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Optimal Site Selection for Women University Using Neutrosophic Multi-Criteria Decision Making Approach

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Abstract: Site selection for an institute or a university is a challenging task. The selection of sites for setting up a new university depends on multiple criteria. In backward, under privileged area people's perception towards the co-educational universities and women universities are different. Poor families with their conservative mentality possess inhibitions while sending their girl child to co-educational universities as they have concerns about safety, security and family honor. Hence many attributes which are not so important for co-educational universities are more pertinent for women university. In this research paper, we have considered a model for selecting women's university sites in different backward locations in the state of West Bengal, India. This model incorporated different types of uncertainty related to site selection. Ten important criteria are chosen for the selection of sites. To capture the uncertainty of the problem, trapezoidal neutrosophic numbers are used along with the Multi-criteria Decision Making tool Analytic Hierarchy Process (AHP) for obtaining criteria weights. Finally, the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and COmplex PRoportional ASsessment (COPRAS) are applied for ranking of the sites. Comparative and sensitivity analyses are conducted to check the steadiness of the techniques used.

Keywords: neutrosophic number; TRNNs; AHP; TOPSIS; COPRAS; university site selection

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1. Introduction

The site selection problem is quite significant in today's world. Location selection for setting up an industry, real estate, hospitality management, or other cases that require proper data, decision experts, future perspective, establishment cost, etc. Moreover, there exist several criteria which make the Decision Maker (DM) select the optimal alternative. Ranking the sites requires a mathematical understanding of the problem. In this context, multi-criteria decision-making (MCDM) can play an important role. Optimal selection or ranking of various disparate sites in decision-making is complicated as it depends on multiple conflicting criteria. Obtaining of criterion's weight is a major part of the DMs. The first step in decision-making is to integrate the opinion of decision experts in linguistic rating. The linguistic rating may not always be transformed to a fixed scale, as the decision experts may consider uncertainty, hesitancy, and vagueness. In this context, the researchers need to solve the MCDM techniques for the site selection problem in an uncertain, hesitant environment.

1.1. Motivation and Novelties of the Study

- MCDM tools in the neutrosophic environment have been applied in different areas, but the literature survey reflects that minimum work has been done on women's university site selection problem (any other type of university site selection also). So, this study focuses on this problem and aims to fill the gap in the literature. It provides encouraging results.

- New De-Neutrosophication technique for trapezoidal neutrosophic number is developed and further used in this study model.
- Finding the trapezoidal neutrosophic numbers (TrNNs), weights are constructed in a new way and applied in the proposed application model.
- A model for Women University site selection is proposed by taking important criteria, and ranking of the sites is conducted using an uncertain MCDM method.
- Questionnaires were made regarding different locations and their attributes. Various experts were questioned, such as transportation engineers, architects, environmental engineers, civil engineers, geologists, environmental experts, and municipal officials. Their opinion about the criteria that correspond to different locations has been taken into consideration as the input and has been aggregated to solve the problem.
- AHP technique has been used to obtain the crisp weight of the criteria, and for consistency check, two MCDM tools, namely Neutrosophic TOPSIS and Neutrosophic COPRAS have been applied for ranking of the sites.
- Sensitivity analysis has been calculated to measure the change in ranking and to check the robustness and steadiness of the methods used.

1.2. Structure of the Paper

In this research, Section 1 covers the introduction and the literature review of neutrosophic number and its application in MCDM as described in Section 2. Section 3 covers preliminaries and different operations of neutrosophic numbers with distance and de-neutrosophication technique of TrNN. MCDM mathematical formulation is mentioned in Section 4. In particular, NAHP is described in Section 4.1, TrNN weight is expressed in Section 4.2, Section 4.3 described NTOPSIS and NCOPRAS described in Section 4.4. The model for setup and Criteria of the application are shown in Sections 5 and 6, respectively. Data collection and Numerical calculations are mentioned in Sections 7 and 8, respectively. Sensitivity analysis is described in Section 9. Finally, the conclusion and future research scope are discussed in Section 10.

2. Literature Review

In this section, we shall review some related published work and some key terms used in this paper.

2.1. Multi Criterion Decision Making

The application of MCDM tool in the fuzzy environment and its importance in real-life situations are discussed in this section. This section depicts the theoretical development and the work done related to these techniques in the last few years in Table 1.

Table 1. Literature review with respect to different MCDM techniques and applications.

	Authors	Years	MCDM Methods	Application Area
[1]	Serrai, W. et al.	2017	AHP, ANP, SAW, TOPSIS, VIKOR, PROMETHEE, MAUT, ELECTRE, BWM & COPRAS	Web service selection
[2]	Jayant, A. et al.	2018	ELECTRE, PROMETHEE, VIKOR, TOPSIS	Business competitive environment
[3]	Zain, Z.M.	2018	Fuzzy TOPSIS	Evaluation of the quality of online information on breast cancer
[4]	Chattopadhyay, A. et al.	2018	Fuzzy TOPSIS	Supplier selection
[5]	Mitra, S. et al.	2018	TOPSIS	Best domestic Refrigerator selection
[6]	Sa L.K. et al.	2018	TOPSIS	Green Material Selection
[7]	Balioti, V. et al	2018	TOPSIS	Spillway Selection
[8]	Khan, S.A. et al.	2018	TOPSIS	Supply Chain Management

Table 1. *Cont.*

	Authors	Years	MCDM Methods	Application Area
[9]	Masum, A.K.M. et al.	2019	AHP-TOPSIS	Ranking Human Capital
[10]	Min Oo, H. et al.	2019	Fuzzy AHP, TOPSIS	Destination selection
[11]	Gholap, A.B. et al	2019	AHP & TOPSIS	Ranking Condition monitoring
[12]	Negi, N. et al	2019	AHP, ARAS, TOPSIS & VIKOR	Quality of Service(QoS) based Web services
[13]	Singh, M. et al	2019	TOPSIS, MTOPSIS, FTOPSIS	Raw material selection in pulp and paper making industry
[14]	Song, Y. et al	2019	TOPSIS	Financial risk prediction
[15]	Cheng, C. et al	2020	MCDM	Selecting a supplier
[16]	Youssef, A.E.	2020	BWM, TOPSIS, AHP	Cloud Service Selection
[17]	Zulqarnain, R.M. et al	2020	TOPSIS	Selection of a car
[18]	Abdelli, A. et al	2020	TOPSIS	Web services characterized by Quality of service (QoS)
[19]	Lin, M. et al	2020	TODIM	Evaluating IoT Platforms
[20]	Pangaribuan, I. et al	2020	SAW, TOPSIS, WPM	Auction application
[21]	Raju, S.S. et al	2020	AHP, TOPSIS, MOORA	Ranking of Al-CSA
[22]	Dr. Kashid, U. et al	2021	AHP, TOPSIS	Players performance evaluation and selection in IPL
[23]	Lee, W.H. et al	2021	TOPSIS, WSM	Sustainable building materials supplier selection
[24]	Trung, DO D.	2021	EDAS, MARCOS, TOPSIS, MOORA & PIV	The weights of surface roughness calculation and finding MRR
[25]	Vassoney, E. et al	2021	SAW, WPM, AHP, TOPSIS, VIKOR, ELECTRE III & SHARE MCA	The optimal flow of downstream of a small run of the river HP plant
[26]	Lata, S. et al	2021	Fuzzy TOPSIS	Selection of Machine Tool
[27]	Basaran, S. et al	2022	Fuzzy TOPSIS	Mobile Mathematics Learning Application Selection
[28]	Ukpanyang, D. et al	2022	PROMETHEE	Waste-to-Energy Technologies for Slum/Informal Settlements selection
[29]	Olgun, M. et al	2022	TOPSIS	Multicriteria Group Decision Making
[30]	Boix-Cots, D. et al	2022	MIVES	Different construction problem (Review paper)
[31]	Casanovas-Rubio, M. M. et al	2019	MIVES	Sustainability assessment of trenches
[32]	Pujadas, P. et al	2018	MIVES	Urban-pavement conditions evaluation
[33]	Pons, O. et al	2016	AHP & MIVES	Sustainability of green building
[34]	Pujadasa, P. et al	2017	MIVES	Evaluation, prioritization and selection of public investment projects
This paper		2023	NAHP, NTOPSIS & NCOPRAS	Women's university site selection

2.2. Neutrosophic Set

The concept of belongingness, non-belongingness, and indeterminacy of Neutrosophic Set was first developed by F. Smarandache [35]. In this study, the Degree of truth, degree of falsity and indeterminacy of every element in the set are considered.

2.3. Neutrosophic Set with MCDM Techniques

The MCDM method is quite a popular approach when it comes to real life complexities. A few real-life problems are also associated with uncertain data. Due to that reason, the uncertain MCDM methodology is developed. After the invention of Neutrosophic set theory, this approach has becomes very successful. The following review is based on the theoretical development and applications in Neutrosophic MCDM in the last five years. Please refer Table 2.

Table 2. Literature review based on theoretical developments by neutrosophic MCDM techniques along with application area.

	Authors	Years	Neutrosophic Number/Set Used	MCDM Technique Used	Application Area
[36]	Zhang et al.	2014	Interval neutrosophic sets	INN Aggregation Operators based MCDM	Money investing problem
[37]	Ren et al.	2017	Single Valued Neutrosophic Set (SVNS)	Prioritized Weighted Geometric (SVNPWG) Operator based MCDM	Selection of an investment company
[38]	Garg & Nancy	2018	Single Valued Neutrosophic Number (SVNN)	Prioritized Muirhead Mean based MCDM	Finding an appropriate Information Technology (IT) software company
[39]	Sodenkamp et al.	2018	Single Valued Neutrosophic Set (SVNS) and Group Decision Making Aggregation	NS-based GMCDM approach	Unequal voting powers be respon-sible for the assessment of ranking alternatives
[40]	Nabeeh et al.	2019	Triangular Neutrosophic Numbers	AHP	Selection of IoT based Enterprises
[41]	Wang et al.	2019	Interval Neutrosophic Sets	Improved cosine similarity measure based MCDM method	Supplier selection
[42]	Garg & Nancy	2019	Single Valued Neutrosophic Set (SVNS), Divergence measure developed	Divergence measure based TOPSIS method	Finding an appropriate Information Technology (IT) software company
[43]	Zeng et al.	2020	Single Valued Neutrosophic Set (SVNS)	Correlation based TOPSIS	Finding an appropriate Information Technology (IT) software company
[44]	Jiao et al.	2020	Interval Neutrosophic Number (INN)	Induced Generalized Interval Neutrosophic Choquet Integral based MCDM	Country selection for investment
[45]	Duong & Thao	2021	Entropy based Neutrosophic Numbers	TOPSIS	Market segment selection and evaluation
[46]	Ye et al.	2021	Neutrosophic enthalpy set	Aggregation operator and score function based MCDM method using the algebraic and the Einstein t-norms and t-conorms	Car selection
[47]	Hezam et al.	2021	Generalized triangular neutrosophic number	Neutrosophic AHP-TOPSIS	Prioritized peoples group selection for vaccine
[48]	Jafar et al.	2021	Neutrosophic Hypersoft Sets	Similarity measures based MCDM	Renewable energy source selection
[49]	Rani et al.	2021	Single Valued Neutrosophic Set (SVNS)	SWARA & CoCoSo	Renewal Energy Source Selection
[50]	Abdullah et al.	2021	Single Valued Neutrosophic Set (SVNS)	DEMATEL	Identification of Influential Criteria in Sub- Contractors Selection
[51]	Elhosini et al.	2021	Single Valued Neutrosophic Set (SVNS)	TOPSIS, PROMETHEE	Selection of Wind Energy Power Plant Location
[52]	Ridvan et al.	2021	Single Valued Neutrosophic Set (SVNS)	Divergence, Projection, Likelihood (DPL)- TOPSIS	Selection of right mask in COVID-19
[53]	Deveci et al.	2021	Type 2 Neutrosophic Sets	MABAC	Site selection of offshore wind farm location
[54]	Nădăban, S. et al.	2016	Neutrosophic Set (NS)	Fuzzy TOPSIS	Supplier selection, sustainable and renewable energy location selection
[55]	Irvanizam et al.	2022	Trapezoidal Fuzzy Neutrosophic Sets	Ordinal Priority Approach (OPA) and MULTIMOORA	Social Aid Distribution Problem
[56]	Bavia et al.	2022	Single Valued Neutrosophic Set (SVNS)	hybrid score accuracy based MCGDM method	Logistics Centre Location Problem
[57]	Abdel-Basset et al.	2022	Single Valued Neutrosophic Set (SVNS)	AD principles based MCDM	Selecting the suitable medical image modality
This paper		2023	Trapezoidal neutrosophic number (TrNN)	NAHP, NTOPSIS & NCOPRAS	Women's university site selection

For further information, you may refer to the recent papers [58–65].

2.4. Site Selection and University Site Selection

Site selection problem is a challenging task as it is based on several multiple conflicting factors (for example [66–70]). For selection of a site, the experts need to consider the long term stability and profitability factor. A comparative study of different types of site selection problem under different methodology is discussed in Table 3.

Table 3. Review of different type of site selection problems with solution strategy.

	Authors	Year	Types of Site	Methodology	Environment
[71]	Wang, C. N. et al.	2018	Renewable energy plants location	FAHP & TOPSIS	Fuzzy
[72]	Wang, C. N. et al.	2018	Solar power plant location	DEA, fuzzy AHP & TOPSIS	Fuzzy
[73]	Maghsoodi, A. I. et al.	2019	Construction project site	BWM, CODAS & T-MADM	Crisp
[74]	Zolfani, S. H. et al.	2022	Different types of site (Review paper)	Different MADM methodology	Fuzzy & crisp
[75]	Kharat, M. G. et al.	2016	Landfill site	Fuzzy AHP & Fuzzy TOPSIS	Fuzzy
[76]	Karaşan, A. et al.	2020	Electric vehicles charging stations	AHP, DEMATEL & TOPSIS	Fuzzy
[77]	Boyacı, A. Ç. et al.	2022	Pandemic hospital location	Fuzzy AHP & TOPSIS	Fuzzy
[78]	Önüt, S. et al.	2010	Shopping center site	AHP & TOPSIS	Fuzzy
[79]	Sennaroglu, B. et al.	2018	Military airport location	AHP, PROMETHEE & VIKOR	Crisp
[80]	Rezaeisabzevar, Y. et al.	2020	Landfill site	AHP, TODIM & ANP	Fuzzy
[81]	Liu, H. C. et al.	2019	Electric vehicle charging stations	DEMATEL & MULTIMOORA	Grey
[82]	Zhou, S. et al.	2012	Biofuel refinery location	Fuzzy TOPSIS	Fuzzy
This paper		2023	Women's university site selection	NAHP, NTOPSIS & NCOPRAS	Neutrosophic

Site selection for educational institutes with some related factors and the procedure of selection have been discussed in [83–85]. In this section, we shall study the present situation of the established universities and institutions in West Bengal, India and try to figure out the problem that forms the basis of the main model in this study.

There are different types of universities and institutes according to their main themes as follows:

1. **Fully research university:** This type of university is primarily focused on research. They have few full-time postgraduate courses but with motivation for research. Also, they have mostly focused Ph.D. programs. The establishment of this type of university needs more funding as the number of students are less.
2. **Fully academic university:** The primary goal of this type of university is academic purposes. They run undergraduate and postgraduate with several specializations. Research might not be the primary focus of this type of university.
3. **Mixed type university (academic and research):** The academic program and research program are both in this type of university. There is a balance between academic and research activity.
4. **Affiliated university:** This type of university is for only controlling the affiliated colleges that are under this university. Different work like inspection of college, control of examination, quality improvement of colleges, etc., plays an important role in this type of university.
5. **University for some special purposes:** University, which is beneficial for the society, country or an organization.

