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An Application of Site Selection for Solid Waste Management System Using Neutrosophic Set

A. Savitha Mary[1], D. Sarukasan[2], C. Kayelvizhi[3,*], L. Jethruth Emelda Mary[4], F. Josephine Daisy[5], K. Pitchaimani[6]

[1,3,*] SRM Institute of Science and Technology, Faculty of Science and Humanity, Department of Mathematics, Ramapuram, Chennai-89, Tamilnadu, India.

[1]savitha.mary139@gmail.com, [3,*]kayelchokkalingam1997@gmail.com

[2] SRM Institute of Science and Technology, Faculty of Engineering and Technology, Department of Mechanical Engineering, Ramapuram, Chennai-89, Tamilnadu, India.

Saru31kasan@gmail.com

[4] PG and Research Department of mathematics, St. Joseph's College of Arts and Science, (Autonomous), Cuddalore-1

jethruth15@gmail.com

[5] PG and Research Department of Mathematics, Jawahar Science College, Neyveli – 607802, Tamil Nadu, India.

josephine266@gmail.com

[6] Department of Mathematics, Velammal College of Engineering and Technology (Autonomous), Viraganoor, Madurai -625 009.

kpitch1975@gmail.com

Abstract - Solid waste generation is an inevitable consequence of human activities, arising from domestic, mineral extraction, commercial, agricultural, and industrial. The improper disposal of solid waste leads to severe environmental and public health hazards, including air and water pollution, soil contamination, and disease outbreaks. Therefore, establishing an efficient solid waste management system (SWMS) is essential to mitigate these adverse effects and promote environmental sustainability. This study aims to determine the most suitable waste management strategies for different sites by analysing four key factors: Air Quality Index (AQI), population density, economic feasibility, and groundwater conditions. These factors significantly influence waste collection, processing, and disposal methods. To improve the efficiency and accuracy of waste management site selection, novel computational algorithms have been developed using a proposed distance formula. The performance of these algorithms is assessed through a comparative analysis with traditional distance measurement techniques, namely Hamming distance and Euclidean distance. The findings of this research provide data-driven insights into optimizing solid waste management for four selected districts in Tamil Nadu. By integrating computational methods with environmental and demographic parameters, the study contributes to improved urban planning, pollution reduction, and enhanced public health standards. The proposed approach serves as a valuable tool for policymakers and environmental agencies in implementing sustainable and efficient waste management practices.

Keywords: Distance Measure, Normalized Hamming distance, Normalized Euclidean distance, Hausdroff distance.

1. Introduction

Neutrosophic logic serves as an advanced formal framework that extends classical and fuzzy logic principles by incorporating three fundamental components: truth, indeterminacy, and falsehood. Unlike traditional binary or multi-valued logic systems, which primarily deal with definitive true or false values [1,2], Neutrosophic logic allows for the representation of uncertainty, contradiction, and incompleteness in a more generalized manner. This makes it particularly useful in fields where information is imprecise, inconsistent, or incomplete, such as artificial intelligence, decision-making systems, and uncertainty modeling.

Florentin Smarandache [3,4], a pioneer in this domain, has extensively studied and distinguished Neutrosophic Logic (NL) from Intuitionistic Fuzzy Logic (IFL). While both frameworks address uncertainty, Neutrosophic logic further generalizes Intuitionistic Fuzzy Sets (IFSs) into Neutrosophic Sets (NSs), offering a broader and more flexible representation of uncertain information. In various recent studies, Smarandache [5,6,7,8,9] has extended IFSs and other mathematical structures to NSs, establishing a NS topology based on a Im-proper interval. This development indicates a potential relationship between Neutrosophic Topology and Intuitionistic Fuzzy Topology on IFSs, paving the way for new applications in complex decision-making systems, knowledge representation, and mathematical modelling [10 - 17].

Neutrosophy, the underlying philosophy of Neutrosophic logic, has created a framework for a wide range of mathematical ideas that generalize conventional and fuzzy set theories. This has led to the evolution of Neutrosophic Set Theory, which has found applications in diverse fields, including medical diagnosis, pattern recognition, optimization problems, and engineering sciences [18 - 22]. Plithogenic sets and their graphical structure visualization have been studied for handling multi-attribute datasets with uncertainty, such as the Air Quality Index (AQI) and its impact on human health. To resolve conflicts between experts regarding AQI's effects, a single-valued neutrosophic Plithogenic set with graphical structure visualization is proposed, as demonstrated through an illustrative example. [24].

2. Solid Waste Management and Environmental Sustainability

Solid waste is an inevitable byproduct of human activities and is generated from domestic households, commercial establishments, industrial operations, healthcare facilities, agricultural activities, and mineral extraction processes. Without effective waste disposal and management strategies, these materials accumulate in streets, public places, water bodies, and landfills, posing serious environmental and public health risks.

Commonly used terms such as garbage, trash, refuse, and rubbish classify different types of solid waste. Waste can be categorized into three major types based on its physical state and origin:

- Solid Waste – Includes materials such as plastics, metals, paper, and organic waste.
- Liquid Waste – Includes industrial effluents, household sewage, and chemical waste.
- Gaseous Waste – Includes emissions from factories, vehicular pollution, and other airborne pollutants.

