0616
		Sessional agriculture	7	
		Builtup area	1	
		Vegetation	3	
		Vacant land	9	
	Distance from residential area (m)	< 200	1	0.1013
		200–400	3	
		400–600	5	
		600–800	7	
		> 800	9	
	Distance from sensitive place and	< 100	1	0.0652
	restricted places (m)	100–200	3	
		200–300	5	
		300–400	7	
		> 400	9	

A hierarchical decision-making procedure was used in the GIS environment, consisting of three stages, with the second stage utilizing GIS-based overlay to identify suitable landfill candidate sites. The alternatives of each sub criterion were assigned scores ranging from 1 to 9, with 1 being unsuitable and 9 being highly suitable. The third stage used to prioritize the candidate sites. These two stages helped to identify the most suitable sanitary landfill site in the study area.

Table 2 Socio-Economic factors: Landfill site suitability criteria, sub criteria, alternatives, scores, and their weight

Criteria	Sub criteria	Alternative	Score	Weight
Socioeconomic	Distance from state highway (m)	< 200	9	0.1006

		200–400	7	
		400–600	5	
		600–800	3	
		> 800	1	
	Distance from urban metalled roads (m)	< 200	9	0.1211
		200–400	6	
		400–600	4	
		600–800	3	
		> 800	1	
		1756–2785	9	
	Population density (persons/km^2)	2785–5006	7	0.1643
		5006–7773	5	
		7773–8938	3	
		8938–11,050	1	
	Land value (lakhs/kata)	0.40–1.24	9	0.2362
		1.24–1.73	7	
		1.73–2.34	5	
		2.34–3.13	3	
		3.13–4.98	1	

CHAPTER 4

RESULTS & DISCUSSIONS

4.1 ENVIRONMENTAL CRITERIA FOR LANDFILL SITE SELECTION

There are several factors that should be considered for identifying suitable landfill sites, such as surface water, groundwater, land elevation, land use land cover, distance from urban residence and build-up, and distance from sensitive and restricted places. Surface water is an important factor to consider as it could be a long-term threat to both surface and groundwater. Landfills should be located at a specific distance from surface water like lakes, rivers, and ponds. The minimum distance recommended by India MSW rules 2016 is 200 m around surface water. Different buffer distances were measured for surface water location, and a higher distance from the water bodies indicates higher suitability for considering suitable landfill sites.

Groundwater is the main source of drinking water, and the contamination of groundwater would be a great threat to the environment and public health. Therefore, distinct distances should be kept from groundwater sources. The present study collected coordinates of the tube well and water supply pipeline to measure the distance from these features to put a suitability rank. Land elevation is a substantial factor for uncovering suitable landfill sites because it is the main determining factor of environmental attributes like slope, aspect, and curvature which maintain an important role in the earth and atmospheric process. Land use land cover is an important land criterion that should be considered for resolving public acceptance regarding the election of land for landfill sites. Distance from urban residence and build-up and distance from sensitive and restricted places are also important factors to consider.

4.1.1 Distance from river and canal

Environmental criteria play a critical role in the selection of landfill sites. One essential consideration is the distance of the landfill site from the groundwater wells. In this regard, ten functional groundwater well points were identified and buffer zones created around each well using proximity tools. The dump site should not be located within a 500-meter distance from the groundwater wells points to avoid contamination of the groundwater. Another critical factor that needs to be considered is the proximity of the site to the shoreline. This factor has economic implications for industrial development, as shorelines provide access to ports, harbours, and marine-based industries. Additionally, seawater can be desalinated to provide water for urban populations. Figure 3 shows the proximity distance from rivers and canals to locate the best site for a waste dump site in Sriperumbudur.

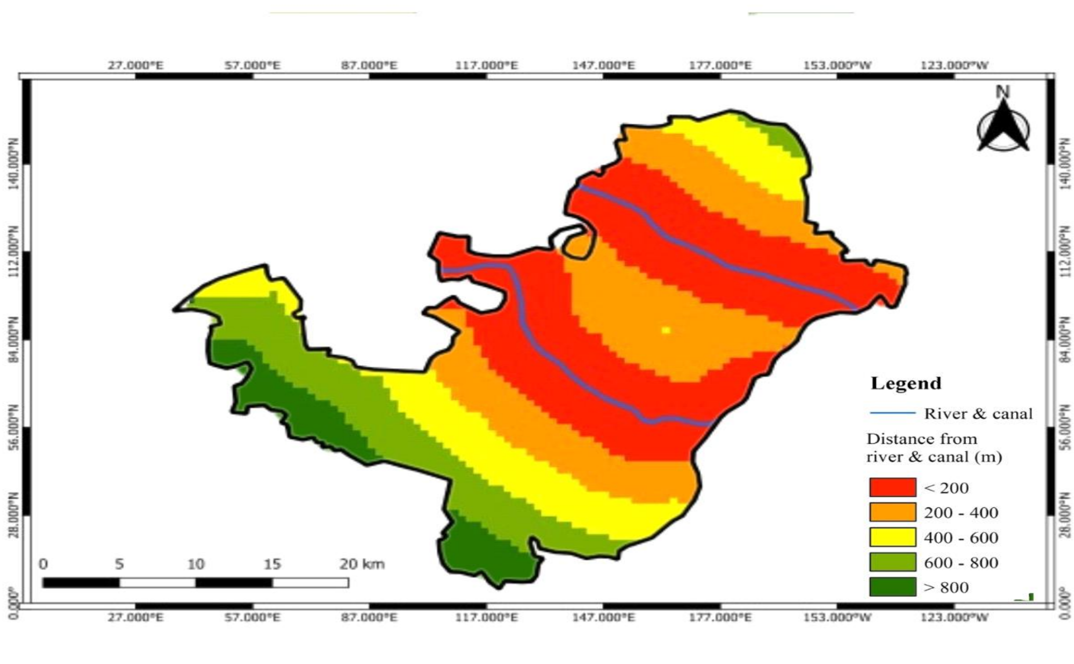

Figure 3 Distance criteria from the river and canal

Therefore, when selecting a landfill site, it is important to consider not only the proximity to groundwater wells but also the shoreline's distance. These environmental factors must be carefully evaluated to ensure that the chosen landfill site is suitable and will not have adverse impacts on the environment and surrounding communities. A thorough and comprehensive evaluation of these criteria is essential for sustainable landfill site selection.

