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HYBRID MCDM METHOD ON INTUITIONISTIC FUZZY SET FOR PLASTIC WASTE DISPOSAL TECHNOLOGY

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Abstract: *In the present paper a novel hybrid multi-criteria decision-making (MCDM) framework on intuitionistic fuzzy environment is proposed. For the intuitionistic fuzzy-MEREC-SWARA-CoCoSo method for ranking the selection of the topmost substitute in decision-making problems is developed. The objective weights are evaluated by MEREC approach, and subjective criteria weights are assessed using the SWARA approach further the CoCoSo method is used to rank the alternatives on intuitionistic fuzzy set. In recent times, the choice of appropriate plastic waste disposal technology is an immensely important challenge. It has an impact on both ecological and commercial growth of the nation. To deal with the situation, several authors have concentrated on selecting an essential plastic waste disposal technique using a decision-making process based on several IFS methodologies. Here, in this paper a methodology is the presented to identify the best technology for plastic waste disposal. A comparative discussion and analysis are presented to performance the rationality and consistency of the technique evolved to rank optimal plastic waste disposal options.*

Keywords*: Intuitionistic Fuzzy Set (IFS), Decision-Making, Plastic Waste Disposal (PWD), Cocoso Method, MEREC Approach.*

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1. Introduction

There are many uncertain precise and incomplete problems in the world. The concept of fuzzy set (FS) introduced by Zadeh (1965) is a successful and effective tool for defining fuzzy and complicated information. To overcome its primary extension and shortcomings, intuitionistic fuzzy sets (IFS) has been established by (Atanassov, 1986), which require the sum total of belongingness degree (BD) and non-belongingness degree (N-BD) equal to or less than or unity. Afterward, ordered pairs of IFS and intuitionistic fuzzy numbers (IFNs) have been studied by Xu and Yager (2006). Thereafter, Xu (2007) characterized some significant operational for IFNs. Lei and Xu (2015) introduce the fundamental operators on IFNs. Various methods have been discussed to deal with MCDM issues in the context of IFS. Using a novel aggregation operator on IFSs, a decision support system for smart city surveillance has been developed by Atanassov (2022); Goala et al. (2022). Garg and Rani (2021, 2022) proposed new intuitionistic fuzzy-aggregation operators for evaluating solid waste management. Rani and Garg (2022) discussed trigonometric operators, making multiple criteria group judgments based on complex IFNs. Bryniarska (2022) discussed scaling IFSs generates mathematical models of clinic information. Gulzar et al. (2021a); Gulzar et al. (2020); Gulzar et al. (2021b) defined a new application of complex IFS in group theory. Thereafter, Gulzar et al. (2021b) Generalized direct product of complex IF-subring. IFS successfully employed by many researchers in several domains to resolve decision-making problems since its inception (Gulzar et al., 2021b; Pamucar, 2020; Pamučar & Janković, 2020; Pant & Kumar, 2022).

MCDM problems have been a concern in real-life applications, different approaches have been applied in many environments to deal with these complex problems, yet the solution is a challenging issue to achieve. Many scholars have developed the different ranking methods to solve MCDM problems like Liu, Adams, and Walker (2018) suggested a new strategy for dealing with IF-MCDM situations involving weakly ordered prioritisation and criteria interaction; Chaurasiya and Jain (2021) proposed Measurement Alternatives and Ranking according to Compromise Solution (MARCOS) method on IFSs. Ecer (2022) presented MAIRCA method of IFS for coronavirus vaccine selection. Rani et al. (2021) presented IF-grey relational analysis framework for telecom service providers. Badi and Pamucar (2020) proposed integrate Grey-MARCOS methods for supplier selection. Weighted Aggregated Sum Product Assessment and Additive Ratio Assessment (Mishra, Singh, & Motwani, 2019, 2020b). Durmić et al. (2020) presented integrated Full Consistency Method-Rough-Simple Additive Weighting (FUCOM-R-SAW) model for sustainable supplier selection. The authors have applied the predictable MCDM method in various fields viz. (Ashraf et al., 2022; Bakır & Atalık, 2021; Chaurasiya & Jain, 2022a; Ejegwa, 2020; Kaya, 2020; Memarpour Ghiaci, Garg, & Jafarzadeh Ghoushchi, 2022; Petrovic & Kankaras, 2020).

Studies reveal that, the criterion weight is very significant in solving MCDM problems. Therefore, the authors have moved their attention to approaches related to criterion weight. Keršuliene, Zavadskas, and Turskis (2010) has established the Stepwise Weight Assessment Ratio Analysis (SWARA) method as influential method for calculating the subjective criteria weights (SCWs). Garg et al. (2022) proposed SWARA-COPRAS method on complex intuitionistic fuzzy soft for software selection. Rani et al. (2020) developed a new integrated SWARA-ARAS method on PFS for healthcare waste technology problem. Alipour et al. (2021) employed a combined SWARA and COPRAS technique to assess the supplier selection of fuel cell and hydrogen constituents in the PFS domain. Saraji et al. (2022) proposed the hesitant fuzzy-SWARA-MULTIMOORA method for online education and different weight methods proposed by Chaurasiya and Jain (2022b); Chen (2019); Stević et al. (2022).

Keshavarz-Ghorabaee et al. (2021) developed MEthod based on the REmoval Effect of Criterion (MEREC) technique as one of the powerful approaches for evaluating the objective criterion weights (OCWs) in a MCDM problem. Hadi and Abdullah (2022) presented integrate MEREC-TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) method for IoT-based hospital place selection. Hezam et al. (2022) proposed an IF-MEREC-ranking sum-double normalization-based multi-aggregation method for evaluating alternative fuel vehicles concerning sustainability. Marinković et al. (2022) employed the MEREC-CoCoSo multi-criteria method to evaluate the application of waste and recycled materials to production. Integrated MEREC method on Fermatean fuzzy environment proposed by Rani et al. (2022) discussed by choosing the best option may be impracticable or inappropriate for decision-makers (DMs), MEREC-MARCOS (Nguyen et al., 2022), MEREC-MULTIMOORA (Mishra et al., 2022), Level based weight assessment-Z-MAIRCA method (Božanić, Jurišić, & Erkić, 2020). Moreover, Analytic Hierarchy Process (Zavadskas et al., 2020), Level based weight assessment (LBWA) (Žižović & Pamucar, 2019).

Yazdani et al. (2019) established the COmbined COmpromise SOlution (CoCoSo) process, which is an adaptive process for disposing of information in a logical and practicable manner. The chief benefit of the CoCoSo method is (a) the CoCoSo framework allows for adaptable decision-making, by considering the interplay between multiple-input criteria (Ecer & Pamucar, 2020), (b) the framework assesses the discussion between criteria and eliminates the effect of unusual data, (c) the easy steps to asses multiple options based on their performance compared to selected appraisal criteria, giving practical, suitable and relatively precise results. Peng and Garg (2022) proposed COCOSO- on IF-soft decision-making technique for content-centric networking cache placement policy selection. Peng and Huang (2020) proposed CoCoSo method on fuzzy set for application financial in risk. Torkayesh et al. (2021) has created a combined, multi-criteria framework to assess the healthcare sector which is a crucial component of any nation's infrastructure. The healthcare sector plays an important role in the economic growth and social stability of countries. Popović (2021) presented an CoCoSo method for personal selection. Simultaneously, Jahan et al. (2022) has applied CoCoSo method for material selection. Mandal and Khan (2022) proposed CoCoSo model for trusted cloud service provider selection. Some scholars have applied CoCoSo method in several domain and applications (see Alrasheedi et al. (2021); Mi and Liao (2020); Peng, Garg, and Luo (2022)).