The primary sources of solid waste creation are agricultural, commercial, industrial, municipal, and residential activities. Typical ingredients of urban garbage include:

- Paper, wood, and cardboard (53%)
- Garbage (22%)
- Ceramics, glass, and crockery (10%)
- Metals (8%)
- Rubber, plastics, and discarded textiles (7%)

Efficient waste management plays a crucial role in maintaining environmental sustainability and minimizing the harmful effects of pollution. Waste reduction, a primary strategy in waste management, focuses on preventing waste at its source. Modern waste management strategies are built on the Four R's principle: Reduce, Reuse, Rebuy, and Recycle. Reusing used items, manufacturing reusable or refillable packaging, and fixing broken items rather than throwing them away are all ways to reduce waste.

3. Site Selection for Solid Waste Management Systems (SWMS)

This study aims to determine the most suitable Solid Waste Management System (SWMS) for different sites by analysing five key environmental and socio-economic factors:

1. Air Quality Index (AQI) – A crucial environmental parameter, as different SWMS approaches impact air quality differently. The current AQI levels in a region serve as a guiding factor in decision-making for selecting the most appropriate SWMS.
2. Population Density – A significant social factor, as waste generation directly correlates with population levels. Each SWMS has a defined ideal and acceptable population threshold recommended by experts to ensure efficiency.
3. Economic Viability – The financial feasibility of implementing a waste management system, considering cost-effectiveness and long-term sustainability.
4. Groundwater Levels – A key geographical factor, as the presence of groundwater sources determines the environmental impact of certain waste disposal methods, such as landfilling.

5. Landform Characteristics – The physical geography of a region influences the choice of a waste management strategy, ensuring minimal environmental degradation.

For this study, three distinct districts in Tamil Nadu—Tirunelveli, Dindigul, and Tuticorin—were selected based on their geographical and environmental diversity. Each district represents a different landform, making it an ideal case for analysing how SWMS can be tailored to specific terrains and ecological conditions.

4. Methods of Solid Waste Management

The three most widely used waste management processes considered in this study are:

1. Landfilling – The most common method, involving the burial of waste in designated landfill sites. It is cost-effective but requires careful monitoring to prevent groundwater contamination.
2. Composting – A biological process where organic waste is decomposed into nutrient-rich compost, promoting sustainable agriculture and reducing landfill waste.
3. Incineration – The controlled burning of waste to generate energy. While effective in reducing waste volume, it has potential environmental concerns, such as air pollution.

Through a detailed comparative analysis, this research aims to determine the most efficient SWMS for the selected districts, ensuring environmental sustainability and public health protection. The findings will serve as a guide for policymakers and urban planners in developing data-driven, region-specific waste management solutions that minimize pollution, optimize resource utilization, and promote eco-friendly practices.

5. Preliminaries

Definition 5.1:[23]

Let X be a fixed, nonempty set. The definition of a Neutrosophic set (NS) A is an object of the following form:

$$A = \{\langle \varkappa, \varphi_A(\varkappa), \psi_A(\varkappa), \omega_A(\varkappa)\rangle : \varkappa \in X\}$$

where for each element $\varkappa \in X$

- $\varphi_A(\varkappa)$ represents the degree of membership,
- $\psi_A(\varkappa)$ denotes the degree of indeterminacy, and
- $\omega_A(\varkappa)$ indicates the degree of non-membership in the set A.

Definition 5.2:[4]

A discrete constrained set D = {D1, D2, … D_n} is considered. For any $Z_i \in$ Z, we have the following if S, T, and U are the three NSs in Z:

$$d_H^*(S,T) = \mathrm{H(S,T)}{=}max\left(\left|(\varphi_{p_i}(D_j) - \phi_{d_k}(D_j)\right|, \left|\psi(_{p_i}(D_j) - \psi_{d_k}(D_j)\right|, \left|(\omega_{p_i}(D_j) - \omega_{d_k}(D_j)\right|\right)$$

where

The extended Hausdroff distance between two Neutrosophic sets, M and N, is represented by the symbol $d_H^*(S,T) = \mathrm{H(S,T)}$

The following characteristics are satisfied by the distance $d_H^*(S,T)$ between neutrophilic sets M and N as stated above:

$\boldsymbol{d_H^*(S,T)}$ = $\boldsymbol{d_H^*(T,S)}$

$d_H^*(S,T) \geq 0$,

$\boldsymbol{d_H^*(S,T)}$ = 0 if and only if S = T, for all S, T ∈ NS,

If S⊆ T ⊆ U for all S, T, U ∈ NS, then $\boldsymbol{d_H^*(S,U)} \geq \boldsymbol{d_H^*(S,T)}$ and $\boldsymbol{d_H^*(S,U)} \geq \boldsymbol{d_H^*(T,U)}$ The distance measure between two Neutrosophic sets is thus denoted by d_H^*.