4.1.2 Distance from waterbodies

The distance from water bodies is an important environmental criterion when selecting a landfill site. Solid waste disposed near rivers can cause ecological, agricultural, and health problems. Therefore, a suitability map for solid waste dump sites was produced to identify areas that are suitable and unsuitable for waste disposal.

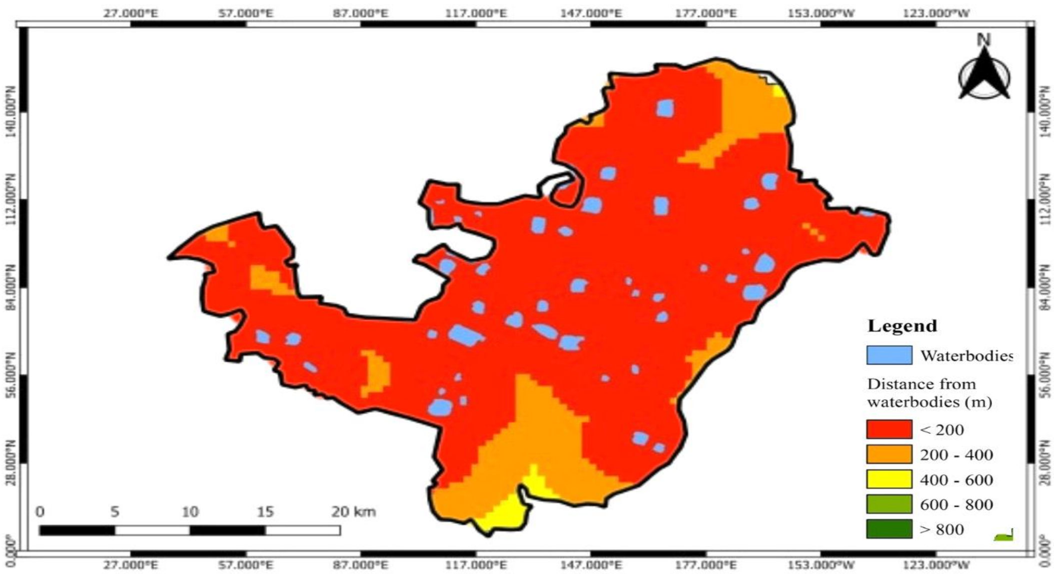

Figure 4 Distance criteria from the waterbodies

According to the results of the suitability map, 5.2% of the area was found to be unsuitable, 56.8% was less suitable, 17.8% was moderately suitable, 9.3% was suitable, and 10.9% was highly suitable for solid waste disposal site in Logia. Furthermore, a suitability map for groundwater well points was prepared, indicating that 37.34%, 18.38%, 25.94%, 12.45%, and 5.9% of the total area were unsuitable, less suitable, moderately suitable, suitable, and highly suitable, respectively, for solid waste disposal site in Sriperumbudur as represented in figure 4.

The distance from water bodies is a crucial environmental criterion that needs to be considered when selecting a landfill site. The results of the suitability maps indicate that certain areas are unsuitable for waste disposal due to their proximity to water bodies. Therefore, a thorough evaluation of this criterion is essential to ensure that the chosen landfill site is sustainable and will not have adverse impacts on the environment and surrounding communities.

4.1.3 Distance from tube wells

The distance from tube wells is an essential environmental criterion when selecting a landfill site. Landfill sites should be located away from water sources, including tube wells, to prevent contamination of the water supply. In this study, seven well water sources were identified, and a buffer zone of 300 meters was defined for all of them, as used in previous studies, which is represented in figure 5. The closer the distance to well water sources, the lower the suitability of a landfill site. To ensure that the chosen landfill site is sustainable and does not have adverse impacts on the environment and surrounding communities, a thorough evaluation of this criterion is crucial. The buffer zone required for tube wells may differ from case to case, depending on the specific characteristics of the site and the local regulations. Therefore, it is essential to identify and map all well water sources in the area before selecting a landfill site and to carefully evaluate the distance to these sources to determine the suitability of the site.