In the present natural situation, plastic usage is unavoidable in our daily life. Disposal of plastic isn't a straightforward task. There are many procedures connected with disposing of plastics. Thus, selecting the most suitable methodology for disposing of plastics is an optimization problem. Plastic waste disposal (PWD) is a serious concern, mainly in emerging nations. Plastic is non-biodegradable (Datta, Mohi, & Chander, 2018), it remains in the environment for many years and disposal of plastic waste in landfills is unsafe as toxic chemicals get into the soil, underground water and polluted water bodies therefore, the disposal of plastic waste is a major problem for the civic authorities. There are some methods that can be employed to plastic waste disposal.

Due to a lack of a working solid waste management system, India creates fifteen million tonnes of plastic garbage each year, yet only one-fourth of this is recycled.

Consequently, medical, household and plastic waste may be considered to develop sound strategies to reduce the risk of downstream effects on the environment and public health (Chauhan, Jakhar, & Chauhan, 2020; UNEP, 2020). Single-use plastics have increased due to online shopping during the lockdown (Singh, 2020), such as polypropylene, high-density polyethylene, polystyrene and polyethylene technology. There has been a massive increase in plastic packaging waste production. Plastic waste in a circular economy (Hahladakis, Iacovidou, & Gerassimidou, 2020). Municipal solid waste incinerators provide a sustainable fixation of fly ash by adding green material (Chen et al., 2019). Plastic pollution has been controlled and disposed of using an integrated approach (Alabi et al., 2019; Prata et al., 2019). "The critical review on converting plastic waste to feedstock for manufacturing" by Lange (2021). An existing life-cycle review evaluating plastic waste management studies (Alhazmi, Almansour, & Aldhafeeri, 2021). Some authors have tackled the problem of plastic waste with different technologies (Addor, Wiah, & Alao, 2022; Aryan, Yadav, & Samadder, 2019; Pan et al., 2020; Santagata et al., 2020; Shahnawaz, Sangale, & Ade, 2019).

The motivation for this study is, that a hybrid IF-MEREC-SWARA-CoCoSo method is developed that can efficiently handle the fuzziness and uncertainty concerned with the decision of DEs. Therefore, we first calculate objective weights by the MEREC approach and evaluate subjective weights by the SWARA approach, then we calculate the combined criterion weights, and finally compute the ranking of alternatives by the CoCoSo method. Notably, there is no study in the current literature regarding the proposed hybrid method in the field of plastic waste disposal. Therefore, this study takes advantage of the IF-CoCoSo method and develops a new approach to rank and evaluate plastic waste disposal technology in manufacturing. However, the aim of this work is to propose a new hybrid method for the following purposes:

- To develop a novel hybrid MCDM method under the IF-domain.
- We calculate the relative performance of decision experts' weights in IFS based on (Boran et al., 2009) formula and evaluate the normalized score values.
- To calculate OCWs by new MEREC and SCWs by SWARA method. Thereafter, we compute combined criterion weights. Thereafter, to employed the CoCoSo method to rank the of alternative.
- To analyse the proposed IF-MEREC-SWARA-CoCoSo method and compare it with existing approaches to express the validity of the got results.

The remainder of the paper is organized as follows: In section 2, we introduce the basics of IFSs. Section 3 presents a novel hybrid MCDM method on IFS. Section 4, an application of plastic waste disposal choice, which shows the capability & applicability of the established model. In addition, section 5 to validate the results, a comparison with other available methods. Finally, in section 6, conclusion, limitations, and future research suggestions work.

2. Basic definitions of FS and IFS

Here, this section includes basic concepts of intuitionistic fuzzy set (IFS).

Definitions 1. (Zadeh, 1965) Assume U be a finite discourse set. The fuzzy set $A \subset U$ is defined as:

$$A = \{(u_i, \mu_A(u_i)) \mid \mu_A(u_i) \in [0,1];\ \forall\, u_i \in U\}. \tag{1}$$

since $\mu_A(u_i)$: U → [0, 1] indicate belongingness degree of A. Fuzzy set is a collection of things with membership gradation having BDs.

Definitions 2. (Atanassov, 1986; Atanassov, 1999) An IFS I ⊂ U where $U = \{u_1, u_2, \dots, u_n\}$ is defined as:

$$I = \{u_i, \mu_I(u_i), \nu_I(u_i) | \, u_i \in U\}. \tag{2}$$

where $\mu_I : U \to [0, 1]$ and $\nu_I : U \to [0, 1]$ indicate the BD and N-BD respectively, $u_i \in U$, such that $0 \le \mu_I(u_i) + \nu_I(u_i) \le 1$, $\forall\, u_i \in U$, we express the non-determinacy degree of IFSs is given as, $\mu_I(u_i) + \nu_I(u_i) + \pi_I(u_i) = 1$. Clearly, $\pi_I(u_i) = 1 - \mu_I(u_i) - \nu_I(u_i)$.

Assume $I, J \in$ IFSs(U) defined by
$I = \{u_i, \mu_I(u_i), \nu_I(u_i) | \, u_i \in U\}$,
$J = \{u_i, \mu_J(u_i), \nu_J(u_i) | \, u_i \in U\}$,

then operations on IFSs are provided by

(a) $I \subseteq J$ iff $\mu_I(u_i) \le \mu_J(u_i)$ and $\nu_I(u_i) \ge \nu_J(u_i), \forall u_i \in U$;
(b) $I = J$ iff $I \subseteq J$ and $J \subseteq I$;
(c) $I \cup J = \left\{u_i, \left(\mu_I(u_i) \vee \mu_J(u_i)\right), \left(\mu_I(u_i) \wedge \mu_J(u_i)\right) | \, u_i \in U\right\}$;
(d) $I \cap J = \left\{u_i, \left(\mu_I(u_i) \wedge \mu_J(u_i)\right), \left(\mu_I(u_i) \vee \mu_J(u_i)\right) | \, u_i \in U\right\}$;
(e) $I^c = \{u_i, \ \nu_I(u_i), \mu_I(u_i) | \, u_i \in U\}$.

Definitions 3. (Xu & Yager, 2006) Let $\xi_j = (\mu_j, \nu_j)$ be an Intuitionistic fuzzy number (IFN).

$$\text{S}(\xi_j) = (\mu_j - \nu_j), \ \hbar(\xi_j) = (\mu_j + \nu_j). \tag{3}$$

where $\text{S}(\xi_j) \in [-1, 1]$, $\hbar(\xi_j) \in [0, 1]$ are the score function.

Definitions 4. (Lei & Xu, 2015) Normalized score and accuracy function of an IFN $\xi_j = (\mu_j, \nu_j)$ defined as:

$$\text{S}^*(\xi_j) = \tfrac{1}{2}(\text{S}(\xi_j) + 1), \hbar^*(\xi_j) = \tfrac{1}{2}(\mu_j + \nu_j). \tag{4}$$

for $\text{S}^*(\xi_j), \hbar^*(\xi_j) \in [0, 1]$.

Definitions 5. (Xu, 2007) Consider $\xi_j = (\mu_j, \nu_j)$ being the IFNs. Then the IF-weighted average operator (IFWAO) and IFW-geometric operator (IFWGO) are as:

$$\text{IFWA}_\text{w}(\xi_1, \xi_2, \dots, \xi_n) = \left(1 - \prod_{j=1}^{\text{n}} (1 - \mu_j)^{w_j}, \prod_{j=1}^{\text{n}} (\nu_j)^{w_j}\right), \tag{5}$$

$$\text{IFWG}_\text{w}(\xi_1, \xi_2, \dots, \xi_n) = \left(\prod_{j=1}^{\text{n}} (\mu_j)^{w_j}, 1 - \prod_{j=1}^{\text{n}} (1 -, \nu_j)^{w_j}\right). \tag{6}$$

Here w_j is a weight vector of ξ_j with $\sum_{j=1}^{n} w_j = 1$.