Thus, the above said institutes can be further categorized into:

A **Fully government university**: University which is run by government funding and direction which is fully controlled by the government.

B **Government aided university**: Public and private partnerships with government collaboration. A few portions are helped and directed by the government and the rest is executed by the institute's internal organization.

C **Private university**: Fully funded and directed by the private sector, i.e., non-governmental organization.

Table 4 and Figure 1 represent the university or institution available in the state of West Bengal, in India, in terms of numbers and locations.

Table 4. Different type of university or institution in West Bengal, India [86,87].

Type of University/Institution	Type	Number of University/Institution
Institute of national importance	Fully government	9
Research institutes	Fully government	15
State universities	Government aided	36
Private universities	Private	12
Deemed universities	Government	2
Central universities	Government	1
National law university	Government	1

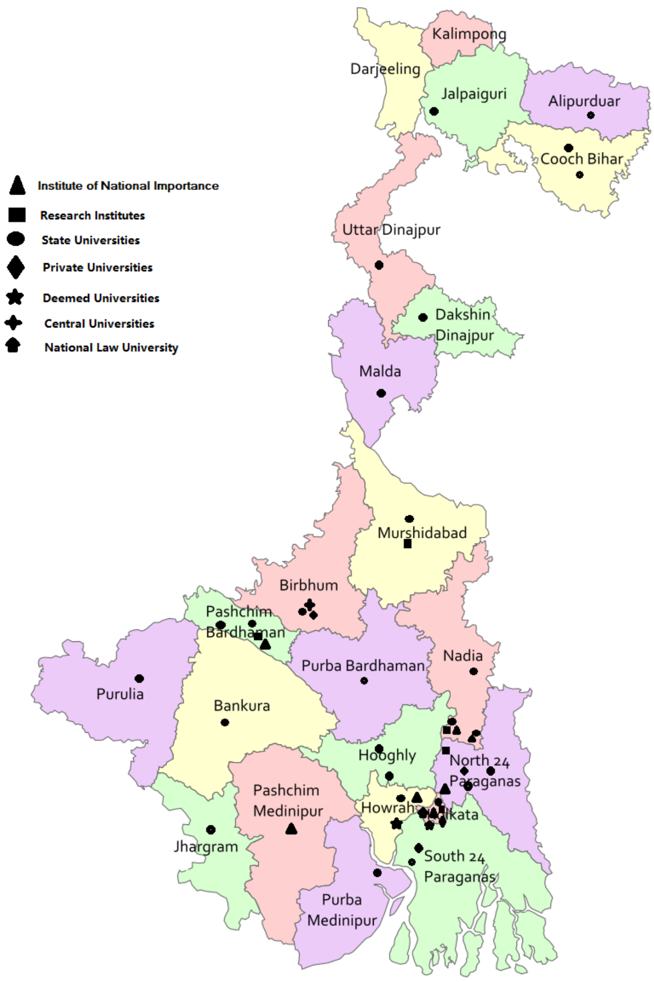

Figure 1. Location wise university & institutions in West Bengal, India [88].

3. Preliminaries

3.1. Neutrosophic Logic

In neutrosophic logic, each proposition is represented by the percentage of occurrence for the truth factor, indeterminacy factor, and falsity factor altogether [35,89].

The range of true membership function/T value, indeterminacy membership function/I value, and falsity membership function/F value are a subset of $]^{-}0, 1^{+}[$ and the supremum of neutrosophic logic and infimum of neutrosophic logic are $n_{sup} = \sup T + \sup I + \sup F \leq 3$ and $n_{inf} = \inf T + \inf I + \inf F \geq 0$ respectively.

Example 1. *Let x(0.7, 0.5, 0.3) be a neutrosophic number with $x \in X$, and the element x is 70% true, 50% indeterminate, and 30% false.*

Example 2. *Consider x((0.7,0.8), (0.5,0.6), (0.25,0.3)) be a neutrosophic number with $x \in X$ and the element x is 70% to 80% true, 50% to 60% indeterminate and 25% to 30% false. Here, we see that the membership value (truth, indeterminacy & falsity) are set with continuous or discrete, closed or open, union or intersection of sets, etc., based on the element/number x.*

3.2. Neutrosophic Sets

Consider three real-valued standard category subsets or non-standard category subsets T, I & I of $]^{-}0, 1^{+}[$ with supremum and infimum defined as true $\sup T = t\_\sup$, $\inf T = t\_\inf$, for indeterminate $\sup I = i\_\sup$, $\inf I = i\_\inf$ and for false $\sup F = f\_\sup$, $\inf F = f\_\inf$. Neutrosophic supremum and neutrosophic infimum are $n_{sup} = \sup T + \sup I + \sup F$ and $n_{inf} = \inf T + \inf I + \inf F$ respectively.

Let us consider the universe of discourse denoted by X with arbitrary subset $A \subset X$. An arbitrary element $y \in X$ belongs to the set A. On the basis of the neutrosophic set, refs. [89–91] denoted as $y(t, i, f)$ and described as follows: y is t% true, i% is indeterminate (undetermined, it may or may not be true) and f% false on the basis of the set A subset of X, where the variables $t \in T, i \in I$ & $f \in F$.

Here, the subsets of $]^{-}0, 1^{+}[$ are T, I & F, are not only fixed set, but are operators/functions calculated on the basis of y and various known/unknown variables. The concept of Neutrosophic sets was given by Florentin Smarandache [35,92].

Definition 1 ([93,94])**.** *Assume X to be a universal set of discourse. Let neutrosophic set N^{+} is presented in the form: $N^{+}(y) = \{< y; T(y), I(y), F(y) : y \in X >\}$, where $T(y)$ is truth, $I(y)$ is indeterminacy and $F(y)$ is falsity functional component of an arbitrary element $y \in X$ with the mapping: $T, I, F : y \rightarrow]0^{-}, 1^{+}[$ and satisfy the following condition: $0 \leq T(y) \leq 1$, $0 \leq I(y) \leq 1$, $0 \leq F(y) \leq 1$ and overall $0 \leq T(y) + I(y) + F(y) \leq 3$.*

3.3. Single Valued Neutrosophic Set (SVNS)

Single Valued Neutrosophic Set (SVNS) [95,96] is a set that consists of element(s) only one element in each membership value. Let $\tilde{\Gamma}(\zeta) = \{\zeta; T_{\Gamma}(\zeta), I_{\Gamma}(\zeta), F_{\Gamma}(\zeta) | \zeta \in \tilde{\Gamma}\}$ be a Neutrosophic Set [97] with each element $\zeta \in \tilde{\Gamma}$ and the true membership functions $T_{\Gamma}(\zeta)$, indeterminacy membership functions $I_{\Gamma}(\zeta)$ and false membership functions $F_{\Gamma}(\zeta)$ are unique value for $\zeta \in \tilde{\Gamma}$ are represented respectively. The range of membership functions lie between $[0, 1]$, i.e., $(0 \leq T_{\Gamma}(\zeta), I_{\Gamma}(\zeta), F_{\Gamma}(\zeta) \leq 1)$.

Example 3. *Let $\tilde{A_1} = \{x; 1, 0.5, 0.6\}$, $\tilde{A_2} = \{x; 0.8, 0.3, 0.5\}$ and $\tilde{A_3} = \{x; 0.7, 0.2, 0\}$ are three SVNSs. Neutrosophic set $\tilde{A_1}$ contains one element x with true membership value 1, indeterminacy membership value 0.5, and false membership value 0.6. Similar rule exists for the set $\tilde{A_2}$ and $\tilde{A_3}$. All these three membership values of the neutrosophic set lie between [0, 1].*

Example 4. *Let $\tilde{B_1} = \{\{y; 0.9, 0.35, 0.42\}, \{z; 0.7, 0.25, 0.15\}\}$ and $\tilde{B_2} = \{x; 1, 0.1, 0.2\}$ are two SVNSs. Here Neutrosophic set $\tilde{B_1}$ consisting of two elements, their three membership values, i.e., true, indeterminacy & falsity membership value of the element $y, z \in \tilde{B_1}$ has exactly one value, i.e.,* *true membership value is 0.9 & indeterminacy and falsity membership values are 0.35 and 0.42 respectively for the element $y \in \tilde{B}_1$ and true membership value is 0.7 & indeterminacy and falsity membership values are 0.25 and 0.15 respectively for the element $z \in \tilde{B}_1$. Similarity true for the neutrosophic set $\tilde{B}_2$, true membership value is 1, and indeterminate and false membership values are 0.1 and 0.2, respectively.*

3.4. Trapezoidal Neutrosophic Number

There are several research papers on neutrosophic numbers and neutrosophic sets. To capture the uncertainties prevailing in real-life situations and to fix the problem, Neutrosophic numbers are more reliable. Different types of developed neutrosophic numbers, such as triangular neutrosophic numbers, trapezoidal neutrosophic numbers [98], pentagonal neutrosophic numbers, and hexagonal neutrosophic numbers, were framed in literature. Considering the problem of this study, TRNNs have been used. The following section includes the definition, arithmetic operations, examples, distance measures, and de-neutrosophication of TRNNs.

Definition 2. *Trapezoidal Neutrosophic Set (TrNS)*

Let $\tilde{\Gamma}(\zeta) = \{(\rho_1, \rho_2, \rho_3, \rho_4; \sigma_1, \sigma_2, \sigma_3, \sigma_4; \phi_1, \phi_2, \phi_3, \phi_4); t_\Gamma(\zeta), i_\Gamma(\zeta), f_\Gamma(\zeta)\}$ be trapezoidal neutrosophic set with ζ be an element on it. Then it's true membership functions $T_\Gamma(\zeta)$, indeterminacy membership functions $I_\Gamma(\zeta)$ and false membership functions $F_\Gamma(\zeta)$ are represented respectively as:

$$T_\Gamma(\zeta) = \begin{cases} 0 & if\ \zeta \le \rho_1 \\ t_\Gamma \frac{(\zeta-\rho_1)}{\rho_2-\rho_1} & if\ \rho_1 \le \zeta \le \rho_2 \\ t_\Gamma & if\ \rho_2 \le \zeta \le \rho_3 \\ t_\Gamma \frac{(\rho_4-\zeta)}{\rho_4-\rho_3} & if\ \rho_3 \le \zeta \le \rho_4 \\ 0 & if\ \rho_4 \le \zeta \end{cases} \quad (1)$$

$$I_\Gamma(\zeta) = \begin{cases} 1 & if\ \zeta \le \sigma_1 \\ \frac{(\sigma_2-\zeta)+i_\Gamma(\zeta-\sigma_1)}{\sigma_2-\sigma_1} & if\ \sigma_1 \le \zeta \le \sigma_2 \\ i_\Gamma & if\ \sigma_2 \le \zeta \le \sigma_3 \\ \frac{(\zeta-\sigma_3)+i_\Gamma(\sigma_4-\zeta)}{\sigma_4-\sigma_3} & if\ \sigma_3 \le \zeta \le \sigma_4 \\ 1 & if\ \sigma_4 \le \zeta \end{cases} \quad (2)$$

$$F_\Gamma(\zeta) = \begin{cases} 1 & if\ \zeta \le \phi_1 \\ \frac{(\phi_2-\zeta)+f_\Gamma(\zeta-\phi_1)}{\phi_2-\phi_1} & if\ \phi_1 \le \zeta \le \phi_2 \\ f_\Gamma & if\ \phi_2 \le \zeta \le \phi_3 \\ \frac{(\zeta-\phi_3)+f_\Gamma(\phi_4-\zeta)}{\phi_4-\phi_3} & if\ \phi_3 \le \zeta \le \phi_4 \\ 1 & if\ \phi_4 \le \zeta \end{cases} \quad (3)$$

here $0 \le T_\Gamma(\zeta) \le 1$, $0 \le I_\Gamma(\zeta) \le 1$, $0 \le F_\Gamma(\zeta) \le 1$ and $0 \le T_\Gamma(\zeta) + I_\Gamma(\zeta) + F_\Gamma(\zeta) \le 3$. Then $\tilde{\Gamma}(\zeta) = \{(\rho_1, \rho_2, \rho_3, \rho_4; \sigma_1, \sigma_2, \sigma_3, \sigma_4; \phi_1, \phi_2, \phi_3, \phi_4); t_\Gamma(\zeta), i_\Gamma(\zeta), f_\Gamma(\zeta)\}$ is trapezoidal neutrosophic set (TrNS) when $\rho_1, \rho_2, \rho_3, \rho_4 \in \mathbb{R}$; $\sigma_1, \sigma_2, \sigma_3, \sigma_4 \in \mathbb{R}$; $\phi_1, \phi_2, \phi_3, \phi_4 \in \mathbb{R}$ and $\rho_1 \le \rho_2 \le \rho_3 \le \rho_4$; $\sigma_1 \le \sigma_2 \le \sigma_3 \le \sigma_4$; $\phi_1 \le \phi_2 \le \phi_3 \le \phi_4$.

Definition 3. *Trapezoidal Neutrosophic Set (TrNS)*

Let $\tilde{\Gamma}(\zeta) = \{(\mu_1, \mu_2, \mu_3, \mu_4); t_\Gamma(\zeta), i_\Gamma(\zeta), f_\Gamma(\zeta)\}$ be trapezoidal neutrosophic set with ζ be an element on it. Then it's true membership functions $T_\Gamma(\zeta)$, indeterminacy membership functions $I_\Gamma(\zeta)$ and false membership functions $F_\Gamma(\zeta)$ are represented respectively as:

$$T_\Gamma(\zeta) = \begin{cases} 0 & if\ \zeta \leq \mu_1 \\ t_\Gamma \frac{(\zeta-\mu_1)}{\mu_2-\mu_1} & if\ \mu_1 \leq \zeta \leq \mu_2 \\ t_\Gamma & if\ \mu_2 \leq \zeta \leq \mu_3 \\ t_\Gamma \frac{(\mu_4-\zeta)}{\mu_4-\mu_3} & if\ \mu_3 \leq \zeta \leq \mu_4 \\ 0 & if\ \mu_4 \leq \zeta \end{cases} \quad (4)$$

$$I_\Gamma(\zeta) = \begin{cases} 1 & if\ \zeta \leq \mu_1 \\ \frac{(\mu_2-\zeta)+i_\Gamma(\zeta-\mu_1)}{\mu_2-\mu_1} & if\ \mu_1 \leq \zeta \leq \mu_2 \\ i_\Gamma & if\ \mu_2 \leq \zeta \leq \mu_3 \\ \frac{(\zeta-\mu_3)+i_\Gamma(\mu_4-\zeta)}{\mu_4-\mu_3} & if\ \mu_3 \leq \zeta \leq \mu_4 \\ 1 & if\ \mu_4 \leq \zeta \end{cases} \quad (5)$$

$$F_\Gamma(\zeta) = \begin{cases} 1 & if\ \zeta \leq \mu_1 \\ \frac{(\mu_2-\zeta)+f_\Gamma(\zeta-\mu_1)}{\mu_2-\mu_1} & if\ \mu_1 \leq \zeta \leq \mu_2 \\ f_\Gamma & if\ \mu_2 \leq \zeta \leq \mu_3 \\ \frac{(\zeta-\mu_3)+f_\Gamma(\mu_4-\zeta)}{\mu_4-\mu_3} & if\ \mu_3 \leq \zeta \leq \mu_4 \\ 1 & if\ \mu_4 \leq \zeta \end{cases} \quad (6)$$

here $0 \leq T_\Gamma(\zeta) \leq 1$, $0 \leq I_\Gamma(\zeta) \leq 1$, $0 \leq F_\Gamma(\zeta) \leq 1$ *and* $0 \leq T_\Gamma(\zeta) + I_\Gamma(\zeta) + F_\Gamma(\zeta) \leq 3$. *Then* $\tilde{\Gamma}(\zeta) = \{(\mu_1, \mu_2, \mu_3, \mu_4); t_\Gamma(\zeta), i_\Gamma(\zeta), f_\Gamma(\zeta)\}$ *is trapezoidal neutrosophic set (TrNS) when* $\mu_1, \mu_2, \mu_3, \mu_4 \in \mathbb{R}$ *and* $\mu_1 \leq \mu_2 \leq \mu_3 \leq \mu_4$.

