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Sustainable assessment for selecting the improved air quality technology under hesitant bipolar fuzzy

R. Rajalakshmi
Research Scholar, Department of Mathematics, Nirmala College for Women, Coimbatore-18
Corresponding Author E-mail: rajimat2020@gmail.com

Dr. K. Julia Rose Mary
Associate Professor, Department of Mathematics, Nirmala College for Women, Coimbatore-18.

***Abstract*---**Due to increasing population and urbanization, it is a complex task to find a better solution to control air pollution without impact on humans. But in this vast world there are numerous technologies and possibilities remain to control air pollution. The possibilities to improve air quality is attained by using a Multi Criteria Decision Making (MCDM) method. The selection of cost effective and efficient improved air quality technologies ensures sustainable development. Thus, in the present study we provide a new version of the Complex Proportional Assessment (COPRAS) method and Stepwise Weight Assessment Ratio Analysis (SWARA) to Hesitant Bipolar Fuzzy (HBF) for the selection of Air Quality Technology (AQT) alternatives. The Hesitant Bipolar Fuzzy Numbers (HBFNs) are used by analysts to assign the preferences of alternatives on the basis of criteria. The study proposes an integrated approach based on SWARA and COPRAS method within the HBFs context named as, HBF-SWARA-COPRAS method. In the integrated framework, the criteria weights are determined by the SWARA process and the ranking of the alternatives is determined by the COPRAS method using HBFs. In addition, sensitivity analysis is also performed to check the stability of the presented methodology. Finally, a comparative study is discussed to analyze the validity of the result obtained.

***Keywords*---**Hesitant bipolar fuzzy set, Improved Air Quality Technique, SWARA, COPRAS, WASPAS.

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Introduction

Pollution is caused by two factors, natural and human. Naturally occurring pollution does not cause much attack in our lives because they have the potential to resurrect. The major hazards of pollution is carried out by human activities. So, we focus on the issue of environmental pollution which is one of the most important problems facing the modern world. Among the types of pollution, air pollution is a catastrophic one that directly affects the health of organisms and humans. Some of the major pollutants produced by human activity include oxides of carbon (CO, CO_2), oxides of nitrogen (NO, NO_2), lead (Pb), ozone (O_3), particulate matter (PM) and oxide of Sulphur (SO_2) etc., Air pollution is more serious than other pollution. For this reason, improved air quality technology is structured with alternatives to avoid pollution and for the safety of the environment. For this purpose, Multi Criteria Decision Analysis (MCDA) tools or techniques can be used to explore the problem in better way. The MCDA method is to rank or select the most suitable alternatives based on several conflicting criteria. Some of the effective MCDM methods such as, including Analytic Hierarchy Process (AHP), Vise Kriterijumska Optimizacija I Kom Promisno Resenje (VIKOR), Elimination Et Choix Traduisant la REalite (ELECTRE), Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE), Additive Ratio Assessment (ARAS), Complex Proportional Assessment (COPRAS), Weighted Aggregated Sum Product Assessment (WASPAS) etc., are the some of the effective MCDM methods.

Review of Literature

In this section we present air pollution and MCDM systems related to improving air quality. Many Researchers have given the causes for air pollution and its effects through numerous studies. Evidence for improving air quality in Tamil Nadu would be beneficial if addressed. Piasecki, M et al., (2020) proposed global weights for improved air quality and indoor environmental quality using multi attribute decision making method. Zeydan O et al., (2021) determining the priorities of air pollutants and calculating the air quality monitoring stations in Turkey by their criteria. Motlagh et al., (2021) developed a new model to find the most suitable green roof to reduce air pollution in cities and selected adequate green roof solution to improve air quality in cities.

The evaluation and selection of a desirable AQT option often involves several quality and quantity criteria. Criterion weight key factors in the MCDM process, the calculation of the attribute weights and the sorting of options are of significant concern to experts. Criterion weight can be classified into two. which are, objective and subjective. Objective weights are estimated from the information in the decision matrix, while Subjective weights are calculated based on the information provided by the decision experts. In 2010, Kersuliene et al., started an innovative process called SWARA. This approach has a slight computation complexity compared to other weight determination techniques which have recently been widely used by various authors in various problems.

Zavadskas et al., (1994) originated the idea of the COPRAS approach. It seeks to rank the options depicted based on two aspects of benefit and cost categories. Furthermore, the COPRAS approach is one of the most well-defined and realistic approaches for sorting options for MCDM problems. In addition, it depicts simultaneously best and worst results in proportion. In recent years different authors have expanded the COPRAS approach to different fields. Zheng et al., (2018) used a hesitant fuzzy linguistic COPRAS approach that is reluctant to assess medical disease. Mishra et al., (2020) evaluated the COPRAS method based on information measures to sort out the hazardous waste and recycling facility assessment problem.