Definition 6. (Szmidt & Kacprzyk, 2001) A function ϕ: IFS(U) → [0,1] is said to be an entropy measure for IFSs, if it fulfills the postulates as given below:

(P_1) $\phi(I) = 0$ (min), iff I is a crisp set.
(P_2) $\phi(I) = 1$ (max), iff $\mu_I(u_i) = \nu_I(u_i), \forall\, u_i \in U$
(P_3) $\phi(I) \le \phi(J)$ if I is less fuzzy than J,
i.e. $\mu_I(u_i) \le \mu_J(u_i)$ and $\nu_I(u_i) \ge \nu_J(u_i)$ for $\mu_J(u_i) \le \nu_J(u_i)$
or $\mu_I(u_i) \ge \mu_J(u_i)$ and $\nu_I(u_i) \le \nu_J(u_i)$ for $\mu_J(u_i) \ge \nu_J(u_i)$, for each $u_i \in U$

(P_4) $\phi(I) = \phi(I^c)$.

3. Intuitionistic Fuzzy MEREC-SWARA-CoCoSo Method

In this section, we have proposed a new decision-making method, as hybrid IF-MEREC-SWARA-CoCoSo method, for handling with the MCDM problems on IFS environment. In this method uses the MEREC approach to appraise the objective criteria weights. A new approach to objective weighting called MEREC uses the effects of removing criteria from the DM to assess their significance. For estimation of OCWs, MEREC differs from previous techniques in that it emphasizes exclusion potential and removal effects in place of an inclusion perspective. The effectiveness of this approach was validated, through simulation-based and comparative assessments. The SWARA approach is an effective tool for evaluating SCWs. The main advantage of the SWARA method is to assess the correctness of the expert's view regarding the weights assigned by the SWARA procedure. Thereafter, the criteria weights are calculated by combined formula. Whereas, the CoCoSo model uses the notion of degree of utility to assess the importance of the order of options. Therefore, we combine these three methods on IFSs to get further precise and suitable judgments in an ambiguous reference. The process of the IF-MEREC-SWARA-CoCoSo framework is presented in figure 1 as follows:

Step 1: For a MCDM process, the objective is to select the suitable option from the set of m options $Pd = \{Pd_1, Pd_2, \dots, Pd_m\}$ under the criteria $H = \{H_1, H_2, \dots, H_n\}$. Let the collection of decision expert's (DEs) $DE = \{DE_1, \dots, DE_\ell\}$ represents their ideas on each option Pd_i with respect to each criterion H_j in terms of linguistic terms (LTs). Let $\mathbb{Z} = \left(z_{ij}^{(\tau)}\right)$, $i = 1(1)m$, $j = 1(1)n$ be a linguistic decision matrix recommended by the DE's, where $z_{ij}^{(\tau)}$ present to the appraisal of an option Pd_i regarding a criterion H_j in forms of LTs for τ^{th} DE.

Step 2: Calculate the DE's weights. For the assessment of the τ^{th} DE's weight, consider $DE_\tau = (\mu_\tau, \nu_\tau, \pi_\tau)$ be a IFSs

$$\lambda_\tau = \frac{\mu_\tau + \pi_\tau \times \left(\frac{\mu_\tau}{\mu_\tau + \nu_\tau}\right)}{\sum_{\tau=1}^{\ell}\left(\mu_\tau + \pi_\tau \times \left(\frac{\mu_\tau}{\mu_\tau + \nu_\tau}\right)\right)}, \forall \tau \tag{7}$$

Since $\lambda_\tau \geq 0$, therefore, $\sum_{\tau=1}^{\ell} \lambda_\tau = 1$.

Step 3: Compute the aggregation intuitionistic fuzzy decision matrix (AIF-DM), corresponding to expert's weight. Let $\mathbb{N} = \left(\varepsilon_{ij}\right)_{m\times n}$ be the IF-decision matrix,

$$\varepsilon_{ij} = \text{IFWA}_\lambda\left(z_{ij}^{(1)}, z_{ij}^{(2)}, \dots, z_{ij}^{(\ell)}\right) = \left(1 - \prod_{\tau=1}^{\ell}(1-\mu_\tau)^{\lambda_\tau}, \prod_{\tau=1}^{\ell}(\nu_\tau)^{\lambda_\tau}\right) \tag{8}$$

Step 4: Determination of subjective criteria weights (SCWs) using MEREC approach.

Step 4.1: The procedure for assessing the criteria weight is given below:

Step 4.1-A: Normalize the AIF-DM represented by $N^1 = \left(\zeta_{ij}\right)_{m\times n}$. If H_b is represent of beneficial criteria and H_c is represent of cost criteria.

$$\zeta_{ij} = \begin{cases} \varepsilon_{ij} & ; j \in H_b \\ (\varepsilon_{ij})^c & ; j \in H_c \end{cases} \tag{9}$$

Step 4.1-B: Compute the overall performance (OAP) of the alternatives (e_i). A logarithmic measure with equal CWs is used to get alternative OAP in this step.

$$\mathrm{e}_i = \ln\left(1 + \left(\frac{1}{n}\sum_j^n |\ln(\zeta_{ij})|\right)\right) \quad (10)$$

Step 4.1-C: Compute the performance of the alternatives by removing each criterion $\left(\mathrm{e}'_{ij}\right)$.

$$\mathrm{e}'_{ij} = \ln\left(1 + \left(\frac{1}{n}\sum_{k,k\neq j}^n |\ln(\zeta_{ik})|\right)\right) \quad (11)$$

Step 4.1-D: Estimate the total absolute deviations $\left(\sigma_j\right)$. We usage the Eqs. (10) and (11)

$$\sigma_j = \sum_i^m |\mathrm{e}'_{ij} - \mathrm{e}_i| \quad (12)$$

Step 4.1-E: Determine the final OCWs. The σ_j is used to calculate the OCWs of each criterion in this step. The procedure is applied to evaluate ϖ_j.

$$\varpi_j = \frac{\sigma_j}{\sum_j^n \sigma_j} \quad (13)$$

Step 4.2: Evaluate the subjective criteria weights (SCWs) by SWARA method.

Step 4.2-A: Determine the score values $S^*(\zeta_{ij})$ of IFNs given in AIF-DM.

Step 4.2-B: The rank of criteria is evaluated on the basis of the expert's observation on the greatest to the smallest substantial element.

Step 4.2-C: Appraise relative significance (δ_j). Relative importance is determined by the criteria placed at second position. The subsequent comparative importance is obtained by comparation of the criteria located at j^{th} and $(j-1)^{th}$ places.

Step 4.2-D: Evaluate the relative coefficient ($\mathcal{C}_j$) by Eq. (14). Where, δ_j determines the relative significance.

$$\mathcal{C}_j = \begin{cases} 1, & j = 1, \\ \delta_j + 1, & j > 1 \end{cases} \quad (14)$$

Step 4.2-E: Calculate the recalculated weight (ρ_j) is given as:

$$\rho_j = \begin{cases} 1 & , j = 1, \\ \frac{\mathcal{C}_{j-1}}{\mathcal{C}_j} & , j > 1 \end{cases} \quad (15)$$

Step 4.2-F: Calculate scaled weight $\left(\omega_j\right)$ given below as:

$$\omega_j = \frac{\rho_j}{\sum_{j=1}^n \rho_j} \quad (16)$$

Step 4.3: Compute the combined criteria weights $\left(w_j\right)$. In the MCDM technique, all criteria have varying degrees of significance given as:

$$w_j = \frac{\varpi_j * \omega_j}{\sum_{j=1}^n \varpi_j * \omega_j} \quad (17)$$

Here $\sum_{j=1}^n w_j = 1$ & $w_j \in [0,1]$.