Definition 2 is generalised definition of Trapezoidal Neutrosophic Set (TrNS).

Note: Geometric presentation of trapezoidal neutrosophic number $\tilde{\Gamma}(\zeta) = \{(\beta_1, \beta_2, \beta_3, \beta_4); t_\Gamma(\zeta), i_\Gamma(\zeta), f_\Gamma(\zeta)\}$ are shown in Figure 2 where $\beta_1, \beta_2, \beta_3$ & β_4 are first, second, third and fourth entry of the trapezoidal neutrosophic numbers respectively and $t = t_\Gamma(\zeta)$ for maximum true membership value, $i = i_\Gamma(\zeta)$ for maximum indeterminacy membership value and $f = f_\Gamma(\zeta)$ for maximum false membership value of TrNN $\tilde{\Gamma}(\zeta)$.

Example 5. *Let* $\tilde{\Gamma}(\zeta) = \{(2, 3, 4, 5); 0.7, 0.3, 0.5\}$ *be trapezoidal neutrosophic set with* ζ *be an element on it. Then it's true membership functions* $T_\Gamma(\zeta)$*, indeterminacy membership functions* $I_\Gamma(\zeta)$ *and false membership functions* $F_\Gamma(\zeta)$ *are represented respectively as:*

$$T_\Gamma(\zeta) = \begin{cases} 0 & if\ \zeta \leq 2 \\ 0.7 \times \frac{(\zeta-2)}{3-2} = 0.7 \times (\zeta - 2) & if\ 2 \leq \zeta \leq 3 \\ 0.7 & if\ 3 \leq \zeta \leq 4 \\ 0.7 \times \frac{(5-\zeta)}{5-4} = 0.7 \times (5 - \zeta) & if\ 4 \leq \zeta \leq 5 \\ 0 & if\ 5 \leq \zeta \end{cases} \quad (7)$$

$$I_\Gamma(\zeta) = \begin{cases} 1 & if\ \zeta \leq 2 \\ \frac{(3-\zeta)+0.3\times(\zeta-2)}{3-2} = (3-\zeta) + 0.3 \times (\zeta - 2) & if\ 2 \leq \zeta \leq 3 \\ 0.3 & if\ 3 \leq \zeta \leq 4 \\ \frac{(\zeta-4)+0.3\times(5-\zeta)}{5-4} = (\zeta - 4) + 0.3 \times (5 - \zeta) & if\ 4 \leq \zeta \leq 5 \\ 1 & if\ 5 \leq \zeta \end{cases} \quad (8)$$

$$F_\Gamma(\zeta) = \begin{cases} 1 & if\ \zeta \le 2 \\ \frac{(3-\zeta)+0.5\times(\zeta-2)}{3-2} = (3-\zeta)+0.5\times(\zeta-2) & if\ 2 \le \zeta \le 3 \\ 0.5 & if\ 3 \le \zeta \le 4 \\ \frac{(\zeta-4)+0.5\times(5-\zeta)}{5-4} = (\zeta-4)+0.5\times(5-\zeta) & if\ 4 \le \zeta \le 5 \\ 1 & if\ 5 \le \zeta \end{cases} \quad (9)$$

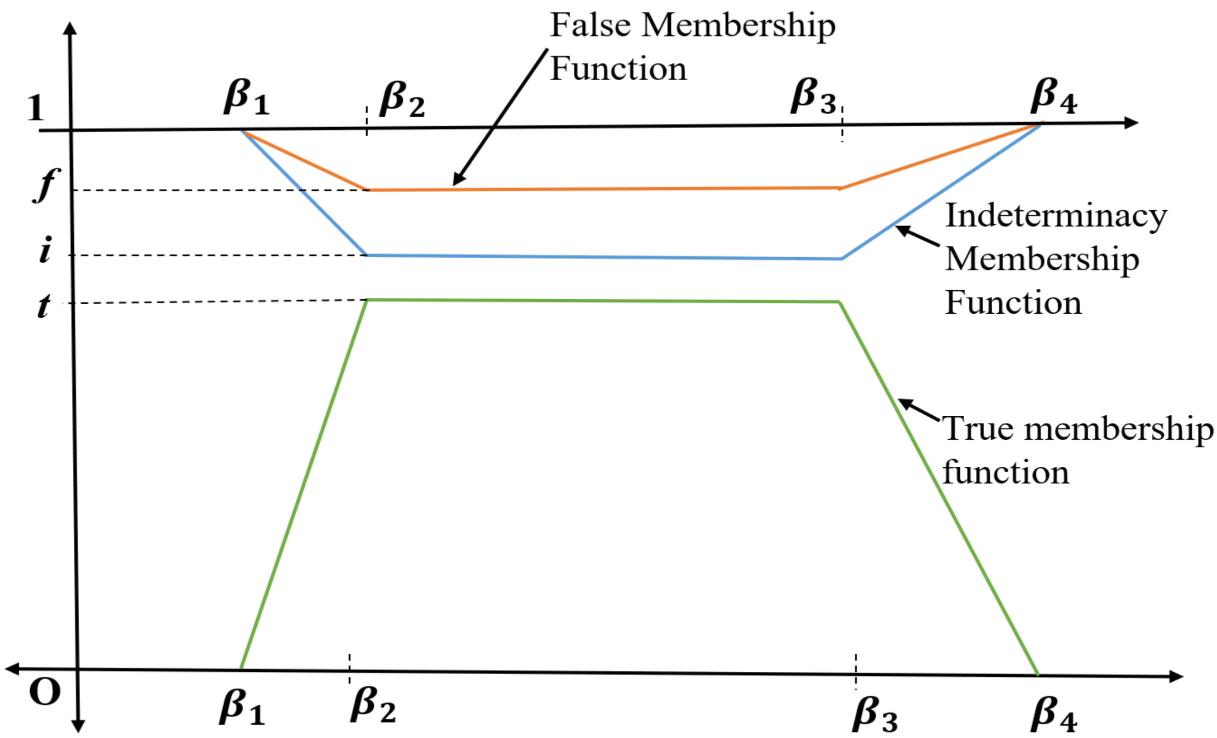

Figure 2. Geometric representation of trapezoidal neutrosophic number (TrNN).

3.5. Arithmetic Operation on TrNN

Let us consider two single-valued trapezoidal neutrosophic numbers (TrNN) $\tilde{\Gamma} = \{(\sigma_1, \sigma_2, \sigma_3, \sigma_4); t_\Gamma, i_\Gamma, f_\Gamma\}$ and $\tilde{\Lambda} = \{(\tau_1, \tau_2, \tau_3, \tau_4); t_\Lambda, i_\Lambda, f_\Lambda\}$ with t_ξ denoted true membership function, i_ξ denoted indeterminacy membership function and f_ξ denoted false membership function where $\xi \in \{\Gamma, \Lambda\}$. Therefore arithmetic operations on TrNN are defined as:

I. **Addition of two TrNNs:**

$$\tilde{\Sigma} = \tilde{\Gamma} \oplus \tilde{\Lambda} = \{(\sigma_1 + \tau_1, \sigma_2 + \tau_2, \sigma_3 + \tau_3, \sigma_4 + \tau_4); t_\Gamma + t_\Lambda - t_\Gamma t_\Lambda,\ i_\Gamma i_\Lambda,\ f_\Gamma f_\Lambda\} \quad (10)$$

II. **Negation of a TrNN:**

$$\tilde{N} = -\tilde{\Gamma} = \{(-\sigma_4, -\sigma_3, -\sigma_2, -\sigma_1); 1 - t_\Gamma, 1 - i_\Gamma, 1 - f_\Gamma\} \quad (11)$$

III. **Subtraction of two TrNNs:**

$$\tilde{\Omega} = \tilde{\Gamma} \ominus \tilde{\Lambda} = \{(\sigma_1 - \tau_1, \sigma_2 - \tau_2, \sigma_3 - \tau_3, \sigma_4 - \tau_4); 1 - t_\Lambda(1 - t_\Gamma), i_\Gamma(1 - i_\Lambda), f_\Gamma(1 - f_\Lambda)\} \quad (12)$$

IV. **Scalar multiplication of a TrNN by k:**

$$\tilde{M} = k \times \tilde{\Gamma} = \left\{(k\sigma_1, k\sigma_2, k\sigma_3, k\sigma_4); 1 - (1 - t_\Gamma)^k,\ i_\Gamma^k,\ f_\Gamma^k\right\} \quad (13)$$

V. **Multiplication of two TrNNs:**

$$\tilde{\Pi} = \tilde{\Gamma} \otimes \tilde{\Lambda} = \{(\sigma_1\tau_1, \sigma_2\tau_2, \sigma_3\tau_3, \sigma_4\tau_4); t_\Gamma t_\Lambda,\ i_\Gamma + i_\Lambda - i_\Gamma i_\Lambda,\ f_\Gamma + f_\Lambda - f_\Gamma f_\Lambda\} \quad (14)$$

VI. **Inverse of a TrNN:**

$$\tilde{I} = \tilde{\Gamma}^{-1} = \frac{1}{\{(\sigma_1, \sigma_2, \sigma_3, \sigma_4); t_\Gamma, i_\Gamma, f_\Gamma\}} = \left\{(\frac{1}{\sigma_4}, \frac{1}{\sigma_3}, \frac{1}{\sigma_2}, \frac{1}{\sigma_1}); t_\Gamma, i_\Gamma, f_\Gamma)\right\} \quad (15)$$

3.6. Distance between Two TrNN

Distance measuring between two neutrosophic numbers plays a significant role in MCDM techniques. It gives an idea of ranking of the alternatives. Biswas, P. et al. [99] introduced a distance measure formula as follows:

Definition 4. *(Hamming distance)*
Let $\tilde{\Gamma} = \{(\beta_1, \beta_2, \beta_3, \beta_4); t_\Gamma, i_\Gamma, f_\Gamma\}$ and $\tilde{\Lambda} = \{(\tau_1, \tau_2, \tau_3, \tau_4); t_\Lambda, i_\Lambda, f_\Lambda\}$ are two Trapezoidal Neutrosophic Numbers (TrNN). Then the Hamming distance between $\tilde{\Gamma}$ and $\tilde{\Lambda}$ is denoted by $d(\tilde{\Gamma}, \tilde{\Lambda})$ and defined as:

$$d(\tilde{\Gamma}, \tilde{\Lambda}) = \left\{ \begin{array}{c} |\beta_1(2 + t_\Gamma - i_\Gamma - f_\Gamma) - \tau_1(2 + t_\Lambda - i_\Lambda - f_\Lambda)| \\ +|\beta_2(2 + t_\Gamma - i_\Gamma - f_\Gamma) - \tau_2(2 + t_\Lambda - i_\Lambda - f_\Lambda)| \\ +|\beta_3(2 + t_\Gamma - i_\Gamma - f_\Gamma) - \tau_3(2 + t_\Lambda - i_\Lambda - f_\Lambda)| \\ +|\beta_4(2 + t_\Gamma - i_\Gamma - f_\Gamma) - \tau_4(2 + t_\Lambda - i_\Lambda - f_\Lambda)| \end{array} \right\} \quad (16)$$

Definition 5. *(Normalized Hamming distance)*
We consider $\tilde{\Gamma} = \{(\beta_1, \beta_2, \beta_3, \beta_4); t_\Gamma, i_\Gamma, f_\Gamma\}$ and $\tilde{\Lambda} = \{(\tau_1, \tau_2, \tau_3, \tau_4); t_\Lambda, i_\Lambda, f_\Lambda\}$ are two trapezoidal neutrosophic numbers (TrNN). Then the normalized Hamming distance between $\tilde{\Gamma}$ and $\tilde{\Lambda}$ is denoted by $d_N(\tilde{\Gamma}, \tilde{\Lambda})$ and defined as:

$$d_N(\tilde{\Gamma}, \tilde{\Lambda}) = \frac{1}{12} \times \left\{ \begin{array}{c} |\beta_1(2 + t_\Gamma - i_\Gamma - f_\Gamma) - \tau_1(2 + t_\Lambda - i_\Lambda - f_\Lambda)| \\ +|\beta_2(2 + t_\Gamma - i_\Gamma - f_\Gamma) - \tau_2(2 + t_\Lambda - i_\Lambda - f_\Lambda)| \\ +|\beta_3(2 + t_\Gamma - i_\Gamma - f_\Gamma) - \tau_3(2 + t_\Lambda - i_\Lambda - f_\Lambda)| \\ +|\beta_4(2 + t_\Gamma - i_\Gamma - f_\Gamma) - \tau_4(2 + t_\Lambda - i_\Lambda - f_\Lambda)| \end{array} \right\} \quad (17)$$

Remark 1. *In Table 5, we consider two sets of two TrNNs and find the distance between them on the basis of different distance measuring scales. In this study, we consider normalized Hamming distance (given in Equation (17)) as our distance measuring scale.*

Table 5. Distance between two TrNNs by different distance measuring scales.

TrNNs	Euclidean Distance [100–102]	Hausdorff Distance [102]	Chebyshev Distance [100]	Minkowski Distance [100] ($p = 3$)	Normalized Hamming Distance [100–102] & This Paper
$A = \{(2,3,4,5); 0.8, 0.2, 0.3\}$ & $B = \{(4,6,7,9); 0.75, 0.15, 0.2\}$	0.2179449472	0.10	0.01666667	0.0687944616	0.20
$C = \{(0.1, 0.2, 0.3, 0.4); 0.7, 0.25, 0.2\}$ & $D = \{(0.3, 0.6, 0.8, 1); 0.85, 0.15, 0.25\}$	0.0345808227	0.01875	0.003125	0.0329153016	0.0375

3.7. De-Neutrosophication of Neutrosophic Number

Let $\tilde{\Gamma} = \{(\beta_1, \beta_2, \beta_3, \beta_4); t_\Gamma, i_\Gamma, f_\Gamma\}$ be trapezoidal neutrosophic numbers (TrNN) with $0 \leq \beta_1 \leq \beta_2 \leq \beta_3 \leq \beta_4 \leq 1$ and membership functions satisfy $0 \leq t_\Gamma, i_\Gamma, f_\Gamma \leq 1$. Therefore, De-neutrosophication of neutrosophic number $\tilde{\Gamma}$ is symbolized by $\mathscr{N}(\tilde{\Gamma})$ and described as:

$$\mathscr{N}(\tilde{\Gamma}) = \frac{1}{10}(\beta_1 + \beta_2 + \beta_3 + \beta_4) \times (2 + t_\Gamma - i_\Gamma - f_\Gamma) \quad (18)$$

Note: We have constructed the formula in Equation (18) in a new way. Basically, the method stands for the transformation of a trapezoidal neutrosophic number to a crisp number. In a similar way, we may construct de-neutrosophication of other numbers, such as triangular neutrosophic numbers, pentagonal neutrosophic numbers, and hexagonal neutrosophic numbers.