Definition 5.3:[4]

Two Neutrosophic sets, S and T, have a normalised Euclidean distance that is determined by

$$d_4^*(S,T){=}\frac{1}{3n}\left\{\left(\sum_{j=1}^{n}\left(\left(\left|(\varphi_{p_i}(D_j) - \varphi_{d_k}(D_j)\right|\right)^2 + \left(\left|(\psi_{p_i}(D_j) - \psi_{d_k}(D_j)\right|\right)^2 + \left(\left|(\omega_{p_i}(D_j) - \omega_{d_k}(D_j)\right|\right)^2\right)^2\right)\right\}^{\frac{1}{2}}$$

Definition 5.4:[4]

The definition of the normalised Hamming distance between two Neutrosophic sets, S and T, is $d_3^*(S,T){=}\frac{1}{3n}\sum_{j=1}^{n}\left(\left|(\varphi_S(D_j) - \phi_T(D_j)\right| + \left|\psi(_S(D_j) - \psi_T(D_j)\right| + \left|(\omega_S(D_j) - \omega_T(D_j)\right|\right)$

Remark 5.1:[23]

1) A Neutrosophic set $A = \{\langle \varkappa, \varphi_A(\varkappa), \psi_A(\varkappa), \omega_A(\varkappa)\rangle : \varkappa \in X\}$ can be identified to an ordered triple $\langle \varphi_A, \psi_A, \omega_A\rangle$ in $[0^-, 1^+]$on X.
2) For simplicity's sake, we'll utilize the symbol A = $\langle \varphi_A, \psi_A, \gamma_A\rangle$ for the neutrosophic set $A = \{\langle \varkappa, \varphi_A(\varkappa), \psi_A(\varkappa), \omega_A(\varkappa)\rangle : x \in X\}$

6. Algorithm

Step 1:

Specify the domains' membership, non-membership, and indeterminacy values accordingly.

Step 2:

Determine the power type using the various distance measurements provided in steps three to seven.

Step 3:

$$d_1(p_i, d_k)=\frac{1}{n}\sum_{j=1}^{n}\frac{1}{6}\left(\left|(\varphi_{p_i}(D_j) - \varphi_{d_k}(D_j)\right| + \left|(\psi_{p_i}(D_j) - \psi_{d_k}(D_j)\right| + \left|(\omega_{p_i}(D_j) - \omega_{d_k}(D_j)\right|\right) + \frac{1}{3}max\left(\left|(\varphi_{p_i}(D_j) - \varphi_{d_k}(D_j)\right|, \left|(\psi_{p_i}(D_j) - \psi_{d_k}(D_j)\right|, \left|(\omega_{p_i}(D_j) - \omega_{d_k}(D_j)\right|\right).$$

Step 4:

$$d_2(p_i, d_k)=\frac{1}{n}\sqrt[r]{n}\left\{\left(\sum_{j=1}^{n}\left(\left|(\varphi_{p_i}(D_j) - \varphi_{d_k}(D_j)\right| + \left|(\psi_{p_i}(D_j) - \psi_{d_k}(D_j)\right| + \left|(\omega_{p_i}(D_j) - \omega_{d_k}(D_j)\right|\right)\right)^r\right\}^{\frac{1}{r}}$$

Step 5:

$$d_3(p_i, d_k)=\frac{1}{3n}\left(\left|(\varphi_{p_i}(D_j) - \varphi_{d_k}(D_j)\right| + \left|(\psi_{p_i}(D_j) - \psi_{d_k}(D_j)\right| + \left|(\omega_{p_i}(D_j) - \omega_{d_k}(D_j)\right|\right)$$

Step 6:

$$d_4(p_i, d_k)=\frac{1}{3n}\left\{\left(\sum_{j=1}^{n}\left(\left(\left|(\varphi_{p_i}(D_j) - \varphi_{d_k}(D_j)\right|\right)^2 + \left(\left|(\psi_{p_i}(D_j) - \psi_{d_k}(D_j)\right|\right)^2 + \left(\left|(\omega_{p_i}(D_j) - \omega_{d_k}(D_j)\right|\right)^2\right)\right)^2\right\}^{\frac{1}{2}}$$

Step 7:

$$d_H(S, T)=max\left(\left|(\varphi_S(D_j) - \varphi_T(D_j)\right|, \left|(\psi_S(D_j) - \psi_T(D_j)\right|, \left|(\omega_S(D_j) - \omega_T(D_j)\right|\right).$$

7. Hamming Distance and Its Application in Solid Waste Management Site Selection

A fundamental metric for comparing two binary data strings is the Hamming distance. It counts how many bit places in the two strings have different corresponding bits. The Hamming distance is just the number of mismatched bit places between two binary strings of the same length. In mathematics, d(a, b) is the Hamming distance between two binary strings, a and b.

In this study, we apply the concept of Hamming distance to analyse and compare solid waste management processes in three districts of Tamil Nadu—Tirunelveli, Dindigul, and Thoothukudi (Tuticorin). The most commonly employed waste management processes in these districts include:

1. Landfill,
2. Composting, and
3. Incineration.

To determine the most suitable solid waste management approach for each district, we consider the following critical factors:

- Air Quality Index (AQI),
- Population,

- Groundwater availability, and
- Economic value.

Let:

- P_i represent the selected districts for solid waste management system implementation.
- d_i represent the most commonly used waste management processes.

By applying distance measurement formulas, we can systematically compare the districts based on their environmental and economic conditions to determine the most effective waste management strategy.

Environmental and Groundwater Conditions in Selected Districts

Air Quality Index (AQI) in Selected Districts:

- **Tirunelveli:** AQI ranges between 20-30, indicating relatively better air quality.