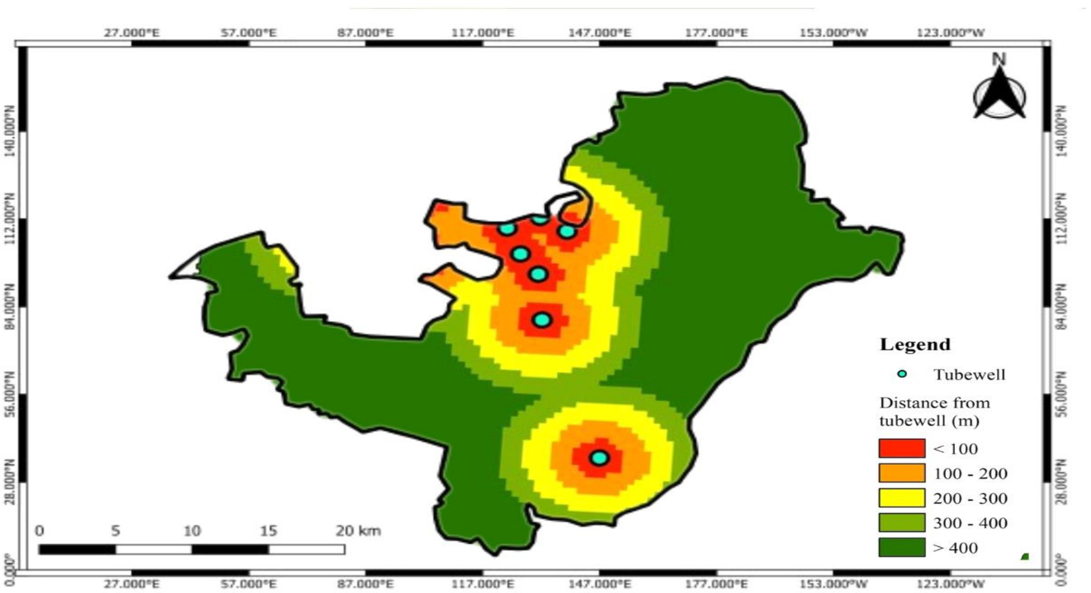

Figure 5 Distance criteria from the tube wells

The distance from tube wells is an important environmental criterion that needs to be considered when selecting a landfill site. A buffer zone of a specific distance from the tube wells should be defined, and the closer the distance to these sources, the lower the suitability of the site. A comprehensive evaluation of this criterion is necessary to ensure that the chosen landfill site is sustainable and does not have adverse impacts on the environment and the local community.

4.1.4 Distance from the water pipeline

Another important environmental criterion to consider when selecting a landfill site is the distance from the water pipeline. Water pipelines are used to transport clean water to households and businesses, and locating a landfill site near them can pose a risk of water contamination. Therefore, a buffer zone should be defined around water pipelines to ensure that the chosen landfill site is located at a safe distance. The buffer zone required may vary depending on the specific characteristics of the site and the local regulations. The figure 6 shows the buffer generation around the pipelines in the study area.

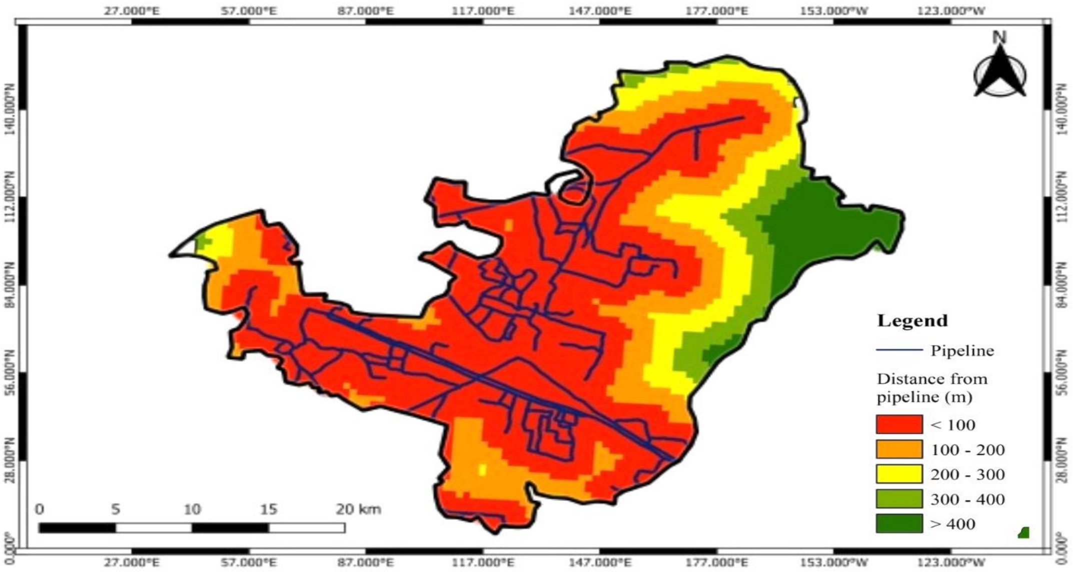

Figure 6 Distance criteria from the water pipeline

A thorough evaluation of the distance from the water pipeline is essential to ensure that the chosen landfill site is sustainable and does not have adverse impacts on the environment and surrounding communities. The buffer zone should be large enough to prevent the risk of water contamination and to comply with the local regulations. The distance from the water pipeline is a crucial environmental criterion to consider when selecting a landfill site. A buffer zone of a specific distance should be defined around the pipeline, and a thorough evaluation of this criterion is necessary to ensure that the chosen landfill site is sustainable and does not pose a risk of water contamination.

4.1.5 Land Elevation

Land elevation is another important environmental criterion to consider when selecting a landfill site. A site located in a low-lying area is more susceptible to flooding, which can cause problems such as leachate discharge and damage to nearby properties.