Example 6. *Consider four trapezoidal neutrosophic numbers* W, X, Y & Z *and they denoted as* $W = \{(3, 4, 6, 7); 0.75, 0.35, 0.3\}$, $X = \{(5, 7, 10, 13); 0.9, 0.4, 0.2\}$, $Y = \{(0.2, 0.4, 0.5, 0.8); 0.8, 0.25, 0.3\}$ & $Z = \{(0.7, 0.8, 0.9, 1); 0.85, 0.1, 0.05\}$. *Then the different de-neutrosophication of TrNNs are shown in Table 6.*

Table 6. De-neutrosophication of trapezoidal neutrosophic number (TrNN).

TrNN	Method 1 [103]	Method 2 [103]	Method 3 [103]	Method 4 [103]	Method 5 [103]	Method 6 [103]	Method 7 [103]	Above Method (18)
W	3.6875	7	3.5	3.5	3.5	0.8333	7.5	4.2
X	7.8433	13	6.7083	6.6444	6.7374	0.2778	3.9	8.05
Y	0.3949	0.63	0.3563	0.35	0.3607	0.6403	0.175	0.4275
Z	0.6524	0.85	0.765	0.765	0.765	0.5344	0.8925	0.918

Remark 2. *De-neutrosophication of TrNNs is shown in Table 6, and methodology is described in Section 3.7 (Equation (18)). Consider four TrNN are* W, X, Y & Z *and find the corresponding de-neutrosophic number of them on the basis of different methods described in [103,104] and in this paper.*

4. Used Multi-Criteria Decision Making Methods

The MCDM methods AHP in the neutrosophic environment, TOPSIS in the neutrosophic environment, and COPRAS in the neutrosophic environment are introduced in this section. The NAHP is used to check the consistency of the decision matrix. The trapezoidal neutrosophic number for criteria weight is computed by the proposed model in the Section 4.2. The ranking of different alternatives was done by NTOPSIS and NCOPRAS method. Graphical representation of complete ranking flowchart figure shown in Figure 3.

4.1. Analytic Hierarchy Process (AHP)

Thomas L. Saaty [105] introduce AHP in the year 1980, which is one of the most familiar MCDM techniques. This method considers the mutual association between the criteria. In real-life situations, the criterion's are dependent, and thus while decision-making, the mutual relationship existence of criterion's should be taken in account. AHP is helpful for handling various qualitative and quantitative multi-criteria factors involving complicated decision-making problems. AHP algorithm works on the principle of construction of pairwise comparison matrix, based on their relative importance. This technique makes decision and calculation simple because of the delight analogy.

Considering ten criterion's and six alternatives to select the best site for women university. The steps of NAHP methods [106–108] are as follows:

I. Recognition and study of the criterion's and their respective sub-criterion's.
II. On the basis of opinions of DMs, construction of a pairwise comparison matrix with the trapezoidal neutrosophic numbers (TrNNs). Let N number of DMs give their

decision. Individual DM reveal their own view in terms of the pairwise comparison matrix of criterion's. Let us assume t number of criterion's, then, the comparison matrix has ordered $t \times t$ square matrix. Now N set of matrices are obtained $D_c = \{d_{ijc}\}$ where $c = 1, 2, \ldots, N$ & $i, j = 1, 2, \ldots, t$.

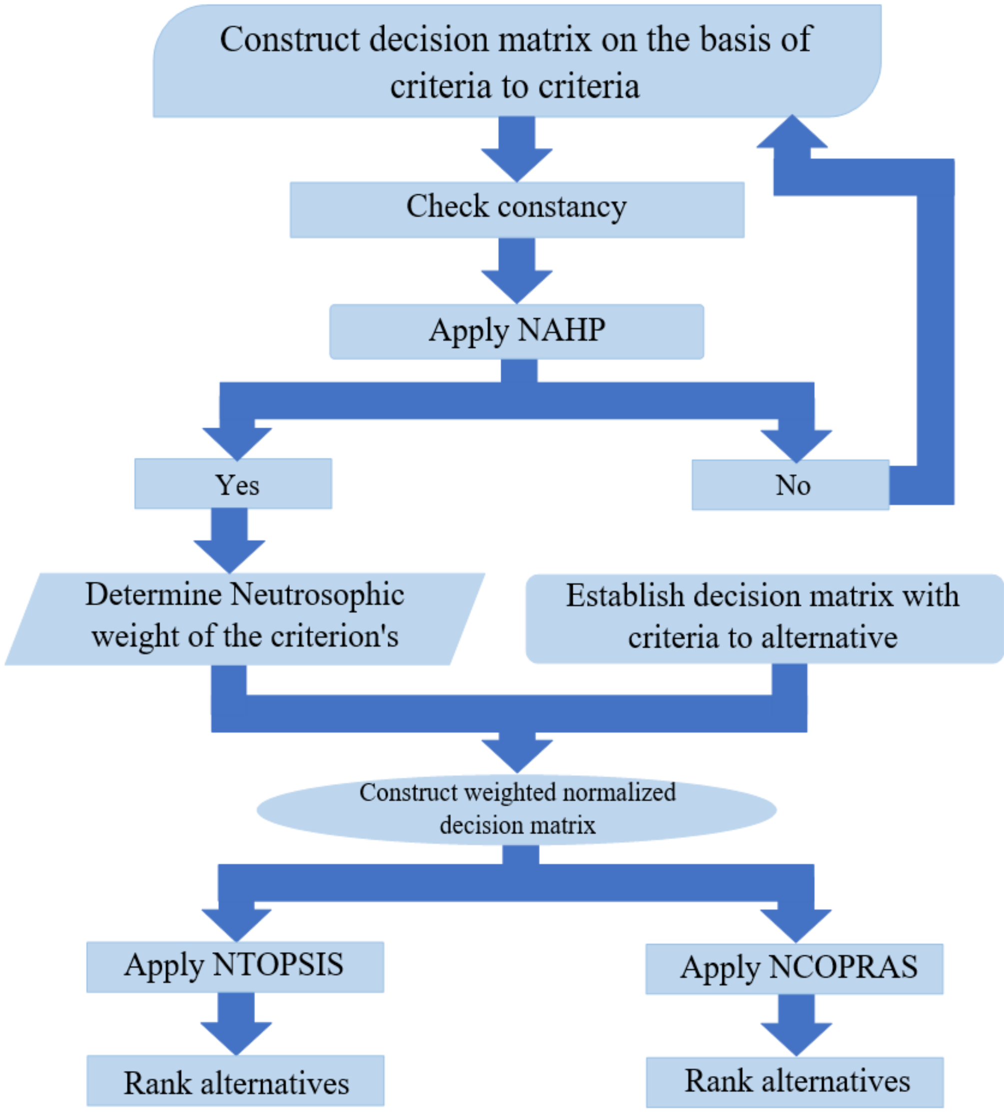

Figure 3. Diagrammatic structure of finding the best site of the women's university.

Now $d_{ijc} = \{(\alpha_{ijc}, \beta_{ijc}, \gamma_{ijc}, \delta_{ijc}); t_{ijc}, i_{ijc}, f_{ijc}\}$ indicate TrNN of i criteria to j criteria as communicate by the DM 'c'.

$$\begin{cases} \alpha_{ij} = \min_{c=1,2,\ldots,N} \alpha_{ijc} \\ \beta_{ij} = \sqrt[N]{\prod_{c=1}^{N} \beta_{ijc}} \\ \gamma_{ij} = \sqrt[N]{\prod_{c=1}^{N} \gamma_{ijc}} \\ \delta_{ij} = \max_{c=1,2,\ldots,N} \delta_{ijc} \\ t_{ij} = \min_{c=1,2,\ldots,N} t_{ijc} \\ i_{ij} = \max_{c=1,2,\ldots,N} i_{ijc} \\ f_{ij} = \max_{c=1,2,\ldots,N} f_{ijc} \end{cases} \quad (19)$$

III. De-neutrosophication of TrNN:
De-neutrosophication of the TrNN is done by using Equation (18) of the matrix

$$A_{t\times t} = [a_{ij}]_{t\times t} \tag{20}$$

where $i, j = 1, 2, \ldots, t$.

IV. Normalization of De-neutrosophication matrix:
Normalized the comparison matrix A get from Equation (20) and converted into matrix B. Each entry of B is evaluated as

$$b_{ij} = \frac{a_{ij}}{\sum_{k=1}^{t} a_{kj}} \tag{21}$$

Note: The weighted sum of each column on the normalization matrix is equal to one.

V. Evaluation of criteria weights:
Criteria weight w_j of each criteria j is determined using

$$w_j = \frac{\sum_{k=1}^{t} b_{kj}}{t} \tag{22}$$

VI. Determination of weight sum value and λ_{max}:
The weight sum value of each criterion j is

$$w'_j = \sum_{k=1}^{t} (a_{ij} \times w_j) \tag{23}$$

then λ_{max} is

$$\lambda_{max} = \frac{1}{t} \times \frac{w'_j}{w_j} \tag{24}$$

VII. Calculation of Consistency Index (CI):
The consistency index (CI) of the matrix is estimated. CI of the matrix is computed using the following:

$$CI = \frac{\lambda_{max} - t}{t-1} \tag{25}$$

where t denotes the number of criteria, which ultimately represents the size of the matrix.

VIII. Finally, the consistency ratio (CR) is calculated.

$$CR = \frac{CI}{RI} \tag{26}$$

where random index (RI) is the standardised. The values of RI varies with respect to the order of the matrix (i.e., the number of criterion). The size of the matrix and corresponding values of RI are shown in Table 7 (values of t vary 1 to 10).

Table 7. Random Index (RI) value for different size of comparison matrix (t) by Saaty [105].

Matrix Size (t)	1	2	3	4	5	6	7	8	9	10
Random Index (RI)	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

The computation of $CR \leq 0.1$ is acceptable and indicates that the weights obtained are consistent.

4.2. Determination of Trapezoidal Neutrosophic Numbers (TrNNs) Weights of Criterion's

In this study, we find an innovative way of finding trapezoidal neutrosophic numbers (TrNNs) weights of criterion. This neutrosophic weight is used in Section 4.3 for NTOPSIS method and Section 4.4 for NCOPRAS method. The computational procedures are as follows:

(a) Recognition and study of the criterion for MCDM. Construction of pairwise comparison matrix in terms of TrNNs given by the DMs.
(b) Aggregation of the opinions of 'N' DMs using the operator followed by the Equation (19).
(c) The geometric mean is calculated of the TrNN in the comparison matrix by using

$$\{(\alpha_j, \beta_j, \gamma_j, \delta_j), t_j, i_j, f_j\} = \left\{\left((\prod_{i=1}^{t}\alpha_{ij})^{\frac{1}{t}}, (\prod_{i=1}^{t}\beta_{ij})^{\frac{1}{t}}, (\prod_{i=1}^{t}\gamma_{ij})^{\frac{1}{t}}, (\prod_{i=1}^{t}\delta_{ij})^{\frac{1}{t}}\right), \min_{i=1}^{t} t_{ij}, \max_{i=1}^{t} i_{ij}, \max_{i=1}^{t} f_{ij}\right\} \quad (27)$$

(d) Addition of trapezoidal numbers and optimization of the membership numbers using the equation

$$\{(\alpha^+, \beta^+, \gamma^+, \delta^+), t^+, i^+, f^+\} = \left\{\left(\sum_{j=1}^{t}\alpha_j, \sum_{j=1}^{t}\beta_j, \sum_{j=1}^{t}\gamma_j, \sum_{j=1}^{t}\delta_j\right), \min_{j=1}^{t} t_j, \max_{j=1}^{t} i_j, \max_{j=1}^{t} f_j\right\} \quad (28)$$

(e) Calculation of the inverse of TrNN getting from the Equation (15) as follows

$$\{(\alpha^-, \beta^-, \gamma^-, \delta^-), t^-, i^-, f^-\} = \left\{\left(\frac{1}{\delta_j}, \frac{1}{\gamma_j}, \frac{1}{\beta_j}, \frac{1}{\alpha_j}\right), t_j, i_j, f_j\right\} \quad (29)$$

(f) The TrNN weights of the criteria is calculated by the equation

$$\{(\alpha_j^w, \beta_j^w, \gamma_j^w, \delta_j^w), t_j^w, i_j^w, f_j^w\} = \left\{(\alpha_j \times \alpha^-, \beta_j \times \beta^-, \gamma_j \times \gamma^-, \delta_j \times \delta^-), min\{t_j, t^-\}, max\{i_j, i^-\}, max\{f_j, f^-\}\right\} \quad (30)$$

Finally, the TrNN weight of the criterion's is obtained from the Equation (30).

4.3. The Neutrosophic Technique for Order of Preference by Similarity to Ideal Solution (NTOPSIS)

Hwang and Yoon [109] proposed MCDM method in the year 1981, which is well known as TOPSIS method. This methodology is imposed on different fields nowadays, such as engineering and manufacturing sector [110], chemical engineering [111], medicine [112], energy [113], water resources studies [114], site selection [115,116], safety and environmental field [117]. In this technique, the decision matrix is created in linguistic terms which are assigned by decision experts.

These linguistic ratings are then transformed to TrNNs [99,118]. The TrNNs are standardized, and then the PIS and NIS are computed for each alternative separately. The concept of this MCDM tool is based on measuring distance in which the optimal alternative is calculated by the nearest distance from the positive ideal solution (PIS) and the farthest distance from the negative ideal solution (NIS). Finally, for each alternative relative closeness (RC) is measured. The higher value of RC depicts the most optimal alternative. The procedure of NTOPSIS method is as follows:

I. Decision matrices are constructed on the basis of DMs in linguistic ratings. The linguistic assignments are then transformed into TrNNs.
II. Aggregation of the opinions of 'N' DMs using the operator follow by the Equation (19).
III. Standardization of the TrNNs, using the formula:

$$\tilde{S} = [S_{ij}]_{k\times l} \quad (31)$$

where $i = 1, 2, 3, \ldots, k$; $j = 1, 2, 3, \ldots, l$;
$S_{ij}^{B} = \left\langle\left(\frac{\alpha_{ij}}{\delta_j^+}, \frac{\beta_{ij}}{\delta_j^+}, \frac{\gamma_{ij}}{\delta_j^+}, \frac{\delta_{ij}}{\delta_j^+}\right), t_{ij}, i_{ij}, f_{ij}\right\rangle$; $\delta_j^+ = \max \delta_{ij}$ and $i \in$ Beneficent Criteria (B.C)
and $S_{ij}^{N.B} = \left\langle\left(\frac{\alpha_j^-}{\delta_{ij}}, \frac{\alpha_j^-}{\gamma_{ij}}, \frac{\alpha_j^-}{\beta_{ij}}, \frac{\alpha_j^-}{\alpha_{ij}}\right), t_{ij}, i_{ij}, f_{ij}\right\rangle$; $\alpha_j^- = \min \alpha_{ij}$ and $i \in$ Non-beneficent Criteria (N.B.C).