Determine the Ranking of Alternative by CoCoSo Method (Combined Compromise Solutions Method)

Step 5: Create score matrix.

$$\varepsilon'_{ij} = \mathrm{S}^*(\zeta_{ij}) = \frac{1}{2}\left(\mu_{\zeta_{ij}} - \nu_{\zeta_{ij}} + 1\right) \tag{18}$$

Step 6: Calculate the weighted sum measure (WSM) comparability sequence for all option as:

$$\mathbb{S}_i = \sum_{j=1}^{n} w_j * \varepsilon'_{ij} \tag{19}$$

Step 7: Compute the weighted product measure (WPM) comparability sequences for every choice as:

$$\mathbb{P}_i = \sum_{j=1}^{n} \left(\varepsilon'_{ij}\right)^{w_j} \tag{20}$$

Step 8: Calculate three appraisal scores ($\mathcal{K}_{ia}, \mathcal{K}_{ib}$ and $\mathcal{K}_{ic}$) of options by three aggregation strategies using Eqs. (21) – (23):

$$\mathcal{K}_{ia} = \frac{\mathbb{P}_i + \mathbb{S}_i}{\sum_{i=1}^{m}(\mathbb{P}_i + \mathbb{S}_i)} \tag{21}$$

$$\mathcal{K}_{ib} = \frac{\mathbb{P}_i}{\min\limits_i \mathbb{P}_i} + \frac{\mathbb{S}_i}{\min\limits_i \mathbb{S}_i} \tag{22}$$

$$\mathcal{K}_{ic} = \frac{\Upsilon\, \mathbb{S}_i + (1-\Upsilon)\mathbb{P}_i}{\Upsilon \max\limits_i(\mathbb{S}_i) + (1-\Upsilon)\max\limits_i(\mathbb{P}_i)}, 0 \le \Upsilon \le 1 \tag{23}$$

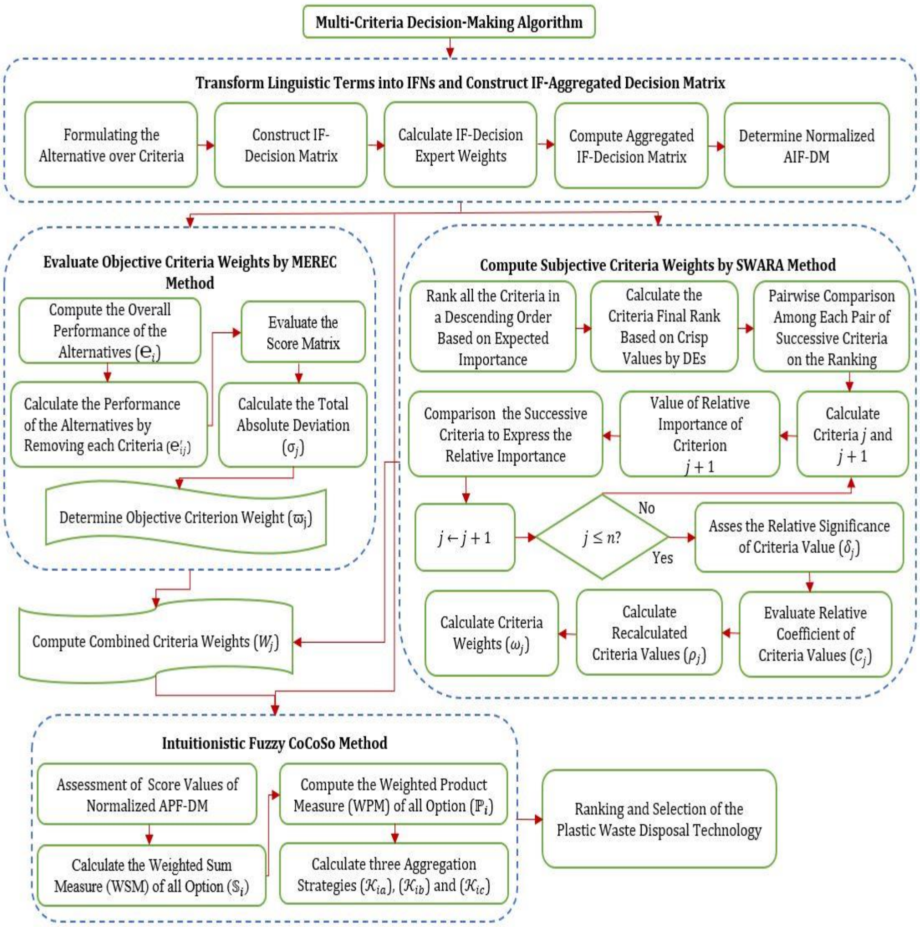

Figure 1: Procedure of Presented Hybrid IF-MEREC-SWARA-CoCoSo Method.

Eq. (21) is regarded as the arithmetic mean of the sum of WSM and WPM scores, whereas Eq. (22) is interpreted as the sum of relative WSM and WPM scores compared to the best Eq. (23) calculates the WSM and WPM model scores as balance compromise. Here, compromise index over parameter $\Upsilon \in [0, 1]$ is the coefficient of decision-making process. Usually we consider the value $(\Upsilon) = 0.5$.

Step 9: The final ranking of the options $(\mathcal{K}_i)$, calculation value is assessed by Eq. (24):

$$\mathcal{K}_i = \sqrt[3]{\mathcal{K}_{ia}\mathcal{K}_{ib}\mathcal{K}_{ic}} + \frac{1}{3}(\mathcal{K}_{ia}+\mathcal{K}_{ib} + \mathcal{K}_{ic}) \quad (24)$$

4. Application of Plastic Waste Disposal Technology

The application of determines the selection of the optimal plastic waste disposal technology using the IF-MEREC-SWARA-CoCoSo technique. In this regard, in the first phase, a comprehensive overview has been undertaken to identify vital parameters by literatures review. For the selected PWD, a decision team of four DE's have formed. Data is employed in the proposed framework by the investigation team. After examining the model offered by various researchers, eight criteria are chosen to be assessed (see Figure 2). Various alternatives respective to the PWD as follows:

4.1. Landfilling

A landfill is a man-made trench in which plastic solid garbage is compacted, and covered before being disposed. It has a base that is coated to avoided groundwater pollution.

4.2. Mechanical recycling

The majority of plastic trash is made up of thermos-softening polymers, which may be melted down and reformed into new objects through mechanical recycling (Gu et al., 2017). Worldwide, it's by far the most general recycling and effectually the only kind of exercise in many nations.

4.3. Feedstock and waste to energy

It entails a variety of techniques such as pyrolysis, plastic waste to fuel conversion, and gasification methods for converting plastic waste into products with unique qualities that are distinct from virgin plastic (Liu et al., 2018). During this procedure, the plastic undergoes molecular and structural changes, and it is changed into much easier raw material products with improved thermal qualities.

4.4. Bio-based and biodegradable plastic

Bio-based plastics are made solely from biological resources rather than fossil basic materials. These aren't necessarily compostable Napper and Thompson (2019). Bio-based plastics must be examined throughout their entire life cycle to make sure that they mileage the environment in ways other than declining fossil fuel usage.

4.5. Incineration with energy recovery

Incineration is a waste disposal method that contains the combustion of plastic waste item's contents. Waste-to-energy (W2E) plants are generally referred to as manufacturing waste incineration plants. The term "thermal disposal" refers to incinerators and other high-temperature waste disposal amenities. The working capability of incineration amenities may variety from 5 to 1,000 tonnes of MSW/day; though, the majority of amenities are in the 200 to 700 tonnes/day range.