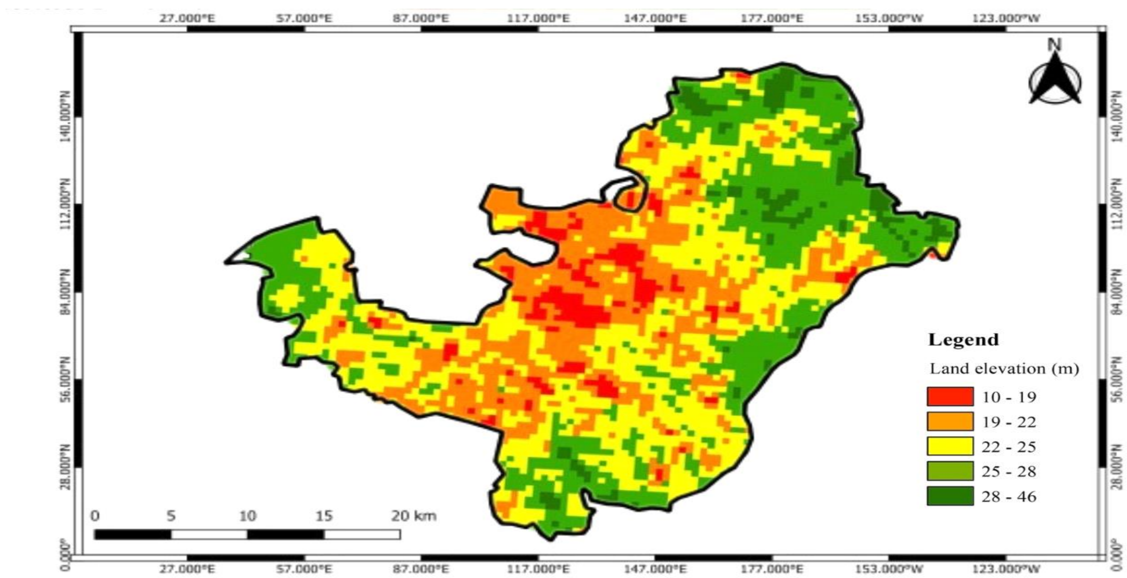

Figure 7 Land Elevation criteria

Therefore, the elevation of the area should be evaluated to ensure that the landfill site is located in a suitable location, the same is represented in figure 7. High elevation areas are also not ideal for a landfill site due to the difficulty of access and the associated higher transportation costs. In this study, it was found that areas with an elevation of over 2158 m above mean sea level were unsuitable for a landfill site. The elevation map of the study area was obtained from Google Earth, and it was found that more than 40% of area has an elevation of 1790 m above mean sea level, which is considered suitable for a landfill site. Overall, the elevation of the area is an important factor to consider when selecting a landfill site. A site located in a low-lying area can cause environmental and health problems, while a site in a high-elevation area can be less accessible and more expensive to operate. Therefore, the elevation of the area should be evaluated to ensure that the landfill site is located in a suitable location.

4.1.6 Land use land cover

The "Land Use Land Cover" criterion is an essential factor in landfill site selection. This criterion aims to exclude land areas that have significant socio-economic values such as agricultural lands, grasslands, and forest zones. In Study area, the land-use/land-cover map was produced for dumping waste with an overall accuracy of 86%. The map represented in figure 8 indicates the areas of vegetation, bare land, built-up area, and water bodies. The majority of the region is occupied by bare land, which is highly suitable for solid waste disposal sites.

However, several lands use such as urban spaces, green areas, and agricultural land were considered unsuitable for landfill sites in this study. The land-use and land-cover suitability map indicated that only 1% of the study area was unsuitable for solid waste disposal site, while 80.3% of the area was highly suitable, and 5.3% and 13.4% of the area were suitable and less suitable, respectively. This is crucial for selecting a suitable landfill site as it helps to protect valuable land areas and prevent potential negative impacts on socio-economic activities. In Logia, the majority of the region is highly suitable for landfill sites due to the presence of bare land, but the exclusion of certain land uses such as urban spaces and agricultural land is necessary to ensure the sustainability of the environment and protect the well-being of the community.

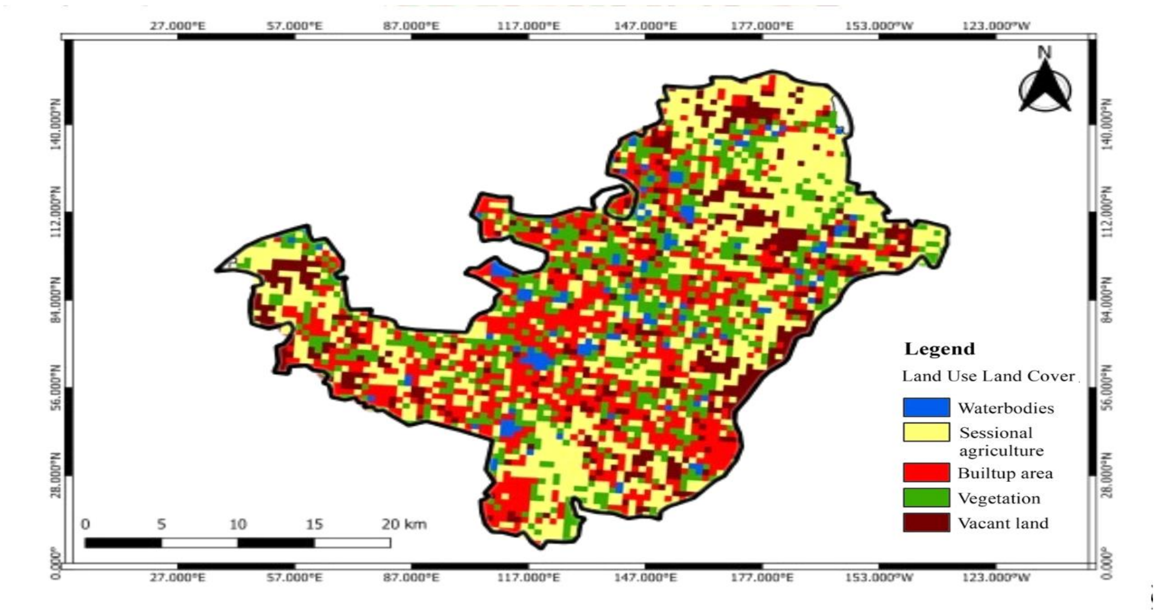

Figure 8 Land Use Land Cover criteria

4.1.7 Distance from urban resident and built-up area

The suitability of a landfill site also depends on its distance from urban residential areas and built-up areas. As per the Municipal Solid Waste Management rules in India, a landfill cannot be located within 500 meters of urban residential areas. Therefore, areas within a 500-meter radius were deemed unsuitable for waste landfill sites. And represented in figure 9 The remaining areas were scored based on their distance from urban residences, with a score of 3 to 7 indicating the most suitable areas for landfill sites.