IV. Weighted standardized matrix is determined by the product of criteria's TrNNs weight (wc) and standardized TrNNs value (S_{ij}).

$$\tilde{WS} = [wcS_{ij}]_{k \times l};\ i = 1, 2, 3, \ldots, k \text{ and } j = 1, 2, 3, \ldots, l \tag{32}$$

where $TrNNW_{ij} = S_{ij} \times wc_j;\ i = 1, 2, 3, \ldots, k$ and $j = 1, 2, 3, \ldots, l$.
For the product of two TrNNs, please follow Equation (14). Trapezoidal neutrosophic numbers (TrNNs) weights of criteria's calculated by the Equation (30).

V. Determination of TrNNs positive ideal solution (TP^+) and TrNNs negative ideal solution TN^-. Here p_i^+ signifies the maximum value of p_{ij} and p_i^- denotes the minimum value of p_{ij}.
$(TP^+) =$
$\langle (r_1^+, \max_i t_{ij}, \min_i i_{ji}, \min_i f_{ij}), (r_2^+, \max_i t_{ij}, \min_i i_{ji}, \min_i f_{ij}), \ldots,$
$(r_l^+, \max_i t_{ij}, \min_i i_{ji}, \min_i f_{ij}) \rangle$

$$= \{(\max p_{ij} | j \in B.C), (\min p_{ij} | j \in N.B.C)\} \tag{33}$$

$(TN^-) =$
$\langle (r_1^-, \min_i t_{ij}, \max_i i_{ji}, \max_i f_{ij}), (r_2^-, \min_i t_{ij}, \max_i i_{ji}, \max_i f_{ij}), \ldots,$
$(r_l^-, \min_i t_{ij}, \max_i i_{ji}, \max_i f_{ij}) \rangle$

$$= \{(\min p_{ij} | j \in B.C), (\max p_{ij} | j \in N.B.C)\} \tag{34}$$

where

$$\begin{cases} r_j^+ = \{(r_j^{+1}, r_j^{+2}, r_j^{+3}, r_j^{+4})\} = \{\max_i(r_{ij}^1), \max_i(r_{ij}^2), \max_i(r_{ij}^3), \max_i(r_{ij}^4)\} \\ r_j^- = \{(r_j^{-1}, r_j^{-2}, r_j^{-3}, r_j^{-4})\} = \{\min_i(r_{ij}^1), \min_i(r_{ij}^2), \min_i(r_{ij}^3), \min_i(r_{ij}^4)\} \end{cases} \tag{35}$$

VI. Relative distance is calculated for each alternative in term of TrNNs (i.e., from positive ideal solution (TP^+) and negative ideal solution (TN^-) respectively).

$$\begin{cases} DP_j^+ = \sum_{j=1}^{l} d(p_{ij}, p_i^+), i = 1, 2, \ldots, k \\ DP_j^- = \sum_{j=1}^{l} d(p_{ij}, p_i^-), i = 1, 2, \ldots, k \end{cases} \tag{36}$$

where DP_j^+ & DP_j^- denotes the Hamming distance. The distance measure used here is given in Equation (17).

VII. Finally, calculation of relative closeness of the alternatives

$$R_j = \frac{DP_j^-}{DP_j^+ + DP_j^-} \tag{37}$$

Ultimately, the ranking of the alternatives by the obtained value of R_j. The higher value of R_j denotes the optimal alternative.

Remark 3. *In this paper, the criteria investment costs $(\tilde{m}_2)$ is only non-beneficiary criteria (NBC), and all other criteria are beneficiary criteria (BC). Beneficiary criteria (BC) are those criteria that are beneficial for selectors, and non beneficiary criteria (NBC) are the ones whose declination is beneficial for selectors.*

4.4. Neutrosophic Complex Proportional Assessment (NCOPRAS) Approach

Zavadskas, Kalklauskas, and Sarka [119] first introduced COPRAS in the year 1994. An extended representation of COPRAS is Fuzzy COPRAS which is used for the ordering of the alternatives in various decision-making problems [120]. This method is based on stepwise ranking and evaluation of the alternative in reference to utility degree and significance. Earlier, COPRAS method was applied by Ghosh, A. et al. in electric vehicle charging station site selection [116], Seker, S. in solar power plants site selection [121], Fouladgar, M.M. et al. in property management [122], economy by Narayanamoothy, S. et al. [123], Evaluating the potential capability of air cargo sector Tolga, A.C. and Durak, G. [124], selection of optimal material for the solar car by Ghose, D. et al. [125]. An application of location selection by Bausys, R. et al. [126] using Neutrosophic COPRAS method. The approach of Neutrosophic COPRAS (NCOPRAS) method is as following steps:

i. Establish of TrNN comparison matrix by the expert of decision makers. The DMs allocate in linguistic terms depending on criterion's.
ii. integration of the decision matrix of the viewpoint of 'N' DMs using the operator followed by the Equation (19).
iii. Standardization of decision matrix is computed in the same way as computed in the TOPSIS method using Equation (31).
iv. Construction of weighted standardization decision matrix which is done by product of the TrNN criteria weight and standardization decision matrix.
v. Calculation of beneficiary criteria (BC) and non-beneficiary criteria (NBC) denoted as BC^+ and NBC^- respectively as follows:

$$BC^+ = \left\{ \sum_{j\in B.C} \alpha_{ij}, \sum_{j\in B.C} \beta_{ij}, \sum_{j\in B.C} \gamma_{ij}, \sum_{j\in B.C} \delta_{ij}, \min_{j\in B.C} t_{ij}, \max_{j\in B.C} i_{ij}, \max_{j\in B.C} f_{ij} \right\}$$
$$NBC^- = \left\{ \sum_{j\in N.B.C} \alpha_{ij}, \sum_{j\in N.B.C} \beta_{ij}, \sum_{j\in N.B.C} \gamma_{ij}, \sum_{j\in N.B.C} \delta_{ij}, \max_{j\in N.B.C} t_{ij}, \min_{j\in N.B.C} i_{ij}, \min_{j\in N.B.C} f_{ij} \right\} \quad (38)$$

where $\alpha_{ij}, \beta_{ij}, \gamma_{ij}, \delta_{ij}, t_{ij}, i_{ij}$ & f_{ij} ($i = 1,2,3,\ldots,k$ and $j = 1,2,3,\ldots,l$) come from the weighted standardization matrix in Equation (32).
vi. Now, de-neutrosophication of the TrNN using the Equation (18). De-deutrosophication of the Beneficiary Criteria (BC) is denoted by S_i^+, and de-neutrosophication of the non-beneficiary criteria (NBC) is denoted by S_i^-.
vii. Calculate

$$Q_i = S_i^+ + \frac{S_{min}^- \times \sum_{i=1}^{k} S_i^-}{S_i^- \times \sum_{i=1}^{k} \left(\frac{S_{min}^-}{S_i^-} \right)} \quad (39)$$

where $S_{min}^- = min\{S_i^- : i = 1,2,3,\ldots,k\}$ and i indicate as alternatives.
viii. Calculation of the value of R_i

$$R_i = \frac{Q_i}{Q_{max}} \times 100\% \quad (40)$$

where $Q_{max} = \{Q_i : i = 1,2,3,\ldots,k\}$.
Finally, ranking of the alternative in ascending order on the R_i score.

4.5. Pseudo Code Depicting the Empirical Study Application

This study model was constructed with k number of criteria and l number of alternatives with N decision makers (DM). The input variable is given by DMs in the form of linguistic terms. The linguistic terms transform to TrNN to get the output, i.e., ranking alternatives on the process of the neutrosophic MCDM method. The comparison matrix is $k \times k$ matrix form, and the decision matrix is $l \times k$ matrix form.

INPUT: Comparison matrix & Decision matrix
OUTPUT: Ranking the alternatives
COMPUTE: Consistency ratio, weight of the criteria in TrNN
INITIALIZE: TrNN
OPERATION: NAHP, weight in TrNN, NTOPSIS & NCOPRAS

1. **FOR NAHP**
2. **MERGE** merge the N number of DMs inputs of comparison matrix
3. **IF** comparison matrix is inconsistent ($CR \geq 0.1$)
4. **THEN** reconstruct the comparison matrix
5. **ELSE** comparison matrix is consistent ($CR < 0.1$)
6. **END FOR**
7. **COMPUTE** TrNN weight of the criteria
8. **CONSTRUCT** comparison matrix
9. **THEN** compute the weighted normalized comparison matrix
10. **FIND** determine the weight of the criteria in TrNN
11. **THEN** consider the N decision matrix given by DMs
12. **MERGE** merge the N number of DMs inputs of decision matrix
13. **COMPUTE** determination of the weighted normalised decision matrix
14. **BEGIN NTOPSIS**
15. **COMPUTE** calculation of the ranking of the alternatives using weighted normalized decision matrix
16. **END NTOPSIS**
17. **BEGIN NCOPRAS**
18. **COMPUTE** calculation of the ranking of the alternatives using weighted normalized decision matrix
19. **END NCOPRAS**

5. Model for Setting Up a Government/Government Aided University for Women (Selection of the Alternatives)

In backward /under privileged area people's perception towards the co-educational universities and women universities are different. Poor families with their conservative mentality possess inhibitions while sending their girl child to co-educational universities as they have concerns about safety, security and family honour. Hence many attributes which are not so important for co-educational universities are more pertinent for women university. Considering the real-life problem of selecting a university site in the state of eastern India, namely West Bengal, which has been chosen for the current study. From [86,87], the references indicates that there is been only two women's universities currently in this state. So, this study focuses on this fact and thus, site selection for upcoming women's Universities has been chosen for this research. To achieve this goal, identification and evaluation of criteria's are conducted by the expert opinion. Further, sites (headquarter of some district) which are satisfying the needs of the criteria are selected. Furthermore, two criteria's are considered and well thought keeping in mind about women university which are safety and sex ratio. Criteria weight's are computed using the FAHP approach and then ranking of the sites are executed using MCDM tool TOPSIS and COPRAS.

Six locations in different districts of West Bengal are selected for the setup of a government/government-aided women's university. Presently in West Bengal, India, there is two women's university. The first one is "Diamond Harbour Women's University" in Diamond Harbour, South 24 Parganas district, and another is "Kanyashree University" in Krishnanagar, Nadia district. According to the 2011 census, [127] population of West Bengal is 91,276,115, where the female population is 44,467,088, and the male population is 46,809,027. The literacy rate for females is 70.54% and for males 81.69% and overall 76.36%. Female literacy is 10.93% more than the 2001 census. Six locations are considered as alternatives for choosing the best site for women university; Table 8 give their details and Figure 4 shows the position in West Bengal, India's map.

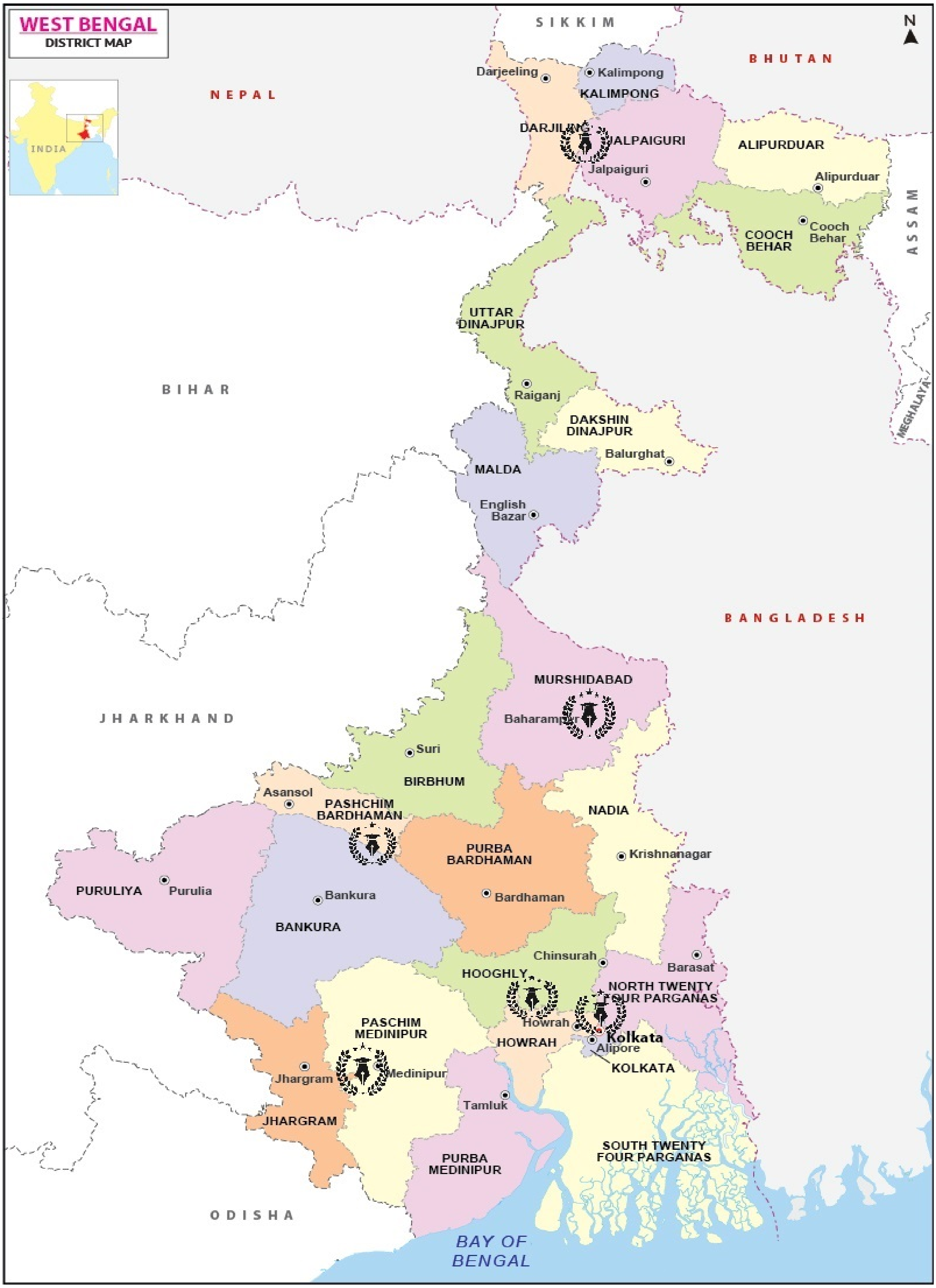

Figure 4. Used locations for Women's University in West Bengal, India [128].

Table 8. Used location (alternative) details.

Location	District	Latitude & Longitude	Location Details
Kolkata (L_{A1})	kolkata	22.5726 °N, 88.3639 °E	It is the capital city of West Bengal.
Howrah (L_{A2})	Howrah	22.5958 °N, 88.2636 °E	It is the capital city of Howrah district.
Berhampore (L_{A3})	Murshidabad	24.0983 °N, 88.2684 °E	It is the capital city of Murshidabad district.
Siliguri (L_{A4})	Darjeeling	26.7271 °N, 88.3953 °E	This city is in Darjeeling district base of the Himalaya mountains and the side of Mahananda river. It is second largest city of West Bengal.
Midnapore (L_{A5})	Paschim Medinipur	22.4257 °N, 87.3199 °E	This city beside the Kangsabati river and capital city of Midnapore district.
Durgapur (L_{A6})	Paschim Bardhaman	23.5204 °N, 87.3119 °E	It is the capital city of Burdwan district.

6. Criteria of Women's University Site Selection

In this section, we are focusing on the different criteria for women's university site selection. After consulting a few experts, we have finalized the following ten criterion. The hierarchical data structure of the Women University site selection is shown in Figure 5.