The efficiency, productivity, and impression of PWD technology methods on the various aspects of society can be based on numerous competing and conflicting criteria, whereby all criteria must be considered to select the optimal option Through a detailed review (Chaurasiya & Jain, 2023; Geetha et al., 2021; Mishra et al., 2020a; Prata et al., 2019) of the literatures on method assessment, we identified eight criteria characterized by the four main aspects, economic, environmental, technical, and social. The considered criteria's are enumerated as follows: Cost H_1 (Chaurasiya & Jain, 2023; Geetha et al., 2021; Mishra et al., 2020a; Prata et al., 2019), Disposal cost (H_2) (Chaurasiya & Jain, 2022b), Technical aspect (H_3) (Geetha et al., 2021), Energy consumption (H_4) (Chaurasiya & Jain, 2023), Release with health effects (H_5) (Mishra et al., 2020b), Environmental effect (H_6) (Geetha et al., 2021), Public acceptance (H_7) (Chaurasiya & Jain, 2022b; Mishra et al., 2020c), and Reliability (H_8) (Mishra et al., 2020b). According to the literature and expert opinion, it is clear that H1 and H2 of the criteria are cost types, and the others are benefit types. After assessing criteria and alternatives through literature and interviews with experts, successive decisions are obtained from a panel of experts. The judgement panel includes for experts: a head of municipal corporation DE1, an experienced scholar DE2, a system analyst DE3, and an environmental experts DE4. Firstly, the DMs supplied her/his rating qualitatively using the likert-scale. The opinions regarding to PWD technology and the criteria are employed to rate these technologies. The qualitative data are converted into IFMNs employing the tabular values from (Kumari & Mishra, 2020). These values are displayed in the tables below as data for the decision-making procedure.

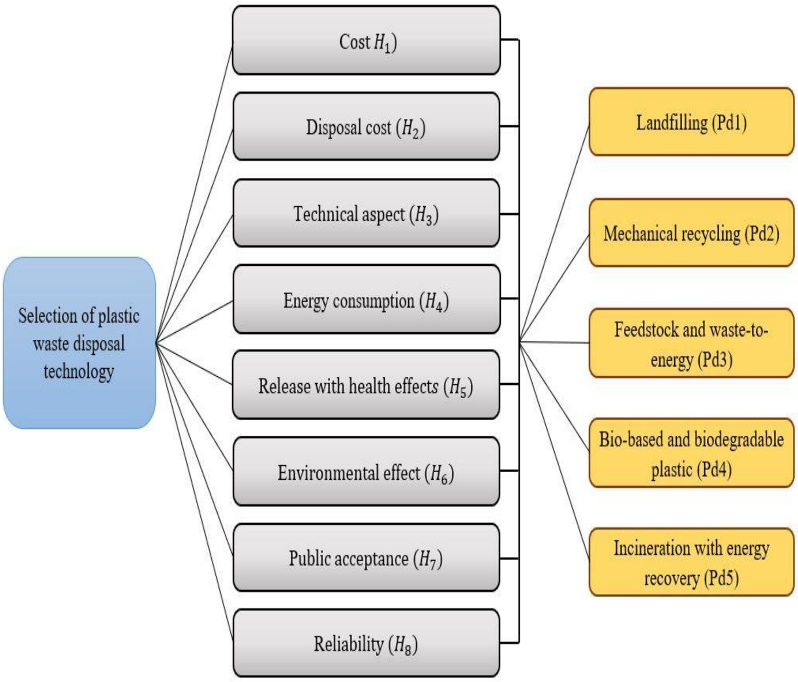

Figure 2. Framework for Select Plastic Waste Disposal Options.

Table 1: Linguistic Terms (LTs) in Terms of IFNs.

LTs	IFNs
Extremely important (EI)	(0.90, 0.10)
Very important (VI)	(0.80, 0.15)
Important (I)	(0.75, 0.20)
Modest (M)	(0.50, 0.45)
Unimportant (UI)	(0.40, 0.55)
Very unimportant (VUI)	(0.20, 0.75)
Extremely unimportant (EUI)	(0.10, 0.80)

Table 2: LTs Estimating the Options.

Importance	IFNs
Excessively high (EH)	(0.95, 0.05)
Very high (VH)	(0.85, 0.10)
High (H)	(0.70, 0.20)
Slightly high (SH)	(0.60, 0.30)
Average (A)	(0.50, 0.45)
Slightly Low (SL)	(0.45, 0.50)
Low (L)	(0.35, 0.55)
Very low (VL)	(0.20, 0.70)
Excessively low (EL)	(0.10, 0.90)

Table 1 presents the LTs given in IFNs for the relative importance rating of weights. In Table 3 presents the weight of each DE's as calculated using Eq. (7).

Table 3: Evaluate the Decision Expert's Weight for LTs.

	DE_1	DE_2	DE_3	DE_4
LTs	VI	I	M	UI
IFNs	(0.80, 0.15)	(0.75, 0.20)	(0.50, 0.45)	(0.40, 0.55)
Expert's weights	0.3265	0.3061	0.2041	0.1633

For assessing the options LTs are transformed in terms of IFNs. Here, Table 4 denotes the ideas of decision experts on each of the option Pd_i respect to each criterion H_j in terms of LTs defined in Table 2.

Table 4: The LTs of Option Employing DE's Judgments.

Alternative	DEs	Criteria							
		H_1	H_2	H_3	H_4	H_5	H_6	H_7	H_8
Pd_1	DE_1	A	H	A	SL	H	VH	A	H
	DE_2	H	A	A	A	A	H	H	H
	DE_3	H	VH	H	A	A	H	A	H
	DE_4	H	H	H	H	H	VH	H	H
Pd_2	DE_1	A	H	H	L	A	H	H	H
	DE_2	L	A	H	A	H	A	H	H
	DE_3	A	H	A	H	H	H	A	A
	DE_4	A	A	A	H	H	EH	VH	H
Pd_3	DE_1	H	VH	A	L	H	A	A	H
	DE_2	A	H	H	A	H	VH	A	H
	DE_3	A	VH	H	A	A	H	A	H
	DE_4	H	H	H	VH	H	VH	VH	VH
Pd_4	DE_1	H	H	H	A	A	H	VH	H
	DE_2	A	A	H	H	A	H	A	A
	DE_3	H	VH	VH	VH	H	H	H	H
	DE_4	VH	H	H	VH	A	VH	H	VH
Pd_5	DE_1	VL	H	A	A	L	EH	H	H
	DE_2	H	H	VH	VH	A	VH	H	VH
	DE_3	A	A	VH	VH	VH	H	A	VH
	DE_4	EH	A	A	A	A	H	VH	EH

In Table 5, the LTs of options given by DE's in Table 4 is converted to AIF-DM using Eq. (8).

Table 5: The Matrix of AIF-DM.

	Pd1	Pd2	Pd3	Pd4	Pd5
$\boldsymbol{H_1}$	(0.6456,0.2606)	(0.4582,0.4785)	(0.6107,0.3025)	(0.6868,0.2289)	(0.6577,0.2833)
$\boldsymbol{H_2}$	(0.6955,0.2225)	(0.6187,0.2926)	(0.7923,0.1385)	(0.6955,0.2225)	(0.6381,0.2694)
$\boldsymbol{H_3}$	(0.5856,0.3341)	(0.6381,0.2694)	(0.6456,0.2606)	(0.7169,0.1736)	(0.7295,0.2089)
$\boldsymbol{H_4}$	(0.5255,0.4080)	(0.5485,0.3567)	(0.5525,0.3758)	(0.7674,0.2020)	(0.7295,0.2089)
$\boldsymbol{H_5}$	(0.6107,0.3025)	(0.6456,0.2606)	(0.6670,0.2359)	(0.5495,0.3814)	(0.5740,0.3535)
$\boldsymbol{H_6}$	(0.7865,0.1424)	(0.7382,0.2044)	(0.7439,0.1882)	(0.7321,0.1786)	(0.8648,0.1029)
$\boldsymbol{H_7}$	(0.6066,0.3075)	(0.7027,0.2107)	(0.5892,0.3520)	(0.7203,0.2044)	(0.7027,0.2107)
$\boldsymbol{H_8}$	(0.7000,0.2000)	(0.6670,0.2359)	(0.7321,0.1786)	(0.6868,0.2289)	(0.8428,0.1120)

This measure reflects the difference between the performance of the composite option and its performance in removing the criterion. The following steps are used to calculate the OCWs by MEREC method: Here, $\{H_1, H_2, \}$ is a set of cost criteria and remaining are benefit type of criteria, then normalize AIF-DM Eq. (9) as shown in Table 6. Subsequent, we compute score matrix using Eq. (4).