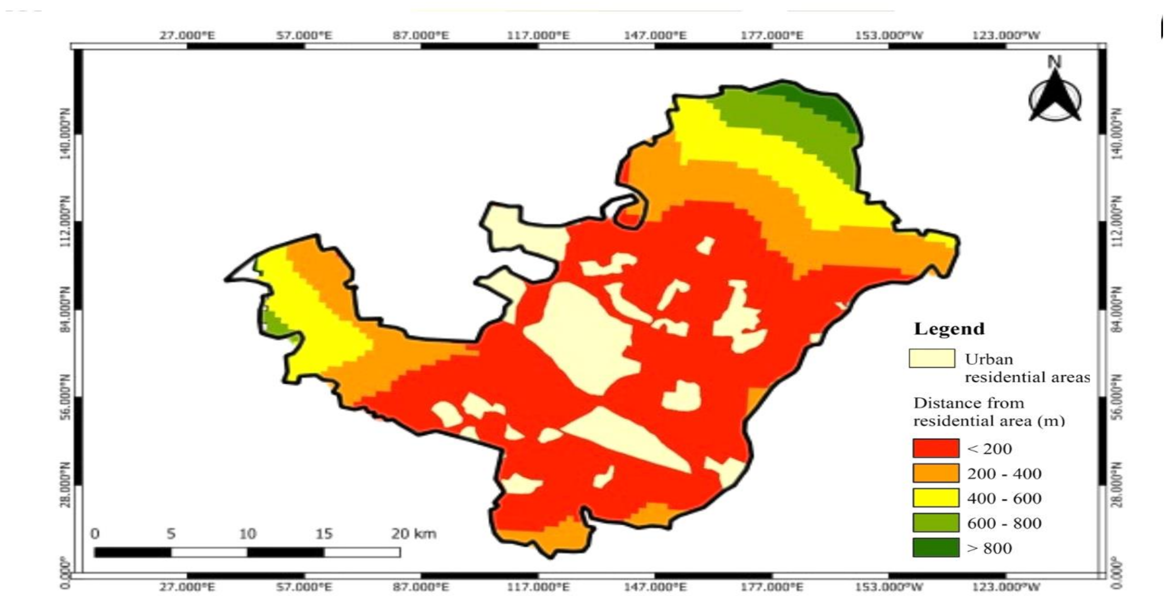

Figure 9 Land Use Land Cover criteria

In addition, the landfill site should also be located away from commercial buildings, urban green spaces, service areas, and industries. Locating a landfill site near residential areas may increase the risk of pollution and public concerns such as air pollution, noise, nuisance, communicable diseases, and fires. In this study, areas greater than 2 km from residences were considered highly suitable.

The built-up areas of the study area were also considered while selecting a landfill site. In this study area using a vector editing polygon tool. The landfill site should be located far away from commercial buildings, urban green spaces, service areas, and industries to avoid any adverse effects on public health and the environment. Overall, the suitability of a landfill site depends on several factors, including its distance from water sources, pipelines, road accessibility, slope, land use and land cover, distance from urban residences, and built-up areas. These factors are taken into account to identify the most suitable areas for a landfill site that ensures the least impact on the environment and human health.

4.1.8 Distance from sensitive and restricted places

The distance from sensitive and restricted places is an important factor to consider when selecting a landfill site. In the case of Sriperumbudur, the Indian Municipal Solid Waste Management rules 2016 dictate that a landfill site cannot be located near sensitive places like children's parks, natural parks, offices, banks, etc., or near critical habitat areas and sensitive eco-fragile areas.

Therefore, the study area needs to be carefully assessed to ensure that waste landfill sites are not located near restricted and sensitive places. To determine the distance from sensitive and restricted places, the study considered an area within 100 meters of schools, colleges, banks, railway stations, children's parks, and offices as unsuitable for landfill sites, that buffer generated and shown in figure 10. A farther distance from these places was deemed suitable for a landfill site.

By considering the distance from sensitive and restricted places, the study aims to mitigate the negative impacts of waste disposal on public health and the environment. This parameter also ensures that waste management practices are aligned with sustainable development goals, which prioritize the protection of natural resources and biodiversity. Overall, the distance from sensitive and restricted places is a critical factor that needs to be taken into account when selecting a landfill site.