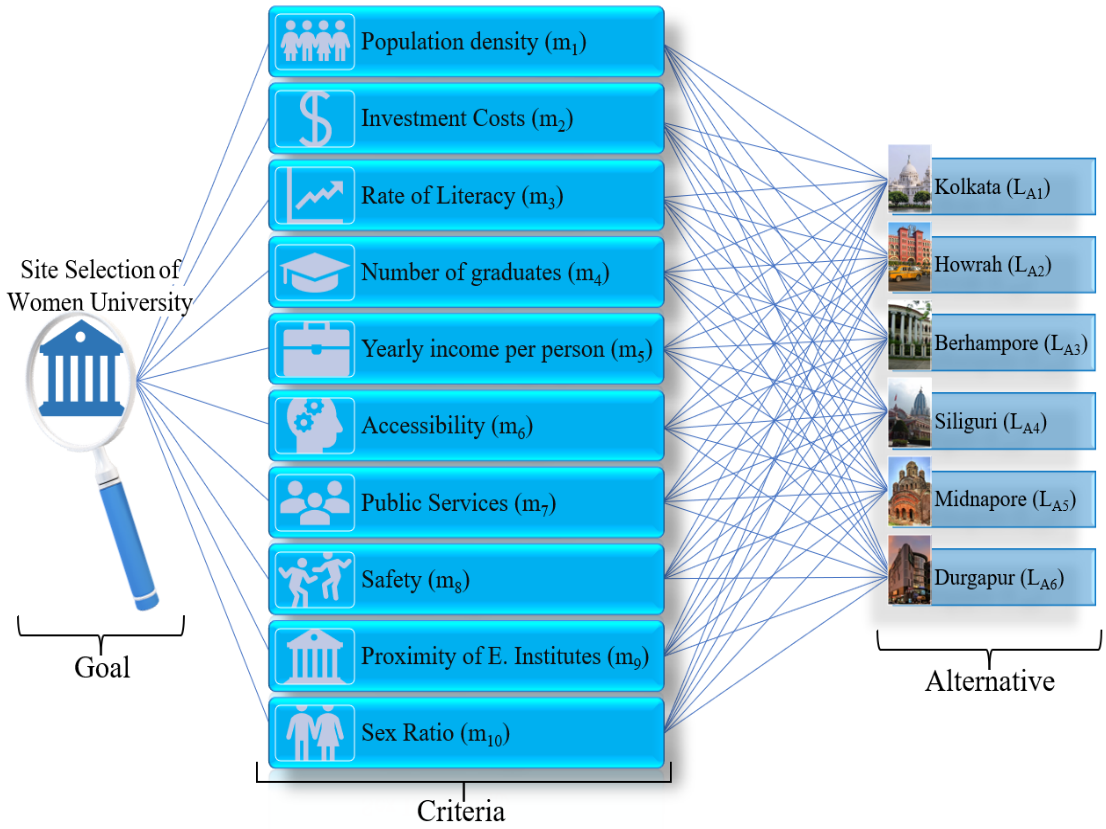

Figure 5. The Hierarchical structure of Women's University site selection problem.

6.1. Population Density ($\tilde{m}_1$) (Fixed Data)

Population density means the number of individuals per unit geographic area. It is commonly expressed in per square km. The large population density of a specific zone implies a greater probability of students enrolling for higher studies. The probability becomes obvious, if the literacy rate of the related area is higher.

6.2. Investment Costs ($\tilde{m}_2$)

Investment cost implies the aggregate cost connected with the project of selecting a site for University construction. This cost includes the price of the land, construction costs, operating costs, and management costs.

6.3. Rate of Literacy ($\tilde{m}_3$) (Fixed Data)

Literacy means the ability of a person in regard to knowledge, optimal decision, behavior, confidence, intellect, rational thinking, communication, etc. Literacy builds a person more willing to acquire or aspire to higher goals. Thus the rate of Literacy is an important attribute when one thinks about the construction of higher educational institutions.

UNESCO, 2010 answers, "Why Is Literacy Important?" in an efficient way, i.e., "Literacy is a human right, a tool of personal empowerment and a means for social and human development. Educational opportunities depend on Literacy. Literacy is at the heart of basic education for all and essential for eradicating poverty, reducing child mortality, curbing population growth, achieving gender equality, and ensuring sustainable development, peace, and democracy".

6.4. Number of Graduates ($\tilde{m}_4$)

This criterion implies the number of the person who has completed their graduation degree and is interested in higher studies. If the number of graduates in a particular location is more, then the possibility of University construction in that specific site increases. The potentiality of a person to study at university is directly proportional to his/her graduate degree.

6.5. Yearly Income per Person ($\tilde{m}_5$)

Income and education have a strong relationship. Higher education leads to multiple professions with good income and vice versa. The person with higher education has low average unemployment than those with less or no education. Thus, data on yearly income per person in the area strongly signifies a greater number of students who can pursue higher studies.

6.6. Accessibility ($\tilde{m}_6$)

Accessible facilities include road transport, i.e., accessibility to vehicles such as trains, buses, and premises accommodation/ hostels for professors, students, and non-teaching staff are quintessential for University site selection.

6.7. Public Services ($\tilde{m}_7$)

Fire safety, such as fire alarms and fire devices, is important to avoid fire dangers in educational institutions. Fire disasters can be prevented if the institutes religiously follow righteous fire safety measures.

6.8. Safety ($\tilde{m}_8$)

Safety for the students and Professors is equally important. Places where social hazards in the neighborhood, such as high incidence of crime and drug or alcohol abuse, are not to be considered safe for University construction. For Women University Site selection, the literacy rate in that area, male/female, is considered significant.

6.9. Proximity of Educational Institutes ($\tilde{m}_9$)

Sites that are selected close to libraries, educational institutions/research institutes are preferred more than those sites which don't have these facilities nearby.

6.10. Sex Ratio ($\tilde{m}_{10}$) (Fixed Data)

The sex ratio or gender ratio is the ratio of females to males in a population. Since this research is about women's University site selection, this factor is quite significant for finding out the optimal site.

7. Data Collection

Data collection for the various sites with respect to different criteria was obtained from the government portal. However, data for every year was not available for all criteria. Thus, the past records were analyzed, and a scale was made corresponding to which the linguistic terms were considered. In criteria-to-criteria comparison, linguistic rating to TrNN transformation by DMs are shown in Table 9. We also give Table 10 for related criterion's with their units and data collection procedure. Researchers may consider another TrNN too. The same concept is applicable in Table 11 where the linguistic rating for criteria to alternative with TrNN is given. The fixed data scaling is also linguistic conversion is performed in our own way (see Tables 12 and 13). Without the fixed data cases, all the linguistic ratings for criteria to criteria and criteria to an alternative are shown in Tables 14 and 15, respectively.

Table 9. Linguistic terms and their corresponding TrNN.

Linguistic Terms	Trapezoidal Neutrosophic Numbers (TrNN)
Equally Important (EI)	$\{(0.4, 0.5, 0.6, 0.7); 0.85, 0.20, 0.15\}$
Moderately Important (MI)	$\{(0.5, 0.6, 0.7, 0.8); 0.85, 0.15, 0.10\}$
Strongly Important (SI)	$\{(0.6, 0.7, 0.8, 0.9); 0.90, 0.15, 0.10\}$
Very Strongly Important (VSI)	$\{(0.7, 0.8, 0.9, 0.95); 0.90, 0.10, 0.05\}$
Absolutely Important (AI)	$\{(0.8, 0.9, 0.95, 1.0); 0.95, 0.10, 0.00\}$
Moderately Not Important (MNI)	$\{(0.3, 0.4, 0.5, 0.6); 0.80, 0.20, 0.15\}$
Strongly Not Important (SNI)	$\{(0.2, 0.3, 0.4, 0.5); 0.80, 0.25, 0.15\}$
Very Strongly Not Important (VSNI)	$\{(0.1, 0.2, 0.3, 0.4); 0.80, 0.25, 0.20\}$
Absolutely Not Important (ANI)	$\{(0.0, 0.1, 0.2, 0.3); 0.75, 0.30, 0.20\}$

Table 10. Related criterion's with their units and data sources.

Serial No	Criteria	Scales (Units)	Source of Data
1	Population density ($\tilde{m}_1$)	This is calculated by average number of population per square kilometer.	This is fixed data collected from Census2011 [129].
2	Investment Costs ($\tilde{m}_2$)	In Rupees.	After considering the investment costs different location.
3	Rate of Literacy ($\tilde{m}_3$)	Divide the number of literates of a given age range by the corresponding age group population and then multiply the result by 100.	This is fixed data collected from Census2011 [129].
4	Number of graduates ($\tilde{m}_4$)	Number of people.	Based on literacy rate.
5	Yearly income per person ($\tilde{m}_5$)	In Rupees.	After considering the average income of the district where the sites are located.
6	Accessibility ($\tilde{m}_6$)	Linguistics term (good, bad etc.).	After seeing the transport and related system of the sites.
7	Public Services ($\tilde{m}_7$)	Linguistics term.	After seeing whether there is public service active or not nearby the sites.
8	Safety ($\tilde{m}_8$)	Linguistics term	After analysing the crime agents women and crime rate nearby the sites.
9	Proximity of E. Institutes ($\tilde{m}_9$)	Linguistics term	After seeing nearby educational institutes exist or not.
10	Sex Ratio ($\tilde{m}_{10}$)	Number of women per 1000 men.	This is fixed data collected from Census2011 [129].

Remark 4. *The linguistic rating by TrNN is given in the above Table 9. This numerical rating is done by us in a scientific manner. Maybe anyone can modify it in their own way but need to follow the ideology of linguistic rating.*

Table 11. Linguistic terms and their corresponding TrNN for rating alternatives.

Linguistic Terms	Trapezoidal Neutrosophic Numbers (TrNN)
Low priority (LP)	$\{(0.0, 0.1, 0.2, 0.3); 0.75, 0.20, 0.20\}$
Below Priority (BP)	$\{(0.2, 0.3, 0.4, 0.5); 0.80, 0.20, 0.15\}$
Medium priority (MP)	$\{(0.4, 0.5, 0.6, 0.7); 0.85, 0.15, 0.15\}$
Very priority (VP)	$\{(0.6, 0.7, 0.8, 0.9); 0.90, 0.10, 0.15\}$
Extremely priority (EP)	$\{(0.7, 0.8, 0.9, 1.0); 0.95, 0.15, 0.00\}$

Table 12. Fixed data for Population density ($\tilde{m}_1$), Rate of Literacy ($\tilde{m}_3$) & Sex Ratio ($\tilde{m}_{10}$).

Alternative	Population Density ($\tilde{m}_1$)	Rate of Literacy ($\tilde{m}_3$)	Sex Ratio ($\tilde{m}_{10}$)
Kolkata (L_{A1})	24306	86.31%	908
Howrah (L_{A2})	3306	83.31%	939
Berhampore (L_{A3})	1334	66.59%	958
Siliguri (L_{A4})	586	79.56%	970
Midnapore (L_{A5})	631	78.00%	966
Durgapur (L_{A6})	1099	76.21%	945

Table 13. Conversion table between fixed data to linguistic terms.

Linguistic Terms	Population Density ($\tilde{m}_1$)	Rate of Literacy ($\tilde{m}_3$)	Sex Ratio ($\tilde{m}_{10}$)
Low priority (LP)	$\tilde{m}_1 < 500$	$\tilde{m}_3 < 65$	$\tilde{m}_{10} < 910$
Below priority (BP)	$500 \leq \tilde{m}_1 < 1000$	$65 \leq \tilde{m}_3 < 70$	$910 \leq \tilde{m}_{10} < 935$
Medium priority (MP)	$1000 \leq \tilde{m}_1 < 3000$	$70 \leq \tilde{m}_3 < 75$	$935 \leq \tilde{m}_{10} < 960$
Very priority (VP)	$3000 \leq \tilde{m}_1 < 15000$	$75 \leq \tilde{m}_3 < 80$	$960 \leq \tilde{m}_{10} < 985$
Extremely priority (EP)	$15000 \leq \tilde{m}_1$	$80 \leq \tilde{m}_3$	$985 \leq \tilde{m}_{10}$

Table 14. Comparison matrix in linguistic term between criterion's by the three DMs.

	Criteria	$\tilde{m}_1$	$\tilde{m}_2$	$\tilde{m}_3$	$\tilde{m}_4$	$\tilde{m}_5$	$\tilde{m}_6$	$\tilde{m}_7$	$\tilde{m}_8$	$\tilde{m}_9$	$\tilde{m}_{10}$
Decision Maker 1	Population density ($\tilde{m}_1$)	EI	VSNI	VSNI	SNI	EI	SNI	ANI	ANI	MNI	AI
	Investment Costs ($\tilde{m}_2$)	VSI	EI	VSNI	SNI	SI	VSNI	SNI	ANI	EI	ANI
	Rate of Literacy ($\tilde{m}_3$)	VSI	VSI	EI	EI	AI	EI	MI	EI	SI	SI
	Number of graduates ($\tilde{m}_4$)	SI	SI	EI	EI	SI	EI	EI	SNI	EI	SI
	Yearly income per person ($\tilde{m}_5$)	EI	SNI	ANI	SNI	EI	ANI	VSNI	ANI	SI	ANI
	Accessibility ($\tilde{m}_6$)	SI	VSI	EI	EI	AI	EI	SI	EI	SI	ANI
	Public Services ($\tilde{m}_7$)	AI	SI	MNI	EI	VSI	SNI	EI	SNI	EI	ANI
	Safety ($\tilde{m}_8$)	AI	AI	EI	SI	AI	EI	SI	EI	AI	AI
	Proximity of E. Institutes ($\tilde{m}_9$)	MI	EI	SNI	EI	SNI	SNI	EI	ANI	EI	MNI
	Sex Ratio ($\tilde{m}_{10}$)	ANI	AI	SNI	SNI	AI	AI	AI	ANI	MI	EI
	Criteria	$\tilde{m}_1$	$\tilde{m}_2$	$\tilde{m}_3$	$\tilde{m}_4$	$\tilde{m}_5$	$\tilde{m}_6$	$\tilde{m}_7$	$\tilde{m}_8$	$\tilde{m}_9$	$\tilde{m}_{10}$
Decision Maker 2	Population density ($\tilde{m}_1$)	EI	SNI	ANI	VSNI	MNI	SNI	SNI	ANI	MNI	AI
	Investment Costs ($\tilde{m}_2$)	SI	EI	ANI	SNI	VSI	SNI	SNI	VSNI	MNI	VSNI
	Rate of Literacy ($\tilde{m}_3$)	AI	AI	EI	MI	VSI	EI	SI	EI	EI	VSI
	Number of graduates ($\tilde{m}_4$)	VSI	SI	MNI	EI	AI	MI	SI	ANI	MNI	SI
	Yearly income per person ($\tilde{m}_5$)	MI	VSNI	VSNI	ANI	EI	ANI	VSNI	ANI	MI	VSNI
	Accessibility ($\tilde{m}_6$)	SI	SI	EI	MNI	AI	EI	EI	EI	SI	ANI
	Public Services ($\tilde{m}_7$)	SI	SI	SNI	SNI	VSI	EI	EI	SNI	EI	VSNI
	Safety ($\tilde{m}_8$)	AI	VSI	EI	AI	AI	EI	SI	EI	VSI	VSI
	Proximity of E. Institutes ($\tilde{m}_9$)	MI	MI	EI	MI	MNI	SNI	EI	VSNI	EI	EI
	Sex Ratio ($\tilde{m}_{10}$)	ANI	VSI	VSNI	SNI	VSI	AI	VSI	VSNI	EI	EI