Table 6: Normalized the AIF-DM.

	Pd1	Pd2	Pd3	Pd4	Pd5
$\boldsymbol{H_1}$	(0.2606,0.6456)	(0.4785,0.4582)	(0.3025,0.6107)	(0.2289,0.6868)	(0.2833,0.6577)
$\boldsymbol{H_2}$	(0.2225,0.6955)	(0.2926,0.6187)	(0.1385,0.7923)	(0.2225,0.6955)	(0.2694,0.6381)
$\boldsymbol{H_3}$	(0.5856,0.3341)	(0.6381,0.2694)	(0.6456,0.2606)	(0.7169,0.1736)	(0.7295,0.2089)
$\boldsymbol{H_4}$	(0.5255,0.4080)	(0.5485,0.3567)	(0.5525,0.3758)	(0.7674,0.2020)	(0.7295,0.2089)
$\boldsymbol{H_5}$	(0.6107,0.3025)	(0.6456,0.2606)	(0.6670,0.2359)	(0.5495,0.3814)	(0.5740,0.3535)
$\boldsymbol{H_6}$	(0.7865,0.1424)	(0.7382,0.2044)	(0.7439,0.1882)	(0.7321,0.1786)	(0.8648,0.1029)
$\boldsymbol{H_7}$	(0.6066,0.3075)	(0.7027,0.2107)	(0.5892,0.3520)	(0.7203,0.2044)	(0.7027,0.2107)
$\boldsymbol{H_8}$	(0.7000,0.2000)	(0.6670,0.2359)	(0.7321,0.1786)	(0.6868,0.2289)	(0.8428,0.1120)

To obtained the OCWs by MEREC method, we compute OAPs of the options values in Eq. (10), given as e_i =(0.3971, 0.3313, 0.3957, 0.3490, 0.2862). According to Eq. (11), we assess the overall performances (e'_{ij}) of each alternative in removing the criterion and are given in Table 7 and we evaluate score values in Eq. (4). Next, we calculate the measure reflects the difference between the performance of the complex option and its performance in removing the criterion basis on the deviation (σ_j) values.

Table 7: Compute the Performance of the Alternatives by REC-matrix.

	Pd1	Pd2	Pd3	Pd4	Pd5
$\boldsymbol{H_1}$	(0.4278,0.7111)	(0.3868,0.7394)	(0.4501,0.7201)	(0.3814,0.7806)	(0.3335,0.8459)
$\boldsymbol{H_2}$	(0.4149,0.7156)	(0.3441,0.7571)	(0.3858,0.7358)	(0.3789,0.7813)	(0.3289,0.8443)
$\boldsymbol{H_3}$	(0.4917,0.6698)	(0.4109,0.7071)	(0.5089,0.6669)	(0.4744,0.6986)	(0.4148,0.7825)
$\boldsymbol{H_4}$	(0.4834,0.6825)	(0.3983,0.7243)	(0.4970,0.6901)	(0.4797,0.7079)	(0.4148,0.7825)
$\boldsymbol{H_5}$	(0.4949,0.6634)	(0.4119,0.7051)	(0.5112,0.6605)	(0.4535,0.7463)	(0.3948,0.8121)
$\boldsymbol{H_6}$	(0.5140,0.6137)	(0.4229,0.6899)	(0.5194,0.6458)	(0.4760,0.7003)	(0.4287,0.7411)
$\boldsymbol{H_7}$	(0.4944,0.6645)	(0.4149,0.6919)	(0.5019,0.6860)	(0.4748,0.7087)	(0.4117,0.7829)
$\boldsymbol{H_8}$	(0.5053,0.6364)	(0.4146,0.6989)	(0.5182,0.6424)	(0.4711,0.7156)	(0.4266,0.7462)

from Eq. (12). Finally, we compute the OCWs (ϖ_j) and are shown in Table 8. The following steps have used to compute the OCWs by MEREC method.

Table 8: The MEREC Weighting Process for Calculating the OCWs.

	e'_{ij}						
	Pd_1	Pd_2	Pd_3	Pd_4	Pd_5	σ_j	ϖ_j
H_1	0.3584	0.3237	0.3650	0.3004	0.2438	0.1680	0.1346
H_2	0.3497	0.2935	0.3250	0.2988	0.2423	0.2500	0.2003
H_3	0.4109	0.3519	0.4210	0.3879	0.3162	0.1286	0.1030
H_4	0.4005	0.3370	0.4035	0.3859	0.3162	0.0838	0.0671
H_5	0.4158	0.3534	0.4254	0.3536	0.2914	0.0803	0.0643
H_6	0.4502	0.3665	0.4368	0.3879	0.3438	0.2259	0.1810
H_7	0.4150	0.3615	0.4080	0.3831	0.3144	0.1227	0.0983
H_8	0.4345	0.3579	0.4379	0.3778	0.3402	0.1890	0.1514

Next, Table 9 the following steps are used to calculate the subjective criteria weights (SCWs) using SWARA technique.

Table 9: Assessment of SCWs by DE's.

Criteria	DE_1	DE_2	DE_3	DE_4	Aggregated PFNs	Crisp values
H_1	H	L	A	H	(0.5781, 0.3217)	0.6282
H_2	A	H	A	H	(0.6066, 0.3075)	0.6496
H_3	A	H	VH	A	(0.6655, 0.2583)	0.7036
H_4	SL	A	H	VH	(0.6182, 0.3087)	0.6548
H_5	L	H	VH	H	(0.6648, 0.2417)	0.7116
H_6	VH	H	H	EH	(0.8214, 0.1272)	0.8471
H_7	A	H	H	VH	(0.6835, 0.2327)	0.7254
H_8	H	H	VH	VH	(0.7674, 0.1550)	0.8062

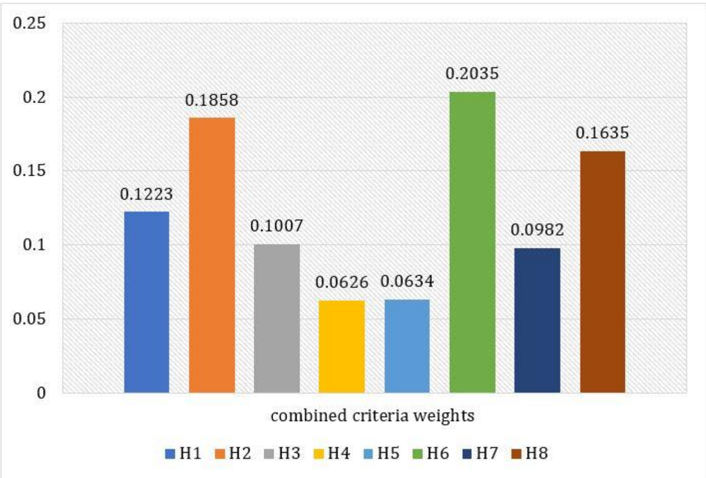

Figure 3. Combined weights for each criterion by MEREC-SWARA method.

Table 10: The SCWs Computed by SWARA Approach.