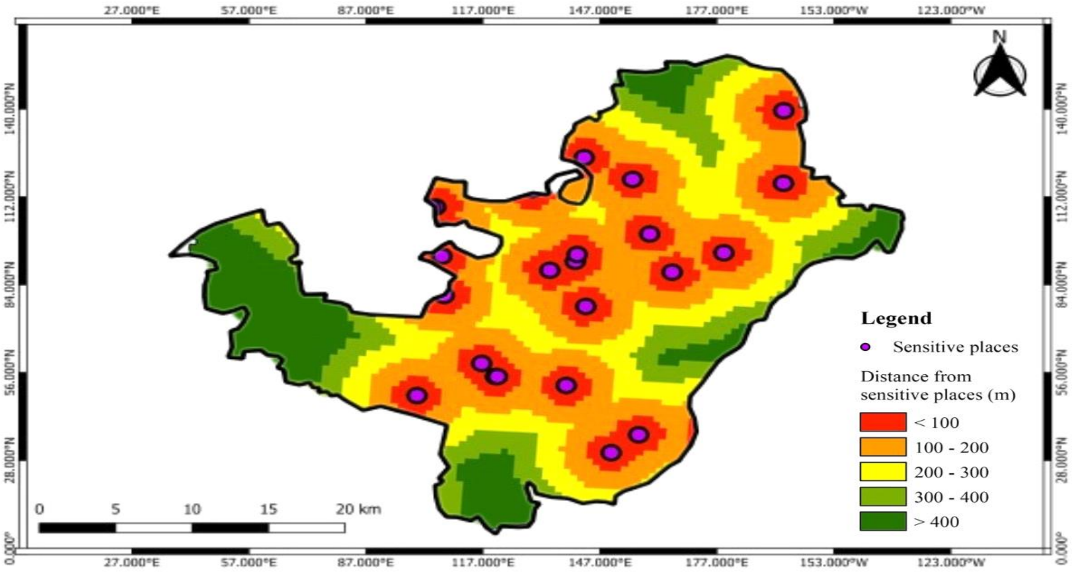

Figure 10 Distance criteria from sensitive and restricted places

4.2 SOCIO-ECONOMIC FACTOR FOR LANDFILL SITE SELECTION

Based on the information provided, the suitability of a landfill site is determined by several factors, including distance from roads, population density, and land value. The Waste Management rules 2016 mandate a minimum buffer of 200 meters from roads, railways, and local urban metalled roads, which is important from an environmental perspective. However, previous literature suggests that a closer distance to roads may be more economically viable due to reduced transport costs. Population density is another important factor to consider when identifying a suitable landfill site. Highly populated areas are typically more accessible and have better amenities, but public opposition increases when landfill sites are located in such areas.

Land value is also a crucial factor to consider as high land prices can significantly increase the construction cost of a landfill site. The land value in the study area ranges from 0.80 to 7 lakhs per kata, and a GPS-based survey was conducted to determine the actual land prices in different places. Overall, the suitability score of a landfill site is determined by considering all of these factors. In the study area, the periphery of the urban centre is given higher priority due to its lower land value and population density.

4.2.1 Distance from the state highway and urban metalled roads

The distance from the state highway (figure 11) and urban metalled roads (figure 12) is an important factor to consider when locating a waste landfill site. While a closer distance to the road network may reduce transportation costs, it also increases the risk of environmental pollution and public health concerns. Therefore, a balance between economic and environmental considerations should be taken when measuring the buffer distance. According to the Waste Management rules 2016, a minimum of 200 m buffer should be maintained from roads, railways, and local urban metalled roads. However, in the present study, both economic and environmental considerations were taken into account, and the buffer distance was measured from the state highway and local metalled roads. In the study area, closer proximity to local roads was given lower scores, as the location of this road is within urban residences, which should have lower suitability scores.