Furthermore, SWARA-COPRAS the two approaches have the advantage of estimating the subjective weights of criteria and ranking based on their priority options respectively. However, past studies have used the SWARA-COPRAS integration method in different domains. But, still no one worked combining SWARA-COPRAS integrated approach with the Hesitant Bipolar Fuzzy sets. Consequently, the resulting work focuses on the HBFs context. Recently, our country has been facing various diseases and problems due to air pollution. For example: 10% rise in cancer in last four years, 12.6 lakhs by 2016 to 13.6 lakhs in 2019. 11% of total deaths caused by lung diseases, CVD-leading cause of death in India, one in four deaths are due to heart disease. Therefore, the problem of air pollution control in this study is discussed from a clear perspective. HBF-SWARA-COPRAS integrated framework is being developed to address this concern. This method allows decision makers to successfully deal with inherent instability and reluctance to evaluate and choose options.
The contribution of this study describes,

- A novel HBF-SWARA-COPRAS integrated work is initiated.
- To evaluate the criteria weights of the HBF using SWARA method.
- To show the feasibility of the proposed HBF-SWARA-COPRAS method.
- A comparative and sensitivity analysis are discussed which conclude the validity and stability of the developed framework.

In our work, we identify the best way to improve air quality in Tamil Nadu using Key factors of Environmental aspects, economic, technological and social aspects. The goal of the MCDM method is to find the most appropriate alternative to the set of options in the set of multiple quantitative and qualitative criteria. However, no one in the HBF environment has combined SWARA and COPRAS methods. We compared our proposed method with COPRAS and Weighted Aggregated Sum Product Assessment (WASPAS) methods. We have also verified the results by sensitivity analysis.

Preliminaries

As specified by Torra (2010), Zhang (1998) and Presenjit Mandal & Ranadive (2019), we considered HBFs and analyzed the solution based on Hesitant Bipolar Fuzzy SWARA-COPRAS method.

Hesitant Bipolar-Valued Fuzzy SWARA-COPRAS method

The computation procedure of the Hesitant bipolar fuzzy COPRAS method is summarized in the following steps.

Step 1: Originate the alternatives and the attributes

In MCDM practice, consider the objectives for selecting the optimal alternative from the set 'm' alternatives B= {B_1, B_2, B_3, ..., B_m} and 'n' criteria F= {F_1, F_2, F_3, ... F_n}. Consider a group of G decision Experts D= {D_1, D_2, ..., D_G} created to achieve the best results. Let $Z = \left(z_{ij}^{k}\right)_{m\times n}$, i=1,2, ... m; j=1, 2, ..., n be the Hesitant bipolar fuzzy decision matrix proposed by the k[th] decision expert (DE), where z_{ij}^{k} gives the estimated value of an option B_i over the criteria F_j in the form of HBFs for kth expert.

Step 2: Calculate the Decision Expert's weights; The formula for determining the weight of kth DE as

$$e(h_k) = -K\sum_{i=1}^{m} Z_{ij} ln Z_{ij} \quad (1)$$

where $K = \frac{1}{\ln m}$ is non-negative constant.

$$\omega_k = \frac{(1-e(h_k))}{\sum_{k=1}^{G}(1-e(h_k))}, \quad k=1(1)G. \quad (2)$$

Clearly, $\omega_k \geq 0$, and $\sum_{k=1}^{G}\omega_k = 1$

Step 3: Compute the aggregated hesitant bipolar fuzzy decision matrix (HBF-DM)
To aggregate the matrix, the HBFWA operator is used, and then $P = \left(\mu_{ij}\right)_{m*n}$ is the matrix's desired result.

$$\mu_{kj} = HBFWA_{\omega}(\mu_{kj}^{(1)}, \mu_{kj}^{(2)}, \ldots\ldots, \mu_{kj}^{(G)} = \{1 - \prod_{K=1}^{G}(1-t_k)^{\omega_k}, -\prod_{K=1}^{G}(-t_k)^{\omega_k}\} \quad (3)$$

Step 4: Determine the weight of the criteria by the SWARA method

Evaluating the criteria is the first step of the SWARA method and compare the pair of direct high- and low-ranking criteria. Then, a corresponding coefficient must be calculated and the weight needed to deal with the MCDM problems should be assessed.