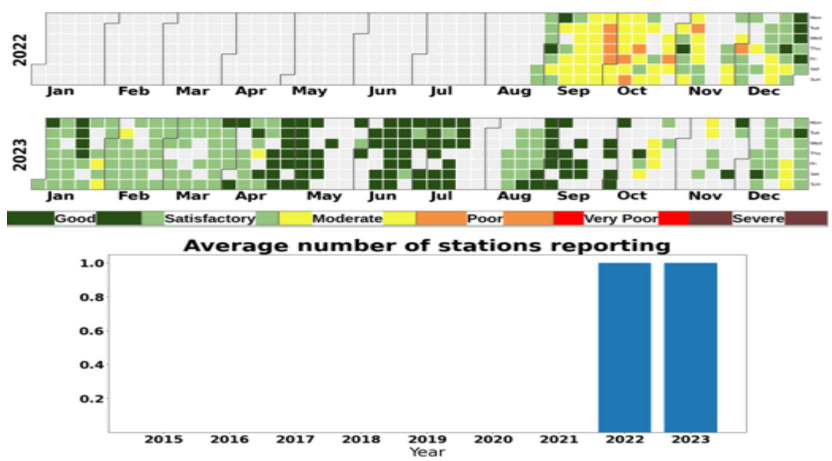

Fig. 1: AQI Reported in Central Pollution Control Board's Daily Bulletin for Tirunelveli

- **Dindigul:** AQI falls in the range of 60-70, reflecting moderate pollution levels.

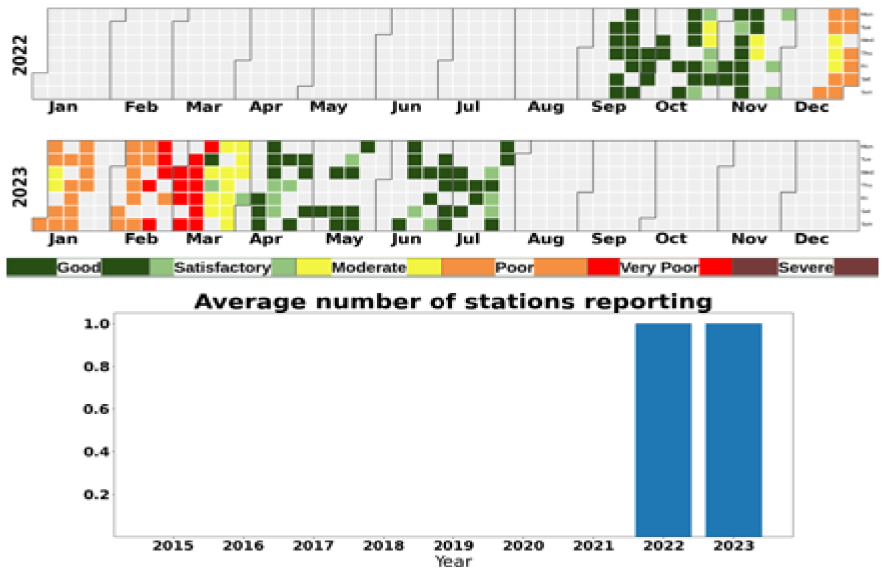

Fig. 2: AQI Reported in Central Pollution Control Board's Daily Bulletin for Dindigul

- **Thoothukudi (Tuticorin):** AQI is around 50-55, indicating a slightly polluted environment.

Fig. 2: AQI Reported in Central Pollution Control Board's Daily Bulletin for Thoothukudi

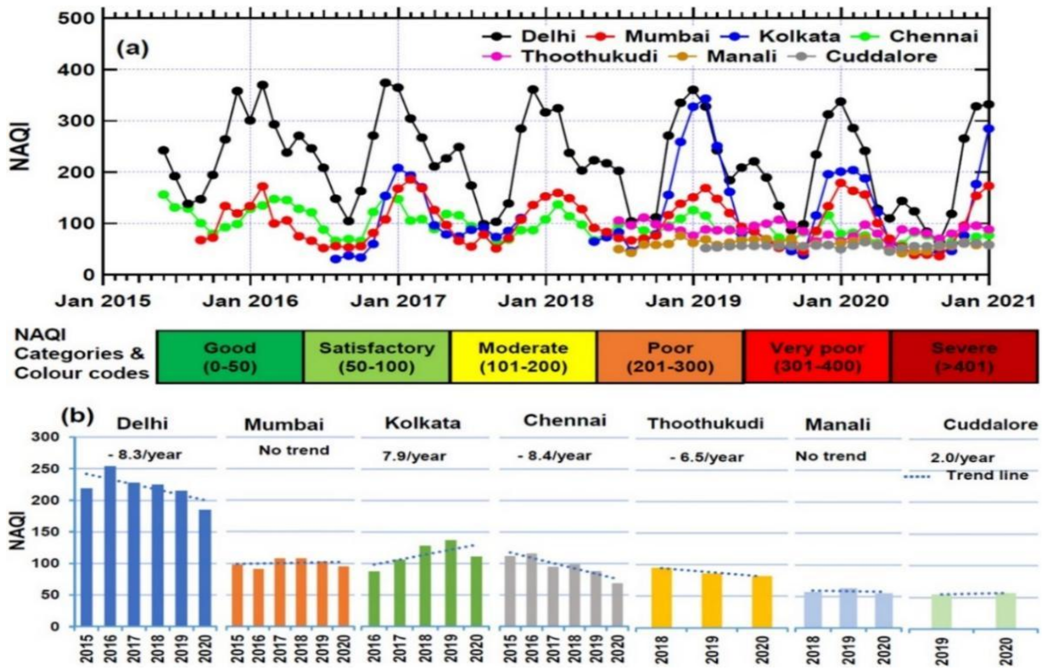

Fig. 3 AQI Report for various places in India

The air quality indices for all districts were collected from the Central Pollution Control Board's official bulletins during the period 2022–2023. Groundwater level data was compiled from reports issued by the Tamil Nadu Groundwater and Water Supply Board spanning 2019 to 2022. Comprehensive source details and reference links are provided in Appendix A.