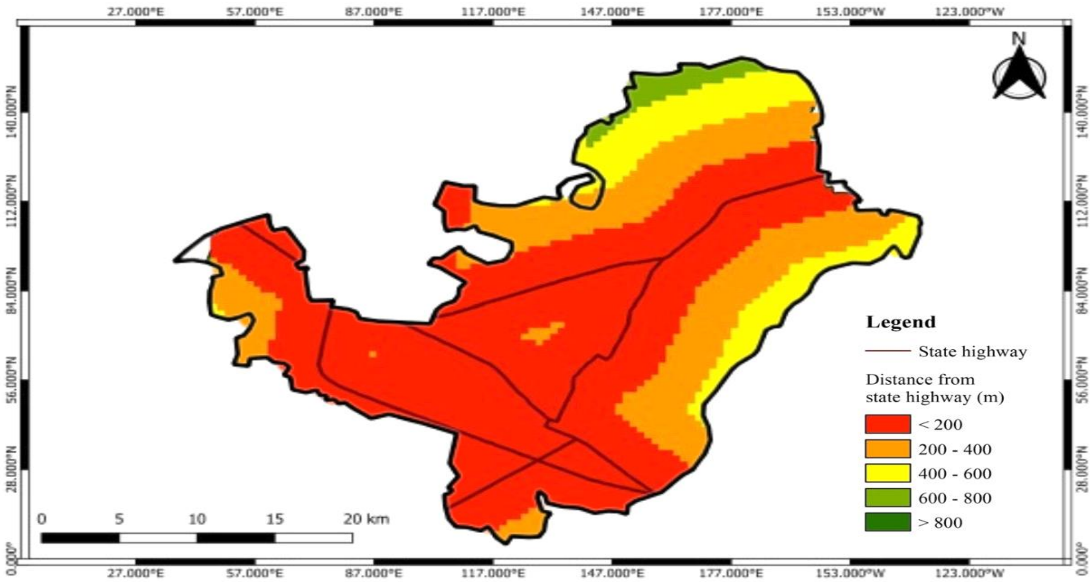

Figure 11 Distance criteria from state highway

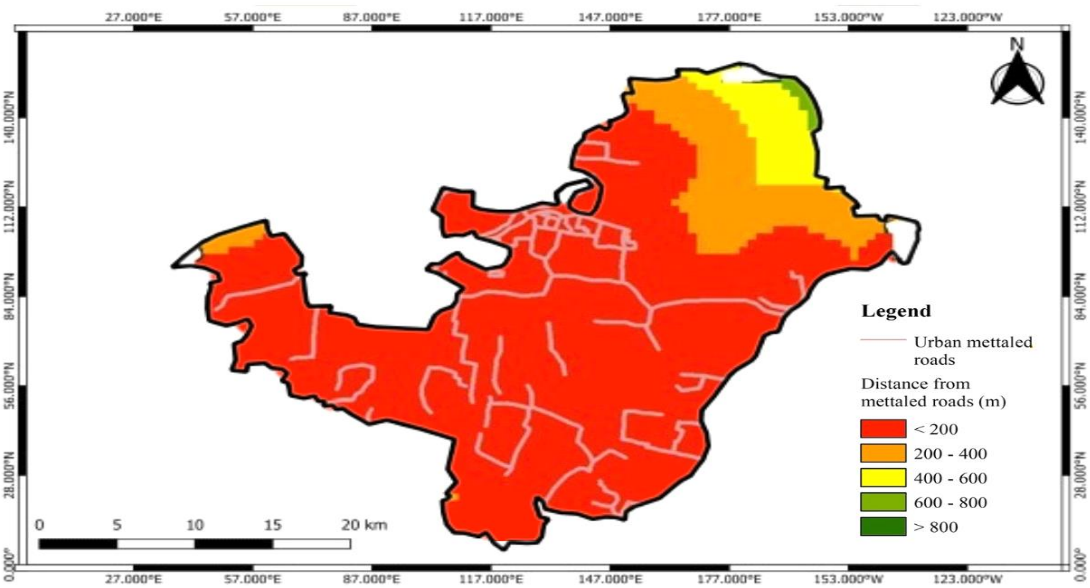

Figure 12 Distance criteria from urban metalled roads

Overall, it is important to consider the distance from the state highway and urban metalled roads when selecting a suitable landfill site to ensure the safety of the environment and the health of the public.

4.2.2 Population Density

Population is an important parameter to define highly built-up and residential areas because high population density is always found in highly accessible areas. Areas with a high density of population are an indication of a high availability of better amenities and landfills should be avoided from those areas. Many research findings have revealed that public opposition increases for siting landfill nearer to highly residential areas, and the suitability score of landfill site decreases with increasing public objection.

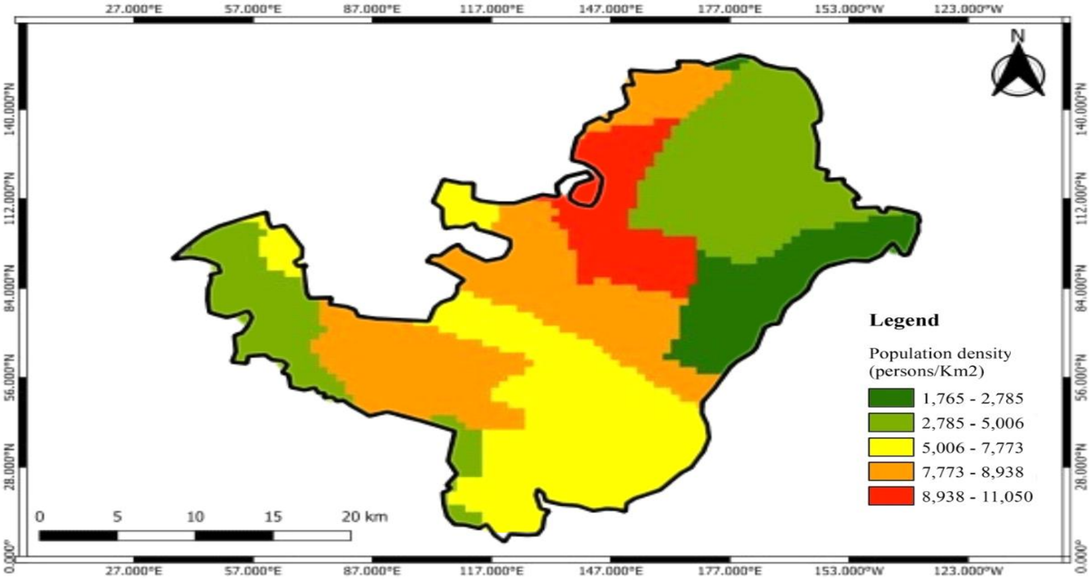

Figure 13 Population density criteria

Hence, a waste landfill site should not be placed nearer to densely populated urban areas. The population density map of the study area was prepared using the GIS technique to show the areal differentiation of population living per square kilometer area represented in figure 13. This thematic map was first converted into a raster layer and then reclassified ac- cording to suitability score.

4.2.3 Land Value

The price of land is a factor that should be considered as a cost criterion. The high land value increases the construction cost of the sanitary landfill sites. The land value in the study area ranges between 0.80 and 7 lakhs per kata (1 kata = 0.00668 ha). A GPS-based survey was conducted throughout the study area to know the actual land prices on different places, and *x*, *y* coordinates were collected for spatial mapping.