Table 14. *Cont.*

	Criteria	$\tilde{m}_1$	$\tilde{m}_2$	$\tilde{m}_3$	$\tilde{m}_4$	$\tilde{m}_5$	$\tilde{m}_6$	$\tilde{m}_7$	$\tilde{m}_8$	$\tilde{m}_9$	$\tilde{m}_{10}$
Decision Maker 3	Population density ($\tilde{m}_1$)	EI	MNI	MNI	SNI	MI	ANI	ANI	VSNI	EI	VSI
	Investment Costs ($\tilde{m}_2$)	MI	EI	VSNI	ANI	SNI	MI	VSNI	ANI	SI	ANI
	Rate of Literacy ($\tilde{m}_3$)	MI	VSI	EI	MI	AI	SI	EI	EI	MI	MI
	Number of graduates ($\tilde{m}_4$)	SI	AI	MNI	EI	AI	SI	EI	EI	SI	VSI
	Yearly income per person ($\tilde{m}_5$)	MNI	SI	ANI	ANI	EI	VSNI	SNI	SNI	SNI	VSNI
	Accessibility ($\tilde{m}_6$)	AI	MNI	SNI	SNI	VSI	EI	MI	SNI	MI	VSNI
	Public Services ($\tilde{m}_7$)	AI	VSI	EI	EI	SI	MNI	EI	EI	SNI	ANI
	Safety ($\tilde{m}_8$)	VSI	AI	EI	EI	SI	SI	EI	EI	MNI	AI
	Proximity of E. Institutes ($\tilde{m}_9$)	EI	SNI	MNI	SNI	SI	MNI	SI	MNI	EI	MNI
	Sex Ratio ($\tilde{m}_{10}$)	VSNI	AI	MNI	VSNI	VSI	VSI	AI	ANI	MI	EI

Remark 5. *All data about Population density* ($\tilde{m}_1$) *& Sex Ratio* ($\tilde{m}_{10}$) *are collect from Census2011 [129] and Rate of Literacy* ($\tilde{m}_3$) *data is from Wikipedia [130] shown in Table 12. Those data are taken from authorised sources in the year 2011. Transformation of fixed data to linguistic term are shown in Table 13.*

Table 15. Comparison matrix in linguistic terms between criterion's and alternatives by three DMs.

	Criteria	$\tilde{m}_1$	$\tilde{m}_2$	$\tilde{m}_3$	$\tilde{m}_4$	$\tilde{m}_5$	$\tilde{m}_6$	$\tilde{m}_7$	$\tilde{m}_8$	$\tilde{m}_9$	$\tilde{m}_{10}$
Decision Maker 1	Kolkata (L_{A1})	EP	EP	EP	MP	MP	EP	EP	MP	EP	LP
	Howrah (L_{A2})	VP	MP	EP	LP	BP	VP	EP	LP	BP	MP
	Berhampore (L_{A3})	MP	BP	BP	LP	BP	BP	LP	LP	LP	MP
	Siliguri (L_{A4})	BP	MP	VP	LP	BP	MP	BP	BP	LP	VP
	Midnapore (L_{A5})	BP	BP	VP	MP	BP	MP	MP	MP	MP	VP
	Durgapur (L_{A6})	MP	MP	VP	MP	MP	BP	BP	MP	BP	MP
	Criteria	$\tilde{m}_1$	$\tilde{m}_2$	$\tilde{m}_3$	$\tilde{m}_4$	$\tilde{m}_5$	$\tilde{m}_6$	$\tilde{m}_7$	$\tilde{m}_8$	$\tilde{m}_9$	$\tilde{m}_{10}$
Decision Maker 2	Kolkata (L_{A1})	EP	EP	EP	MP	VP	EP	EP	VP	VP	LP
	Howrah (L_{A2})	VP	VP	EP	BP	MP	EP	VP	BP	MP	MP
	Berhampore (L_{A3})	MP	BP	BP	LP	LP	MP	LP	MP	LP	MP
	Siliguri (L_{A4})	BP	BP	VP	LP	MP	VP	MP	BP	LP	VP
	Midnapore (L_{A5})	BP	MP	VP	EP	MP	VP	BP	VP	MP	VP
	Durgapur (L_{A6})	MP	BP	VP	BP	BP	MP	BP	BP	BP	MP
	Criteria	$\tilde{m}_1$	$\tilde{m}_2$	$\tilde{m}_3$	$\tilde{m}_4$	$\tilde{m}_5$	$\tilde{m}_6$	$\tilde{m}_7$	$\tilde{m}_8$	$\tilde{m}_9$	$\tilde{m}_{10}$
Decision Maker 3	Kolkata (L_{A1})	EP	VP	EP	VP	VP	VP	EP	VP	EP	LP
	Howrah (L_{A2})	VP	VP	EP	MP	MP	VP	EP	BP	BP	MP
	Berhampore (L_{A3})	MP	BP	BP	BP	LP	BP	LP	BP	BP	MP
	Siliguri (L_{A4})	BP	MP	VP	LP	BP	MP	BP	MP	BP	VP
	Midnapore (L_{A5})	BP	MP	VP	VP	MP	BP	MP	VP	MP	VP
	Durgapur (L_{A6})	MP	BP	VP	BP	BP	BP	LP	MP	LP	MP

8. Numerical Illustration

The numerical computation using the said strategy mentioned in Section 4 for the proposed model mentioned in Section 5 associated with the data set mentioned in Section 6 is performed in this section. The following steps are followed by us for numerical computation. The flowchart of the selection process is also shown in Figure 3.

8.1. Step 1

Using the data of Table 14 associated with the Table 9 apply the NAHP formulas, which are described in Section 4.1. The consistency of the decision matrix is examined. The decision matrix is found out to be consistent (<0.1). The criterion's weight in crisp value is described in Table 16.

Table 16. Normalized criterion's weight using neutrosophic AHP.

Criteria	$\tilde{m}_1$	$\tilde{m}_2$	$\tilde{m}_3$	$\tilde{m}_4$	$\tilde{m}_5$	$\tilde{m}_6$	$\tilde{m}_7$	$\tilde{m}_8$	$\tilde{m}_9$	$\tilde{m}_{10}$
Criteria weight	0.0696	0.0677	0.1400	0.1197	0.0578	0.1074	0.0989	0.1478	0.0932	0.0979

Remark 6. *The crisp weight of all criteria is shown in Table 16 using NAHP. The values reflect that the criteria 'Safety' ($\tilde{m}_8$) is the most important followed by 'Rate of Literacy' ($\tilde{m}_3$), 'Number of Graduates' ($\tilde{m}_4$), 'Accessibility' ($\tilde{m}_6$), 'Public Services' ($\tilde{m}_7$), 'Sex ratio' ($\tilde{m}_{10}$), 'Proximity of E. Institutes' ($\tilde{m}_9$), 'Population Density' ($\tilde{m}_1$), 'Investment Costs' ($\tilde{m}_2$) and 'Yearly income per Person' ($\tilde{m}_5$) is the least significant criteria amongst the site selection criteria.*

8.2. Step 2

Utilization of the DMs data given in Table 14 with the linguistic term to converted TrNN using Table 9 we apply the neutrosophic weight calculating formulas, described in Section 4.2. The neutrosophic weight of all criteria is shown in Table 17 where $\beta_1, \beta_2, \beta_3$ & β_4 are the first, second, third, and forth entries of the trapezoidal neutrosophic numbers respectively and t for true, i for indeterminacy and f for false membership value.

Table 17. Depiction of neutrosophic criteria weight for criterion's.

Criteria	β_1	β_2	β_3	β_4	t	i	f
Population density ($\tilde{m}_1$)	0.0000	0.0536	0.0929	0.6438	0.7500	0.3000	0.2000
Investment costs ($\tilde{m}_2$)	0.0000	0.0528	0.0925	0.6458	0.7500	0.3000	0.2000
Rate of literacy ($\tilde{m}_3$)	0.0634	0.1146	0.1647	0.9274	0.8500	0.2000	0.1500
Number of graduates ($\tilde{m}_4$)	0.0000	0.0972	0.1454	0.9104	0.7500	0.3000	0.2000
Yearly income per person ($\tilde{m}_5$)	0.0000	0.0425	0.0791	0.6024	0.7500	0.3000	0.2000
Accessibility ($\tilde{m}_6$)	0.0000	0.0873	0.1340	0.8142	0.7500	0.3000	0.2000
Public services ($\tilde{m}_7$)	0.0000	0.0798	0.1247	0.7703	0.7500	0.3000	0.2000
Safety ($\tilde{m}_8$)	0.0649	0.1228	0.1734	0.9633	0.8000	0.2000	0.1500
Proximity of E. institutes ($\tilde{m}_9$)	0.0000	0.0751	0.1178	0.7849	0.7500	0.3000	0.2000
Sex ratio ($\tilde{m}_{10}$)	0.0000	0.0764	0.1222	0.7359	0.7500	0.3000	0.2000

8.3. Step 3

Application of NTOPSIS ranking model which is described in Section 4.3. The positive ideal solution (TP_j^+), negative ideal solution (TN_j^-), and relative closeness R_j with ranking on the basis of R_j values are represented in Table 18.

Table 18. Alternatives ranking with their adjacent data by using the **NTOPSIS** method.

Alternatives	TP_j^+	TN_j^-	$R_j = \frac{TN_j^-}{TP_j^+ + TN_j^-}$	Ranking
Kolkata (L_{A1})	0.1382	0.8824	0.8646	**1**
Howrah (L_{A2})	0.3527	0.6680	0.6545	**2**
Berhampore (L_{A3})	0.8321	0.1886	0.1847	**6**
Siliguri (L_{A4})	0.6078	0.4160	0.4063	**5**
Midnapore (L_{A5})	0.3555	0.6656	0.6518	**3**
Durgapur (L_{A6})	0.6058	0.4178	0.4082	**4**

8.4. Step 4

Using all data as the previous Section 8.3, we perform an analysis using by NCOPRAS method for ranking, which is discussed in Section 4.4. The De-Neutrosophication sum of beneficiary criteria (BC) is denoted by S_i^+, and the De-Neutrosophication sum of non-beneficiary criteria (NBC) is denoted by S_i^-. The factor Q_i is mentioned in Equation (39), and its percentage is denoted by R_i. All the computation values and ranking of the alternative on ascending order of R_i values are described in Table 19.

Table 19. Alternatives ranking and their adjacent data by using the **NCOPRAS** method.

Alternatives	S_i^+	S_i^-	Q_i	$R_i(\%)$	Ranking
Kolkata (L_{A1})	1.807561	0.056614	2.062153	100.0	**1**
Howrah (L_{A2})	1.58208	0.082565	1.756652	85.18	**2**
Berhampore (L_{A3})	1.099746	0.165103	1.187046	57.56	**6**
Siliguri (L_{A4})	1.356608	0.159694	1.446866	70.16	**5**
Midnapore (L_{A5})	1.653031	0.159694	1.743288	84.53	**3**
Durgapur (L_{A6})	1.361117	0.162181	1.44999	70.31	**4**

Remark 7. *From Table 18, Table 19, and Figure 6, we see that the ranking for alternative gives the same result for two methods NTOPSIS and NCOPRAS, respectively. So the decision maker can easily take the preferable sites for the mentioned alternatives. The sites 'Kolkata' come to the first position, Howrah becomes the second position, Midnapore becomes the third position, Durgapur becomes the fourth position, Siliguri becomes the fifth position, and Berhampore becomes the sixth position.*

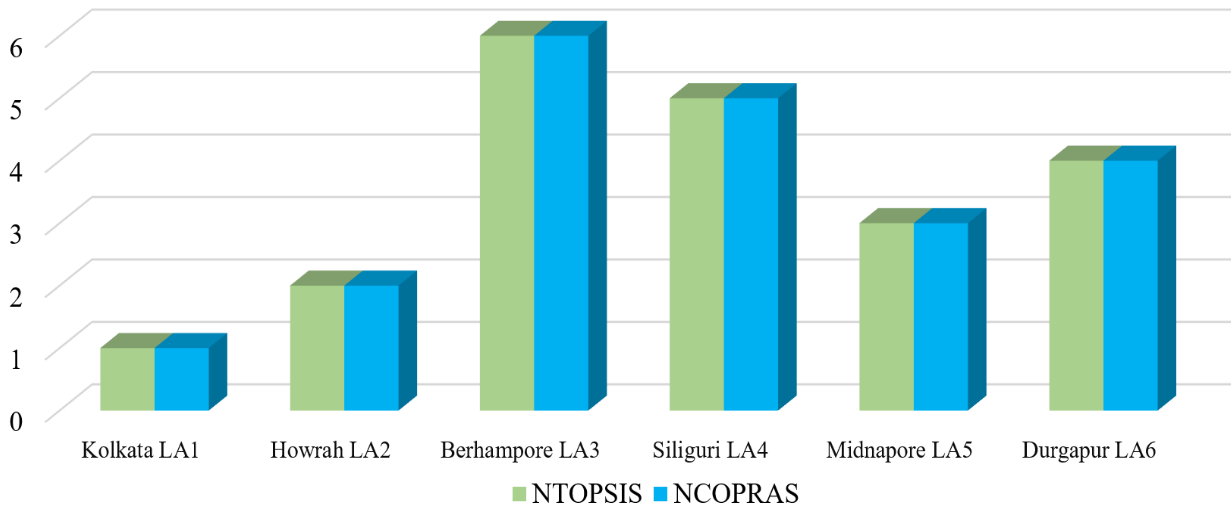

Figure 6. Comparative ranking diagram between NTOPSIS & NCOPRAS methods.

8.5. Computational Complexity

The computational complexity of the proposed fuzzy MCDM methodology has been described in this section. For example, the concept of computational complexity is also described in [131–133]. The number of mathematical operations has been performed to get the result is determined by time complexity which is denoted by TC in this study. We also assume l as the number of factors, k as the number of alternatives with N as the number of decision-makers. Thereafter, the following steps are taken to compute the computational complexity.

1. For NAHP, the comparison matrix is of l^2 entries; therefore, by N DMs gives $N \times l^2$ entries. Finding a comparison matrix has been Nl^2 operations needed. Then De-Neutrosophic process l^2 number of operations performed and to get normalized

De-Neutrosophic comparison matrix l^2 operations conducted. Thereafter to find the nth root and factor weight needed $2l + 1$ operations. Also, factor weight needs l^2 operations. Then factor sum and sum/weight are calculated by $2l$ operations. Finally, the consistency ratio is calculated by 3 more operations. Total operations conducted for NAHP are $N \times l^2 + l^2 + l^2 + 2l + 1 + l^2 + 2l + 3 = (N+3)l^2 + 4(l+1)$.