8. Groundwater Resources and Availability

Tirunelveli District:

- The district is predominantly covered by hard rock formations (approximately 99% of the area).
- The long-term fluctuations in groundwater levels range from ground level (G.L.) to 14.0m in various parts of the district.
- During the pre-monsoon period, the water table generally shows a declining trend, with levels ranging from G.L. to 15m.
- Wells with depths below 12.0m often dry up during the hot season.

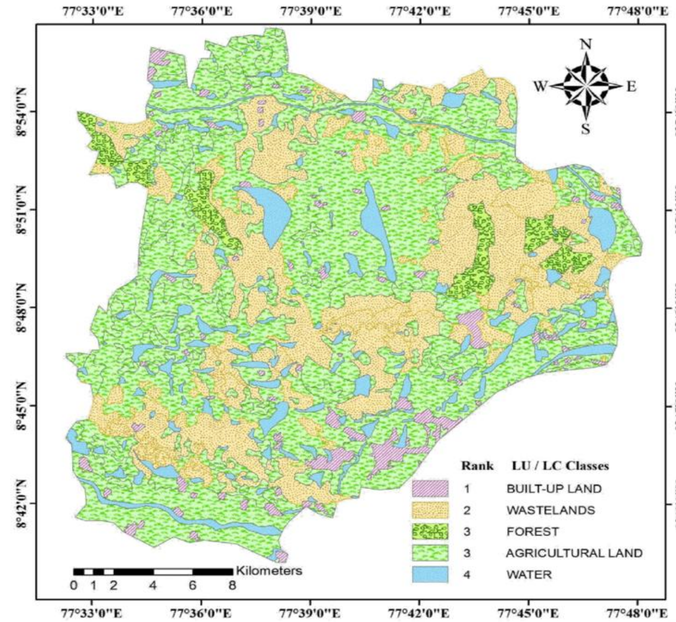

Fig. 4 Land Use and Land Cover Classification Map of Tirunelveli

Dindigul District:

- Similar to Tirunelveli, more than 97% of the district consists of hard rock formations.
- The predominant geological feature is gneissic rock, which serves as the country rock.
- During the pre-monsoon period, groundwater levels generally decline, ranging from G.L. to 15m.
- Wells below 12.0m depth frequently dry up during the hot season.

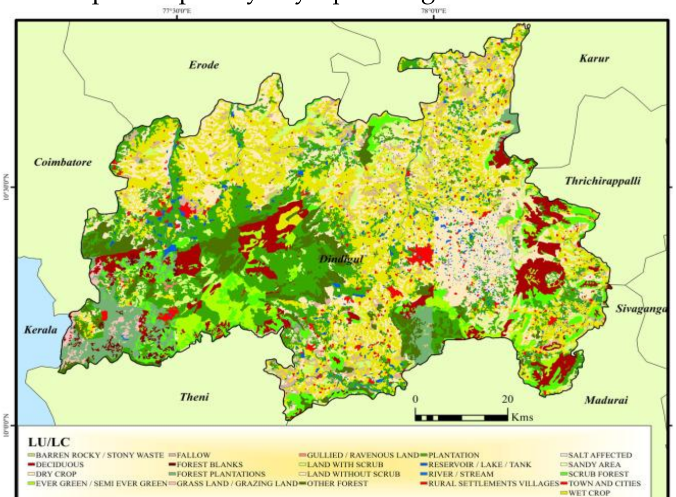

Fig. 5 Land Use and Land Cover Classification Map of Dindigul

Thoothukudi (Tuticorin) District:

- Nearly 70% of the western region of the district is covered by hard rock formations.
- The gneissic type of rock formations occupies a significant portion of the hard rock terrain.

- Groundwater levels exhibit long-term fluctuations between G.L. and 14.0m in many parts of the district.
- Pre-monsoon water levels show a declining trend, generally ranging from G.L. to 15m, and wells below 12.0m become dry during the hot season.