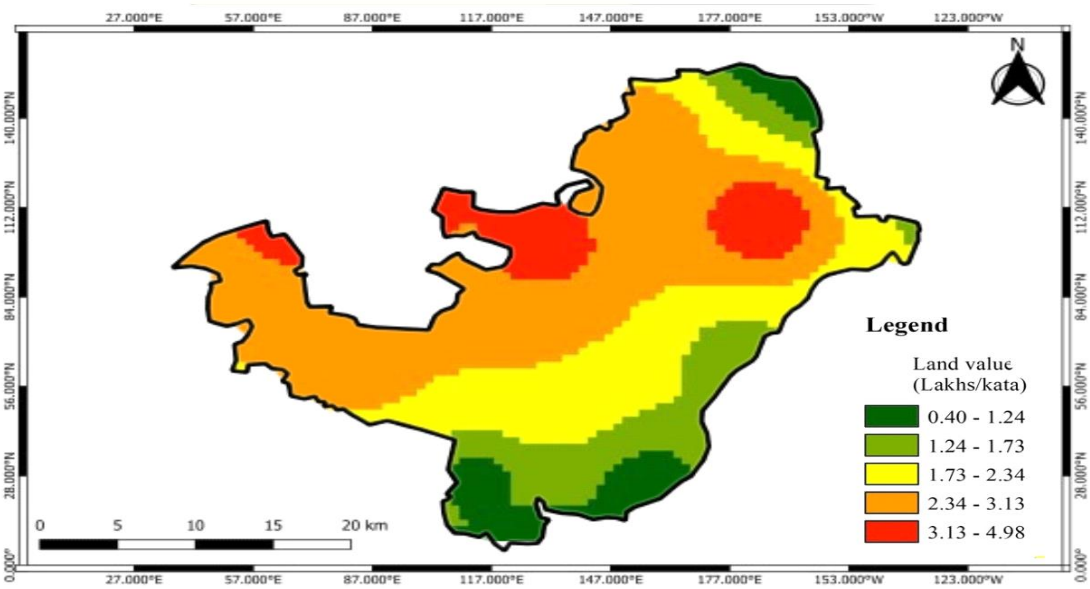

Figure 14 Land Value criteria

Figure 14 shows that land value criteria map in the center of the city are quite high than the periphery part of the growing urban area. Land price is very much important for the study area because financial assistance is a great concern. So, for a suitable landfill site, the periphery of the urban center has high priority. The present study demonstrates a landfill site suitability map created using GIS and multicriteria analysis for Sriperumbudur. The study was conducted in two stages. Firstly, GIS were employed to map the landfill suitability and identify the landfill candidate sites. Then, QGIS was used to prioritize the landfill candidate sites and select the most suitable site. Total landfill evaluation criteria were selected based on environmental and economic considerations. The results showed that the distance from residential area and sensitive places gained the highest weight of 0.01013 and 0.0652, respectively, out of a total of eight environmental sub-criteria.

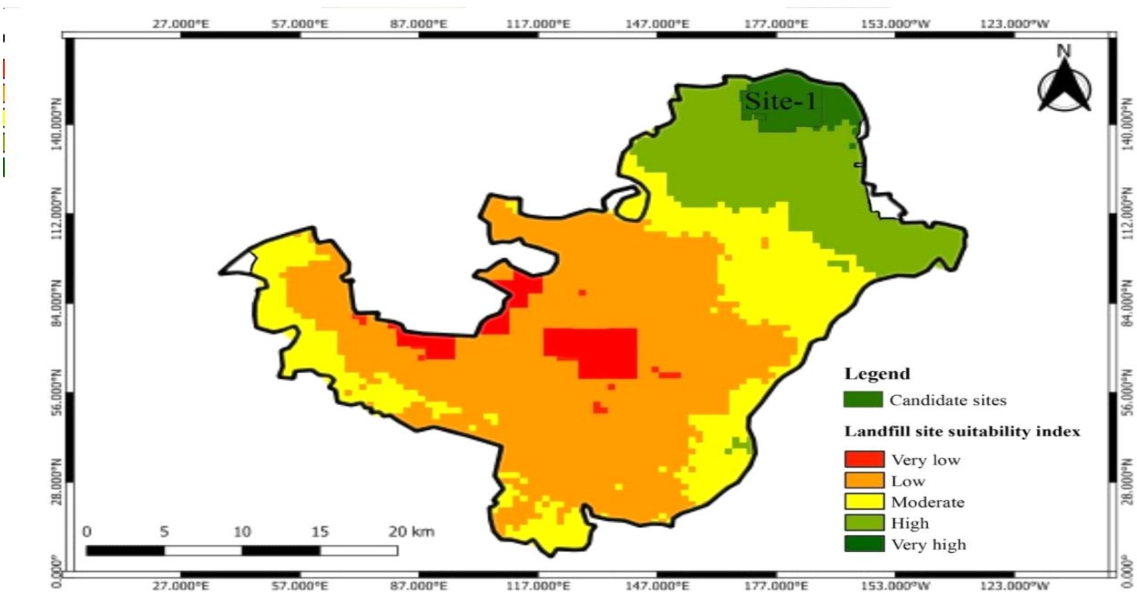

Figure 15 GIS overlay for calculating landfill site suitability index

Land value showed the highest priority with a weight of 0.2362 out of four economic criteria. The final suitability map was classified into five discrete classes: very high suitable area, high suitable area, moderate suitable area, low suitable area, and unsuitable area for landfill. The GIS-based was used to calculate the maximum and minimum values of each evaluation sub-criterion of landfill site selection, and seven candidate sites were identified. The result revealed that candidate site-7 has the highest preference rank with a value of 0.62, and it is considered as the best sanitary landfill site for the study area. A post-analysis investigation was carried out on each landfill candidate site for ground verification, which also proves geospatial overlay technique, which is represented in figure 15 as a significant technique for selecting the best and worst choice of alternatives. Multicriteria decision-making (MCDM) is the best option for landfill site selection because it considers multiple factors instead of selecting any single criterion.

CHAPTER 5

CONCLUSION

5.1 CONCLUSION:

The study focuses on using geographic information system (GIS) and multicriteria decision-making techniques to determine suitable landfill sites for municipal solid waste disposal in Sriperumbudur, Kanchipuram District, Tamil Nadu India. With the increasing population and generation of municipal solid waste, selecting an appropriate landfill site with adequate management resources and waste treatment options is a significant challenge for the Sriperumbudur. Hence, the study employs a decision-making process to achieve effective problem-solving in urban planning and local area development. Using the GIS based procedure, the study identifies site-1 as the most suitable landfill site based on its distance from surface water, groundwater, habitation, and urban buildup, location in a vacant land with low land price, and proximity to a state highway (fulfilling the MSWM rules 2016, India). Field surveys validate this finding, and the study recommends two new landfill sites (site-1 at the southeast and site-2 at the northern portion of the city) instead of a single large landfill site to increase waste management efficiency, reduce transport costs, and improve waste collection, carriage, number of trips, and disposal facility. The study concludes that proper strategies and allocation of landfill sites considering environmental and economic factors are crucial in managing increasing rates of waste, particularly in developing countries where environmental issues are emerging due to poor MSW management. Thus, the study can serve as a source of research for other growing urban cities facing similar challenges.

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