	Crisp values	Relative Importance(δ_j)	Relative coefficient (C_j)	Recalculated weight (ρ_j)	Criteria weight (ω_j)
H_6	0.8471	-	1.0000	1.0000	0.1417
H_8	0.8062	0.0409	1.0409	0.9607	0.1361
H_7	0.7254	0.0808	1.0808	0.8889	0.1259
H_5	0.7116	0.0138	1.0138	0.8768	0.1242
H_3	0.7036	0.0080	1.0080	0.8698	0.1232
H_4	0.6548	0.0488	1.0488	0.8293	0.1175
H_2	0.6496	0.0052	1.0052	0.8250	0.1169
H_1	0.6282	0.0214	1.0214	0.8077	0.1145

Table 10 displays the SCWs. We compute the combined criteria weights by Eq. (17)

and display figure 3.

$$w_j = (0.1223, 0.1858, 0.1007, 0.0626, 0.0634, 0.2035, 0.0982, 1635)^T$$

Steps 5-9 are used to obtain the rank, in which the score matrix from Table 6 is calculated by Eq. (18) shown Table 11, from Equations. (19)-(24) is applied to find the rank by the CoCoSo method. The ranking of alternative show above figure 4.

Table 11: Score values for PWD.

	Pd1	Pd2	Pd3	Pd4	Pd5
H_1	0.3075	0.5102	0.3459	0.2711	0.3128
H_2	0.2635	0.3369	0.1731	0.2635	0.3157
H_3	0.6258	0.6844	0.6925	0.7717	0.7603
H_4	0.5588	0.5959	0.5884	0.7827	0.7603
H_5	0.6541	0.6925	0.7156	0.5841	0.6103
H_6	0.8221	0.7669	0.7779	0.7768	0.8809
H_7	0.6496	0.7460	0.6186	0.7579	0.7460
H_8	0.7500	0.7156	0.7768	0.7289	0.8654

Table 12: Find the rank of IF-CoCoSo method (ϒ = 0.5).

	$\mathbb{S}_i$	$\mathbb{P}_i$	$\mathcal{K}_{ia}$	$\mathcal{K}_{ib}$	$\mathcal{K}_{ic}$	$\mathcal{K}_i$	Ranking
Pd1	0.5797	7.4112	0.1984	2.0178	0.9831 (0.2) 0.9773 (0.5) 0.9598 (0.8)	1.7993(0.2) 1.7959(0.5) 1.7857(0.8)	4
Pd2	0.6214	7.5114	0.2019	2.1043	0.9975 (0.2) 0.9947 (0.5) 0.9861 (0.8)	1.8524(0.2) 1.8508(0.5) 1.8457(0.8)	2
Pd3	0.5724	7.3738	0.1973	2.0000	0.9780 (0.2) 0.9719 (0.5) 0.9532 (0.8)	1.7865(0.2) 1.7829(0.5) 1.7720(0.8)	5
Pd4	0.5975	7.4311	0.1993	2.0516	0.9863 (0.2) 0.9819 (0.5) 0.9687 (0.8)	1.8179(0.2) 1.8154(0.5) 1.8076(0.8)	3
Pd5	0.6538	7.5224	0.2030	2.1622	1.0000 (0.2) 1.0000 (0.5) 1.0000 (0.8)	1.8817(0.2) 1.8817(0.5) 1.8817(0.8)	1

5. Result Discussion and Comparative Analysis Incineration with Energy Recovery

The empirical outcomes of the proposed method provide some important insights related to the evaluation criteria and key options for PWD in India. As shown in Table 12, the effectiveness of incineration with energy recovery technique (Pd_5) is of paramount importance, based on waste disposal and their environmental impacts.

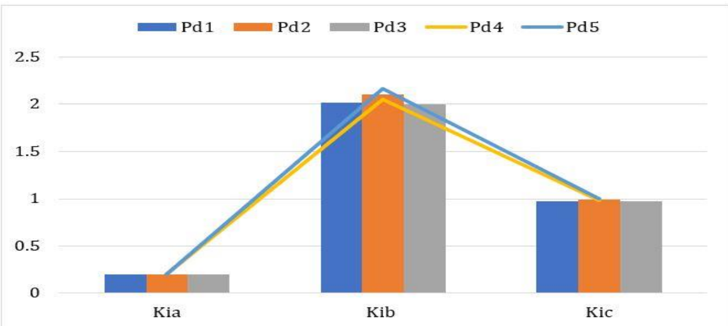

Figure 4: Performance calculations on the ranking $\mathcal{K}_{ia}, \mathcal{K}_{ib}$ and $\mathcal{K}_{ic}$.

The ranking of PWD options is shown in Table 12. It can be seen that incineration with energy recovery (Pd_5) ranks first with respect to all the criteria, hence it has been selected as the best PWD alternative meeting all the appraisal criteria. We can observe in the section that the background provided here has a lot of likenesses with the extent approaches. The IF-MEREC-SWARA-CoCoSo method has been found to be capable of dealing with both qualitative and quantitative MCDM challenges, especially when there are multiple competing criteria.

Table 13: Comparative Results of Ranking Order with Different Methods.

Methods	Benchmark	DE's weight	Criteria's weights	Ranking order	Option
(Kuo, Hsu, & Chen, 2015)	TOPSIS method	Assume	ANP method	$Pd_5 \succ Pd_2 \succ Pd_4 \succ Pd_3 \succ Pd_1$	Pd_5
(Mishra et al., 2020b)	IF-ELECTRE method	Evaluate	Entropy measures method	$Pd_5 \succ Pd_2 \succ Pd_4 \succ Pd_3 \succ Pd_1$	Pd_5
(Kumari & Mishra, 2020)	IF-COPRAS method	Completely known & numeric	Entropy measures method	$Pd_5 \succ Pd_2 \succ Pd_4 \succ Pd_3 \succ Pd_1$	Pd_5
Proposed method	IF-CoCoSo	Evaluate	MEREC and SWARA combined method	$Pd_5 \succ Pd_2 \succ Pd_4 \succ Pd_1 \succ Pd_3$	Pd_5

In Table 13, the comparative study of the developed hybrid method along with the already prevailing techniques is presented. Outcomes of the comparison shown that the proposed method is in synchronization with the existing techniques. Ranking of the proposed method and the CoCoSo, and the all given by Kumari and Mishra (2020); Kuo et al. (2015); Mishra et al. (2020b) is the same. As reveals the rationality and accurateness of the submitted method. Some of the benefits of the proposed hybrid method as visible, in Table 13 are as: initially, IFSs are robust preference genre that is comprehensive and allows the DM to express their select on each alternative independently. Thereafter, prevailing methods work on the supposition that all data is available. However, in applied MCDM problems, it may not always be true. Unlike existing methods, the suggested method considers missing values and applies them systematically using a case-based method. furthermore, the criterion evaluated, the criterion alternative and the degree of importance of the DEs are measured as IFNs.

On the other hand, in the presented approach, the criterion weights are evaluated by combining MEREC and SWARA based formulas, which indicates that the found weight is of high accuracy and optimal. The stability, effectiveness and stability of hybrid method used separately are superior to those of single technique. In the proposed IF-MEREC-SWARA-CoCoSo method, we have estimated the weights based on the criteria experts' judgment and computed the criterion weights after performing the normalization, which leaves no room for the vagueness. It specifies that the MCDM with more criterions or options for the IF-MEREC-SWARA-CoCoSo method can growth the quantity of working efficiencies and have better operability. The following are some advantage or aspects of the offered framework:

- In the developed IF-MEREC-SWARA-CoCoSo method, we have considered experts, whereas the ANP-TOPSIS (Kuo et al., 2015) process does not involve experts.
- In the hybrid developed IF-MEREC-SWARA-CoCoSo method, we have estimated expert weights on the basis of expert opinion, leaving no space to treat vagueness, whereas ANP and TOPSIS (Kuo et al., 2015), IF-ELECTRE (Mishra et al., 2020b) and IF-COPRAS (Kumari & Mishra, 2020) the procedure does not involve expert

opinion, (see Table 13).