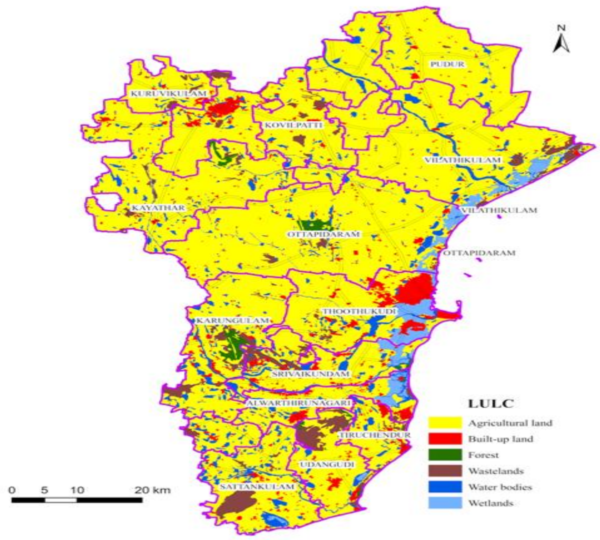

Fig. 6 Land Use and Land Cover Classification Map of Thoothukudi

By utilizing Hamming distance as a comparative metric, we can assess the suitability of different solid waste management strategies for each district based on their environmental factors. The combination of AQI, groundwater levels, and economic value provides a robust criterion for determining the most appropriate waste disposal method in Tirunelveli, Dindigul, and Thoothukudi. Through this systematic approach, decision-makers can optimize solid waste management practices to ensure environmental sustainability and resource efficiency in these districts.

Table 1: District wise Ranking on the Population in Tamil Nadu

District	Area (Sq. Km)	Total Population(Lakhs)	Ranking (Based on Population)
Tirunelveli	3,842	16.65	20
Dindigul	6,036	21.60	13
Tuticorin	4,745	17.5	18

Table 2: Decision Matrix

Districts	AQI	Ground water	Population	Economy value
Tirunelveli	(0.3,0.3,0.6)	(0.6,0.4,0.4)	(0.8,0.1,0.2)	(0.4,0.3,0.6)

Dindigul	(0.9,0.1,0.4)	(0.7,0.1,0.1)	(0.6,0.4,0.3)	(0.5,0.3,0.6)
Tuticorin	(0.5,0.4,0.4)	(0.6,0.3,0.1)	(0.7,0.3,0.2)	(1.0,0,0.1)

A detailed rationale for determining the membership, non-membership, and indeterminacy values for each district and criterion is as follows: Each value was obtained by normalizing raw data (e.g., AQI ranges, population density) onto a [0,1] scale based on historical and regional benchmarks. For example, Tirunelveli's average AQI of 25 falls within the "Good" category (0–50), suggesting favorable air quality. Accordingly, a higher membership value (0.6) was assigned. Non-membership was set to 0.3, reflecting limited unfavorability, and indeterminacy was fixed at 0.3 to account for seasonal or data uncertainties. This methodology was similarly applied to other factors across all districts.

Table 3: Decision Matrix between Criteria's and the Regions

Types of process	AQI	Ground water	Population	Economy value
Landfill	(0.5,0.3,0.2)	(0.6,0.4,0.4)	(0.4,0.4,0.6)	(0.1,0.4,0.6)
Composting	(0.7,0.2,0.4)	(0.7,0.4,0.7)	(0.8,0.2,0.3)	(0.4,0.4,0.5)
Incinerator	(0.9,0.1,0.1)	(0.8,0.3,0.1)	(0.7,0.3,0.5)	(0.6,0.3,0.4)

$$d_1(p_i,d_k)=\frac{1}{n}\sum_{j=1}^{n}\frac{1}{6}\left(\left|(\boldsymbol{\varphi}_{\boldsymbol{p_i}}(\boldsymbol{D_j}) - \boldsymbol{\varphi}_{\boldsymbol{d_k}}(\boldsymbol{D_j})\right| + \left|(\boldsymbol{\psi}_{\boldsymbol{p_i}}(\boldsymbol{D_j}) - \boldsymbol{\psi}_{\boldsymbol{d_k}}(\boldsymbol{D_j})\right| + \left|(\boldsymbol{\omega}_{\boldsymbol{p_i}}(\boldsymbol{D_j}) - \boldsymbol{\omega}_{\boldsymbol{d_k}}(\boldsymbol{D_j})\right|\right) + \frac{1}{3}max\left(\left|(\boldsymbol{\varphi}_{\boldsymbol{p_i}}(\boldsymbol{D_j}) - \boldsymbol{\varphi}_{\boldsymbol{d_k}}(\boldsymbol{D_j})\right|, \left|(\boldsymbol{\psi}_{\boldsymbol{p_i}}(\boldsymbol{D_j}) - \boldsymbol{\psi}_{\boldsymbol{d_k}}(\boldsymbol{D_j})\right|, \left|(\boldsymbol{\omega}_{\boldsymbol{p_i}}(\boldsymbol{D_j}) - \boldsymbol{\omega}_{\boldsymbol{d_k}}(\boldsymbol{D_j})\right|\right) \quad (1)$$

By using the formula (1) for n=2 we obtain table 4

Table 4: comprehensive evaluation of the Solid Waste Management System (SWMS)

Districts	Landfill	Composting	Incinerator
Tirunelveli	0.1775	**0.15**	0.1775
Dindigul	0.207	0.202	**0.165**
Tuticorin	**0.225**	0.23	0.235

The data presented in Table 4 provides a comprehensive evaluation of the Solid Waste Management System (SWMS), considering three primary waste management techniques: composting, incineration, and landfilling. The results derived from this analysis indicate the most suitable waste management process for each district based on environmental and infrastructural factors.

From the analysis:

- **Tirunelveli** emerges as the most appropriate district for composting, as its environmental conditions and waste composition support this process.
- **Dindigul** is best suited for incineration, given its waste characteristics and urban infrastructure.
- **Tuticorin** is identified as the optimal location for landfilling, considering its available land resources and waste disposal needs.