2. For Trapezoidal Neutrosophic Number (TrNN) factor weight calculated on comparison matrix with given N DMs total $N \times l^2$ entries. Calculation of geometric mean by $7l$ operations. The sum and inverse operations performed by 2 number of operations. Finally, factor weight calculation require $7l$ operations. Therefore, total calculations performed are $7l + 2 + 7l = 14l + 2$.
3. For NTOPSIS method, decision matrix is $k \times l$ entries therefore N DMs gives Nkl entries. The decision matrix has Nkl operations needed. Then normalized and weighted normalized decision matrix was calculated using $2kl + l$ operations. Finding positive and negative ideal solution there are $2l$ operations. To measure the relative closeness from the positive and negative ideal solutions there are $2kl$ operations performed, and the calculated total sum is by $2k$ number of operations. Finally, the comparison ratio and ranking of the alternatives need $2k$ number of operations. The total number of calculations conducted is $Nkl + 2kl + l + 2l + 2kl + 2k + 2k = (N+4)kl + 4k + 3l$.
4. For NCOPRAS techniques, up to weighted normalized decision matrix $Nkl + 2kl + l$ operations are performed, which is already done in NTOPSIS. Then calculated sum of beneficial and non-beneficial attributes $2k$ number of operations needed. For the De-Neutrosophic method, $2k$ operations were performed. Then find Q_i values for k number of operations needed and lastly, k operations performed to rank the alternatives. The total calculation performed are $Nkl + kl + l + 2k + 2k + k + k = (N+1)kl + 6k + l$.

Time complexity of this study TC is calculated as factor $l = 10$, alternatives $k = 6$ and decision maker $N = 3$ for the present problem as follows

- For NAHP, number of calculations are $(3+3) \times 10^2 + 4 \times 10 + 4 = 644$.
- For weight, number of operations are $14 \times 10 + 2 = 142$.
- For FTOPSIS, number of operations are $(3+4) \times 6 \times 10 + 4 \times 6 + 3 \times 10 = 474$.
- For FCOPRAS, number of calculations are $(3+1) \times 6 \times 10 + 6 \times 6 + 10 = 286$.

Then the time complexity $TC = 644 + 142 + 474 + 286 = 1546$.

9. Sensitivity Analysis

Sensitivity analysis generally expresses the different ranking of the alternatives in a different environment. As it is known that decision-making depends on various conflicting criteria, in sensitivity analysis, removal of criteria or interchange of criterion's weight with respect to some conditions can be executed. Thus, in this study, three different cases have been considered. Different rankings obtained under these cases using two MCDM tools NTOPSIS and NCOPRAS are represented graphically, and a detailed explanation is given as to why these cases are taken.

9.1. Removing Investment Cost $(\tilde{m}_2)$

In the first case, the removal of the criteria and investment cost has been considered. Several times, it is seen that during the construction of a University, a government or charitable trust offers funds for the construction. Thus, in this scenario, the investor need not necessarily think about the investment cost.

Remark 8. *Ranking obtained under removal of investment cost shows Table 20 and Figure 7 that the alternatives 'Kolkata', 'Berhampore' and 'Siliguri' remained consistent with position first, sixth and fifth, respectively.*

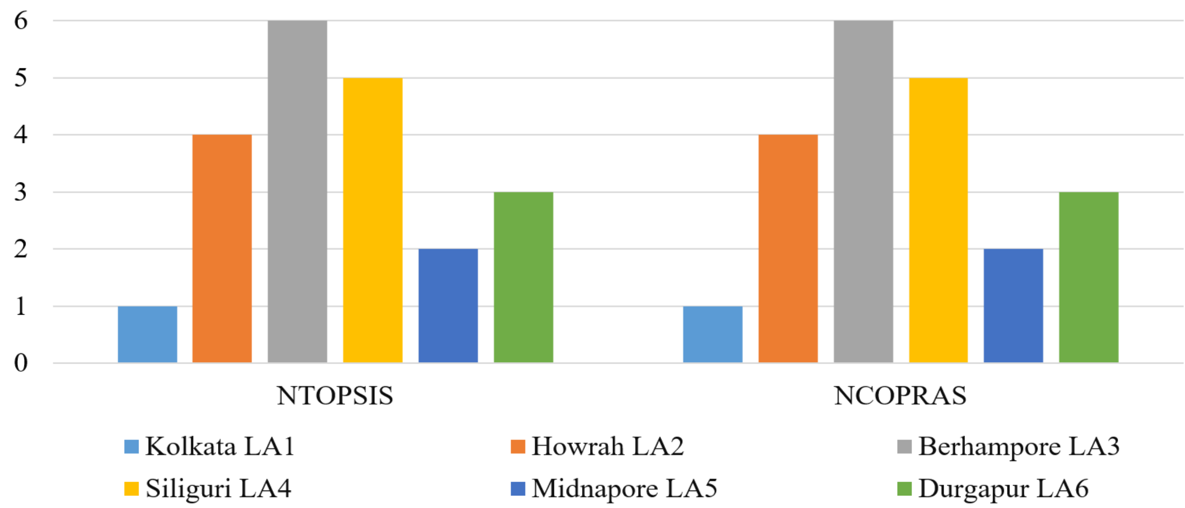

Figure 7. Depiction of ranking alternatives by removing Investment Cost $(\tilde{m}_2)$.

Table 20. Ranking alternatives by removing Investment Cost $(\tilde{m}_2)$.

Alternatives	Ranking Using NTOPSIS	Ranking Using NCOPRAS
Kolkata (L_{A1})	1	1
Howrah (L_{A2})	4	4
Berhampore (L_{A3})	6	6
Siliguri (L_{A4})	5	5
Midnapore (L_{A5})	2	2
Durgapur (L_{A6})	3	3

Note: Here we make a note of how this case numerical is done. Removing the criteria of Investment Cost $(\tilde{m}_2)$ from the Table 15 and TrNN weight from Table 17 in Section 8.2, we get a weighted normalized decision matrix where the criteria weight of Investment Cost $(\tilde{m}_2)$ may not zero or if we forcefully take zero, then all criteria weight are not normalized. So we need to calculate TrNN criteria weight for removing Investment Cost $(\tilde{m}_2)$ using the formula in Section 4.2 and then calculate the weighted normalized matrix and apply NTOPSIS and NCOPRAS as described in Sections 4.3 and 4.4 respectively.

9.2. Removing Accessibility $(\tilde{m}_6)$

The criteria 'accessibility' has been removed in the second case considering the three environments:

1. Government has proposed public accessibility.
2. The investors might set up its own accessibility.
3. Fully residential university need not require accessibility.

Remark 9. *Ranking obtained under this environment reveals in Table 21 and Figure 8 shows that the locations 'Kolkata', 'Durgapur', 'Siliguri' and 'Berhampore' are at the same position whereas the alternatives 'Howrah', and 'Midnapore' rankings have been interchanged.*

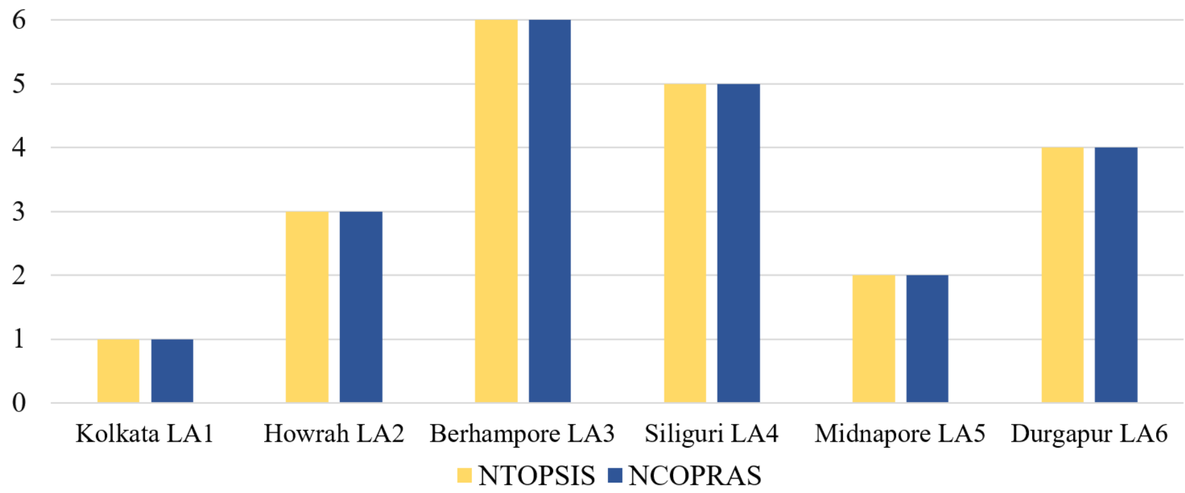

Figure 8. Pictorial of alternatives ranking by removing Accessibility $(\tilde{m}_6)$.

Table 21. Alternatives ranking by removing criteria Accessibility $(\tilde{m}_6)$.

Alternatives	Ranking Using NTOPSIS	Ranking Using NCOPRAS
Kolkata (L_{A1})	1	1
Howrah (L_{A2})	3	3
Berhampore (L_{A3})	6	6
Siliguri (L_{A4})	5	5
Midnapore (L_{A5})	2	2
Durgapur (L_{A6})	4	4

Note: For calculation purposes, if we remove the criteria Accessibility $(\tilde{m}_6)$ from the Table 15 and TrNN weight from Table 17 in Section 8.2 we get weighted normalized decision matrix where the criteria weight of Accessibility $(\tilde{m}_6)$ may not be zero or if we forcefully take zero then all criteria weight are not normalized. So we calculated TrNN criteria weight for removing Accessibility $(\tilde{m}_6)$ as previous Section 9.1 and ranking the alternatives using the NTOPSIS and NCOPRAS methods as described in Sections 4.3 and 4.4 respectively.

9.3. Removing Proximity of Educational Institute $(\tilde{m}_9)$

Individual Universities has it's own infrastructure, such as libraries, research cell, academic development cell, etc. Thus, the proximity of educational institutes to the University may not be considered necessary.

Remark 10. *Ranking obtained under this condition represents in Table 22 and Figure 9 that the same ranking of Section 9.2 order for the locations 'Kolkata', 'Durgapur', 'Siliguri' and 'Berhampore'. It is observed that consistent ranking is obtained for the two cases taken in sensitivity analysis, i.e., 'removal of accessibility* $(\tilde{m}_6)$*' and 'removal of the proximity of educational institute* $(\tilde{m}_9)$*'.*

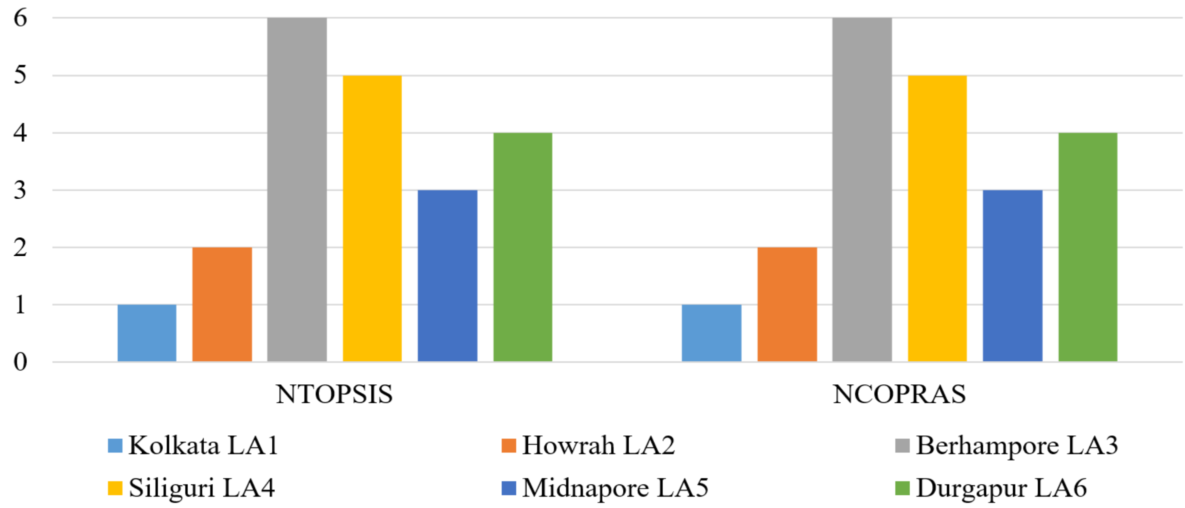

Figure 9. Depiction of alternatives ranking by removing Proximity of Educational institute $(\tilde{m}_9)$.

Table 22. Alternatives ranking by removing Proximity of Educational institute $(\tilde{m}_9)$.

Alternatives	Ranking Using NTOPSIS	Ranking Using NCOPRAS
Kolkata (L_{A1})	1	1
Howrah (L_{A2})	2	2
Berhampore (L_{A3})	6	6
Siliguri (L_{A4})	5	5
Midnapore (L_{A5})	3	3
Durgapur (L_{A6})	4	4

Note: For calculation purposes, if we remove the criteria Proximity of Educational institute $(\tilde{m}_9)$ from the Table 15 and TrNN weight from Table 17 in Section 8.2 we get new weighted normalized decision matrix where the TrNN criteria weight of Proximity of Educational institute $(\tilde{m}_9)$ may not be zero or if we forcefully take zero then all criteria weight are not normalized. So we calculated TrNN criteria weight for removing Proximity of Educational institute $(\tilde{m}_9)$ as above Section 9.1 and ranking the alternatives on MCDM method NTOPSIS and NCOPRAS as described in Sections 4.3 and 4.4 respectively.

10. Conclusions and Future Research Scope

The neutrosophic MCDM method uses a screening methodology to find the solution for different complex problems with uncertain data. It is capable of finding valuable information for the decision-makers by comparing a host of different parameters before making the final conclusion. Finding the best location for setting up a women's university is a major social and economic concern requiring the trade-off and weighting of various factors. The core aim of this study is the selection of the best location for women's universities by considering social and national needs. This study provides a model to the stakeholder, e.g., investors and government, who are searching for an optimal site keeping in mind requirements like Universities site selection, hospital site selection, landfill site selection, college site selection, etc.

In this work, two different selection methods have been used for choosing an optimum site. The most commonly used methods that have been elaborated upon include AHP, TOPSIS, COPRAS, and neutrosophic set theory. A new de-neutrosophication technique has been introduced and applied in this present work. Comparisons between the two methods NTOPSIS and NCOPRAS have been carried out. This comparison showed that the proposed methodology is reliable. Sensitivity analysis has been carried out by incorporating different possible weights and using a combination of influencing factors to accommodate different organizational needs.

The following steps are taken for doing the numerical study:

1. Check the consistency of the decision matrix using Neutrosophic AHP.
2. Obtain the neutrosophic weight of the criteria to evaluate the weighted decision matrix.
3. Calculate the nearest distance from the positive ideal solution, and the farthest distance from the negative ideal solution is calculated using the MCDM method Neutrosophic TOPSIS.
4. Determine the maximizing and minimizing index values, and consequently, the attributes of maximizing and minimizing indexes are the assessment of the results examined individually using the Neutrosophic COPRAS method.

Since the paper deals with optimal site selection for women's universities, we considered alternative locations for numerical study. We consulted experts and conducted a thorough literature review to ascertain relevant criteria. We considered ten important criterion's for the problem. This methodology can be extended and applied in numerous fields. Some of the future scope/extensions are

- the methodology can be used for setting up a private university, fully research-oriented institute, etc.,
- different sub-criterion may be taken for each criterion,
- different de-neutrosophication techniques associated with different efficient MCDM methods, like MIVES, WASPAS, CoCOSo, PROMETHEE, VIKOR may be applied,
- different uncertain environments may be considered like hesitant neutrosophic environment, Pythagorean fuzzy,
- same methodology may be extended with more alternatives,
- different new distance measures may be used.

The findings of the work presented here may be helpful for a decision-maker who deals with the site selection problem with some uncertainties in data. Our results should also encourage a more straightforward method with appropriate decision outcomes.

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