- The methods ANP and TOPSIS (Kuo et al., 2015), to find distance between two sets whereas in IF CoCoSo method we find compromise solution.

IF-CoCoSo outperformed IF-ELECTRE (Mishra et al., 2020b) and IF-COPRAS (Kumari & Mishra, 2020) in term of efficiency and effective. Moreover, the hybrid IF-MEREC-SWARA-CoCoSo method is more powerful and stable in terms of criterion weight disparity than IF-COPRAS (Kumari & Mishra, 2020).

Table 14: The Technology Compromise Index Over Parameter (ϒ).

	Pd_1	Pd_2	Pd_3	Pd_4	Pd_5
ϒ=0.0	1.8005	1.8529	1.7878	1.8188	1.8817
ϒ=0.1	1.7999	1.8527	1.7872	1.8184	1.8817
ϒ=0.2	1.7993	1.8524	1.7865	1.8179	1.8817
ϒ=0.3	1.7984	1.8519	1.7856	1.8172	1.8817
ϒ=0.4	1.7974	1.8514	1.7845	1.8164	1.8817
ϒ=0.5	1.7959	1.8507	1.7829	1.8153	1.8817
ϒ=0.6	1.7939	1.8497	1.7808	1.8138	1.8817
ϒ=0.7	1.7908	1.8482	1.7775	1.8115	1.8817
ϒ=0.8	1.7857	1.8457	1.7720	1.8076	1.8817
ϒ=0.9	1.7752	1.8406	1.7609	1.7998	1.8817
ϒ=1.0	1.7423	1.8247	1.7259	1.7752	1.8817

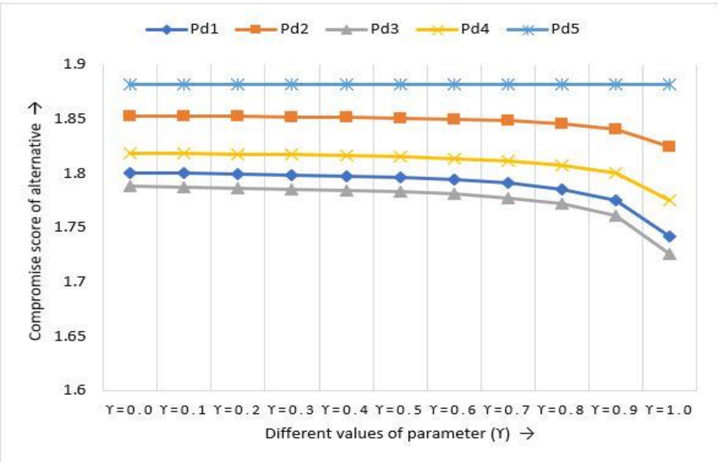

Figure 5: The Technology Compromise Index Over Parameter (ϒ).

Here we present a sensitivity analysis involving various values of the mechanism coefficients. As shown in Table 14, *ϒ= 0.0, 0.1…, 0.9* by significance, as incineration with energy recovery the maximum value of *ϒ=1.0* the various sets of ranking are displayed in Table 14 and Figure 5.

6. Conclusion

The goal of this paper is to develop an MCDM method on IF-environment. To do this, we first developed a novel hybrid IF-MEREC-SWARA-CoCoSo method under IFS. Finally, the IF-CoCoSo methodology is proposed for ranking the alternatives. In addition, the discussion of comparative study of the presented method with the existing methods is done. Based on a comparison with existing method, it is worth saying that the IF-CoCoSo method provides an effortless calculation with accurate and efficient results for the development of MCDM problems. The application of the proposed hybrid IF-MEREC-SWARA-CoCoSo method on selecting the optimal technique helps in finding the best plastic waste disposal. Industry experts evaluate the value of dimensions, and imprecise ideas are used to account for the ambiguity of decision-making. In our study, a new hybrid IF-MEREC-SWARA-CoCoSo method is used. The most appropriate plastic recycling process was found among the given options for the plastic disposal process. Finally, the IF-CoCoSo methodology is proposed for ranking the alternatives.

- A new normalization score function for IFN is presented, which minimizes intimation loss by taking vagueness information into account. Compared to existing score functions, it has a more vigorous ability to segregate when comparing two IFNs.
- The combined weight framework has been presented basis on the MEREC and SWARA weighted extensive methods, which is considered both objective and subjective weight.
- MEREC presented a new IF-decision-making method basis on the CoCoSo method, which can obtain the best alternative without any adverse events, obtain the outcome of the decision without segmentation, and has a robust capability.

There are some limitations to this research, presenting a stage for undertaking added theoretical and practical study in this developing region. (a) PWD are still at an initial stage, and more innovative approaches to unified them could be internet technologies for urbanization schemes. (b) Plastic waste is a wide space that may be connected to services, and it'll be more emphatic for stakeholders to appliance it in an additional suitable manner. (c) The limitation of the current study is that only a small number of DE's were included, and it does not take into account the interrelationships among the criteria, which somehow limits the scope of the application of the proposed framework. Consequently, further research is still desired, which considers massive number of decision experts. this article framework of the study may be extended to the empirical methodology for checking the legality of variables. The application of the proposed hybrid method in selecting the optimal technique helps in finding the best plastic waste disposal. In the future, developed MCDM method can be further proceed to interval-valued IFNs, PFN, q-rung & picture fuzzy sets. Furthermore, the authors can extension our research via many MCDM platforms (such as, Gained and Lost Dominance Score (GLDS), FUCUM-MARCOS and MAIRCA) to select the most appropriate PWD selection and more features can be assessed.

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Appendix

Table A1

Abbreviation	Meaning
COPRAS	COmplex PRoportional ASsessment
CRITIC	CRiteria Importance Through Inter-criteria Correlation
ANP	Analytic Network Process
TOPSIS	Technique for Order of Preference by Similarity to Ideal Solution
ELECTRE	ELimination Et Choix Traduisant la REalite
MULTIMOORA	Multi-Objective Optimization on the basis of Ratio Analysis
MAIRCA	Multi-Attribute Ideal-Real Comparative Analysis
Grey-MARCOS	Grey- Measurement of Alternatives and Ranking according to the Compromise Solution
IoT	Internet of Thing
OAP	Overall Performance
CWs	Criteria Weights
DE	Decision Expert

Table A2: Sample Questionnaire for PWD Technology Selection.

Questions	Qualitative rating based on Likert scales								
	EH	VH	H	SH	A	SL	L	VL	EL
What is your opinion on landfilling with respect to cost?									
What is your opinion on landfilling with respect to disposal cost?									
What is your opinion on landfilling with respect to technical aspect?									
What is your opinion on landfilling with respect to energy consumption?									
What is your opinion on landfilling with respect to release with health effects?									
What is your opinion on landfilling with respect to environmental effect?									
What is your opinion on landfilling with respect to public acceptance?									
What is your opinion on landfilling with respect to reliability?									

Note: Landfilling; EH- Excessively high; VH- Very high; H-High; SH- Slightly high; A-Average; SL- Slightly Low; L-Low; VL- Very low; EL- Excessively low.

EH-(0.95, 0.05); VH-(0.85, 0.10); H-(0.70, 0.20); SH-(0.60, 0.30); A-(0.50, 0.45); SL-(0.45, 0.50); L-(0.35, 0.55); VL-(0.20, 0.70); EL-(0.10, 0.90) are the qualitative terms and its respective IFNs obtained from Kumari and Mishra (2020).