Building upon this framework, we now introduce an alternative method aimed at identifying the least intensive waste management system within SWMS. This refined approach will further optimize the waste disposal strategy by considering additional parameters such as waste generation rates, economic feasibility, environmental sustainability, and resource efficiency. Through this advanced methodology, we seek to develop a more sustainable and adaptable waste management model tailored to the specific needs of each district. Implementing composting in Tirunelveli would require a multi-pronged approach, including the establishment of both centralized and community-level composting facilities, conducting public awareness and training programs, and introducing incentives to promote the segregation of organic waste at the source. Comparable strategies can be adapted for Dindigul and Tuticorin, focusing on incineration and landfilling respectively, while ensuring adherence to environmental regulations and public health standards.

$$d_2(p_i, d_k)=\frac{1}{n}\sqrt[r]{n}\left\{\left(\sum_{j=1}^{n}\left(\left|(\boldsymbol{\varphi}_{p_i}(\boldsymbol{D}_j)-\boldsymbol{\varphi}_{d_k}(\boldsymbol{D}_j)\right|+\left|(\boldsymbol{\psi}_{p_i}(\boldsymbol{D}_j)-\boldsymbol{\psi}_{d_k}(\boldsymbol{D}_j)\right|+\left|(\boldsymbol{\omega}_{p_i}(\boldsymbol{D}_j)-\boldsymbol{\omega}_{d_k}(\boldsymbol{D}_j)\right|\right)\right)^{r}\right\}^{\frac{1}{r}} \quad (2)$$

And r is the positive number we take n=4 examine the above relation for r = 1, 2, 3, 4, 5

Table 5: Calculation for r = 1 Using Equation (2)

DISTRICTS	Landfill	Composting	Incinerator
Tirunelveli	3.33	**2.7**	3.83
Dindigul	3.35	3.66	**2.83**
Tuticorin	**4.33**	4.5	4.6

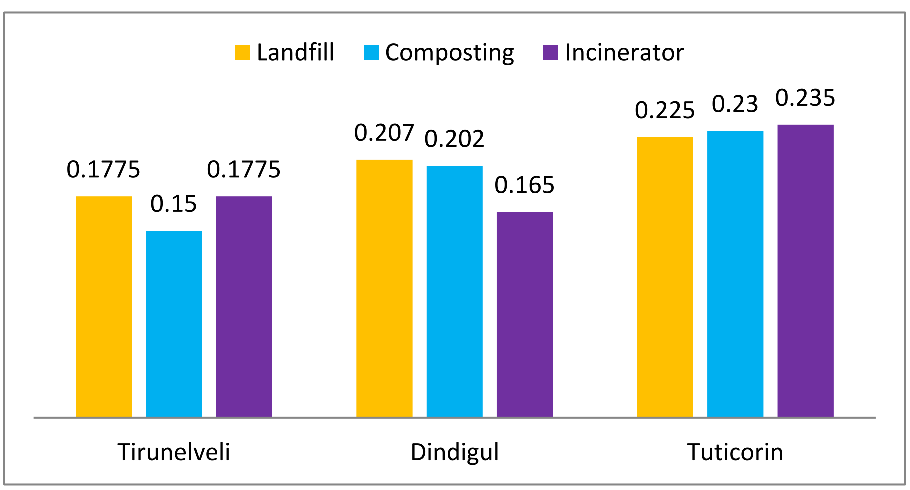

Fig. 7: Comparative results using the proposed method

Table 6: Calculation for r = 2 Using Equation (2)

DISTRICTS	Landfill	Composting	Incinerator
Tirunelveli	0.92	**0.63**	1.06
Dindigul	0.89	0.90	**0.70**
Tuticorin	**1.05**	1.08	1.16

Table 7: Calculation for r = 3 Using Equation (2)

DISTRICTS	Landfill	Composting	Incinerator
Tirunelveli	0.60	**0.52**	0.73
Dindigul	0.58	0.60	**0.48**
Tuticorin	**0.70**	0.72	0.78

Table 7: Calculation for r = 4 Using Equation (2)

DISTRICTS	Landfill	Composting	Incinerator
Tirunelveli	0.50	**0.45**	0.62
Dindigul	0.54	0.47	**0.39**
Tuticorin	**0.56**	0.57	0.61

Table 7: Calculation for r = 5 Using Equation (2)

DISTRICTS	Landfill	Composting	Incinerator
Tirunelveli	0.46	**0.37**	0.59
Dindigul	0.40	0.44	**0.36**
Tuticorin	**0.50**	0.52	0.56

As the dataset increases in size, the variations between the values presented in the tables become less significant. This indicates that the data progressively converges toward the actual values. Upon analysing Tables 4 to 8, it is evident that the results remain consistent across different scenarios.

In particular, when examining the first row of all tables, the smallest difference is observed, making Tirunelveli the most suitable district for composting. Similarly, in the second row, the optimal waste management process for Dindigul is incineration. Finally, in the third row, the most appropriate method for Tuticorin is landfill.

This pattern highlights that, as the data size increases, the decision-making process becomes more refined, leading to a more accurate selection of solid waste management methods for each district.

9. Process of Normalized Hamming Formulas

The normalized hamming distance for all the three district(i) and the Types of process (k)

$$d_3(p_i,d_k)=\frac{1}{3n}\left(\left|(\boldsymbol{\varphi}_{\boldsymbol{p_i}}(\boldsymbol{D_j})-\boldsymbol{\varphi}_{\boldsymbol{d_k}}(\boldsymbol{D_j})\right|+\left|(\boldsymbol{\psi}_{\boldsymbol{p_i}}(\boldsymbol{D_j})-\boldsymbol{\psi}_{\boldsymbol{d_k}}(\boldsymbol{D_j})\right|+\left|(\boldsymbol{\omega}_{\boldsymbol{p_i}}(\boldsymbol{D_j})-\boldsymbol{\omega}_{\boldsymbol{d_k}}(\boldsymbol{D_j})\right|\right) \tag{3}$$

And the normalized Euclidean distance

$$d_4(p_i,d_k)=\frac{1}{3n}\left\{\left(\sum_{j=1}^{n}\left(\left(\left|(\boldsymbol{\varphi}_{\boldsymbol{p_i}}(\boldsymbol{D_j})-\boldsymbol{\varphi}_{\boldsymbol{d_k}}(\boldsymbol{D_j})\right|\right)^2+\left(\left|(\boldsymbol{\psi}_{\boldsymbol{p_i}}(\boldsymbol{D_j})-\boldsymbol{\psi}_{\boldsymbol{d_k}}(\boldsymbol{D_j})\right|\right)^2+\left(\left|(\boldsymbol{\omega}_{\boldsymbol{p_i}}(\boldsymbol{D_j})-\boldsymbol{\omega}_{\boldsymbol{d_k}}(\boldsymbol{D_j})\right|\right)^2\right)\right)^2\right\}^{\frac{1}{2}} \tag{4}$$

Let (n = 4) and by the formula (3), (4) respectively, the results are given in the tables 10 and 11

Table 10: Using the formula (3)

DISTRICTS	Landfill	Composting	Incinerator
Tirunelveli	0.16	**0.12**	0.18
Dindigul	0.19	0.18	**0.14**
Tuticorin	**0.21**	0.22	0.23

Table 11: Using the formula (4)

DISTRICTS	Landfill	Composting	Incinerator
Tirunelveli	0.23	**0.17**	0.25
Dindigul	0.238	0.26	**0.20**
Tuticorin	**0.28**	0.281	0.29

While the normalized Hamming and Euclidean distance methods produce comparable outcomes, they do not fully capture the indeterminacy inherent in neutrosophic representations. In contrast, the proposed method effectively incorporates this uncertainty, providing a more comprehensive assessment framework. A comparative overview of each method's sensitivity, computational efficiency, and interpretability in the context of solid waste management is presented in Table 11. Thus, we studied the result that has been obtained from formula (3), (4) are same results.

The new process of best site section

$$d_H(S,T)=max\left(\left|(\varphi_S(D_j)-\varphi_T(D_j)\right|,\left|(\psi_S(D_j)-\psi_T(D_j)\right|,\left|(\omega_S(D_j)-\omega_T(D_j)\right|\right). \tag{5}$$

Table 12: Using the formula (5)

DISTRICTS	Landfill	Composting	Incinerator
Tirunelveli	0.3	**0.2**	0.27
Dindigul	0.35	0.35	**0.3**
Tuticorin	**0.37**	0.38	0.38

10. Conclusion

In this study, we have formulated and developed a set of optimized algorithms for an efficient Solid Waste Management System (SWMS) by integrating a newly proposed distance formula. The primary objective of this approach is to systematically assess and compare various solid waste management processes across different districts, thereby enabling the selection of the most appropriate method based on environmental and infrastructural factors.

The developed algorithms were rigorously implemented and tested to ensure their reliability and accuracy in evaluating different waste management techniques. To validate the effectiveness of our proposed method, we conducted a comparative analysis by measuring the distance-based differences between the results obtained from our algorithm and those derived using Hamming distance and Euclidean distance. This step was crucial in determining the efficacy of our approach in identifying optimal solid waste management strategies tailored to each district's specific conditions.

By employing this computational approach, we have successfully determined the most suitable waste disposal method for each district, ensuring optimal utilization of resources while minimizing environmental impact. The findings of this study provide a structured, data-driven, and scalable framework that can be applied to enhance waste management planning and policy-making. Our proposed methodology not only improves decision-making in solid waste management but also promotes sustainability, efficiency, and environmental responsibility in urban and rural waste disposal systems. While the analytical outcomes are promising, future research should incorporate field-level validation through site visits, consultations with local waste management authorities, and assessments of current infrastructure. Such efforts would enhance the alignment of the proposed recommendations with real-world implementation scenarios.

District	**Recommended Waste Management Process**
Tirunelveli	Composting
Dindigul	Incineration
Tuticorin	Landfilling

Limitations and Future work

The study acknowledges certain limitations, particularly related to the use of fixed normalization techniques and static weight assignments for the evaluation criteria. Additionally, the complexities associated with district-level implementation and policy frameworks were not extensively addressed. Future investigations may consider adopting adaptive weighting schemes, integrating predictive models such as machine learning algorithms, and broadening the scope to include additional regions or the management of hazardous waste streams.

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Appendix

A. https://www.iqair.com/in-en/india/tamil-nadu?srsltid=AfmBOopq3Zt87U-z8tu4lklg6wVtp9V14fNnUufZb3lNIgws8lP-kQdf

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