Step 5: Adding the values of benefit and cost criteria

In the developed framework, each option is described to increase its benefit type criteria and decrease the cost type criteria. Under these conditions, the procedures for calculating x_i and y_i are given,

Let us assume that $\Delta = \{1,2,\ldots\ldots q\}$ be the beneficial criteria. Now each option is assigned a maximum index value based on HBF as $x_i = \bigoplus_{j=1}^{q} w_j\mu_{ij}$, i=1(1)m (4)

Let us assume that $\nabla = \{q+1, q+2, \ldots . n\}$ be non-beneficial criteria (or) cost criteria. Now each option is assigned a index value based on HBFs and obtained by $y_i = \bigoplus_{j=1}^{q+1} w_j\mu_{ij}$, i=1(1)m (5)

where q and n are the number of beneficial criteria and the total number of criteria.

Step 6: Estimate the degree of relative weight

$$\theta_i = S(x_i) + \frac{\min(S(y_i)\sum_{i=1}^{q} S(y_i)}{S(y_i)\sum_{i=1}^{q}\frac{minS(y_i)}{S(y_i)}} \quad (6)$$

Here $S(x_i)$ is the score value of x_i and $S(y_i)$ is the score value of y_i.

$$\theta_i = \gamma S(x_i) + (1-\gamma)\frac{\sum_{i=1}^{q} S(y_i)}{S(y_i)\sum_{i=1}^{q}\frac{1}{S(y_i)}}$$

(7)

Step 7: Compute the Priority order
Based on the relative weight, the preference sequence of options is calculated. The option with higher relative weight is the first rank and best choice.
Thus, $Q^* = max\theta_i$, i=1, 2…m.
The degree of utility is calculated by evaluating the options with the best option and the degree of utility is defined by λ_i.

$$\lambda_i = \frac{\theta_i}{\theta_i max} \times 100\%, \qquad i=1(1)m$$

(8)
where θ_i and θ_{imax} are the relative significance.
Step 8: End

An Empirical study: Improved Air Quality selection alternatives

The HBF-SWARA-COPRAS framework proposed in the current section is used to calculate the optimal alternative from the set of advanced air quality technological alternatives, which demonstrates the compatibility and feasibility of the developed structure. According to the results of the survey, four key dimensions of environmental aspects, economy, technology, and social aspects were identified with 10 related criteria. Here, we consider the decision-maker as environmental engineer, air pollution management engineer, and air quality engineer. Then, the alternatives are S_1—Move to Renewable Energy sources, S_2—Increasing Electric Vehicles, S_3— Promoting Waste Reduction, S_4— Dust collectors, S_5- Use LED and CFL lights, and S_6—Create Green spaces. Based on that, we discuss the selected alternatives and criteria as shown in Figure 1.

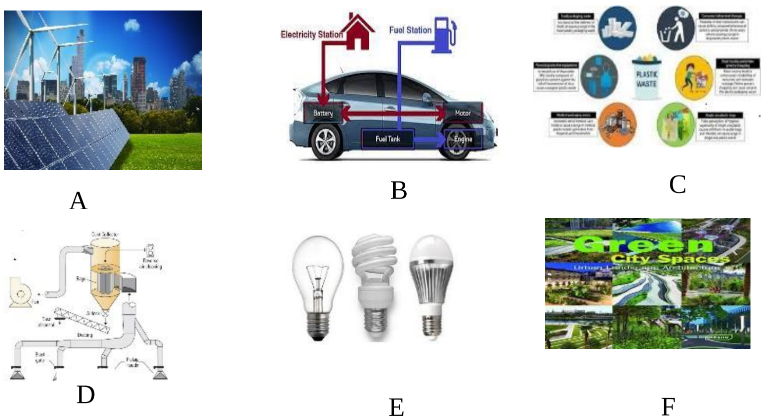


Figure .1 Alternatives: (A) Move to Renewable energy sources, (B) Increasing Electric vehicles, (C) Promoting waste Reduction, (D) Dust collectors, (E) Use LED and CFL lights, (F) Create Green spaces.

Next, the linguistic terms are described in a qualitative manner, and these terms are very relevant for dealing with inaccurate practical decision-making problems. The linguistic terms for the preferential evaluation of decision makers and the performance values of the alternatives and criteria are now illustrated in table 1 and table 2.

Table 1. Linguistic terms (LTs) and their equivalent HBFNs for alternatives and criteria

Linguistic terms	**HBFNs**
Extremely Preferable (EP)	(0.9, 0.95, 1.0), (0, -0.1, -0.2)
Strong Preferable (SP)	(0.7, 0.8, 0.9), (-0.1, -0.2, -0.3)
Preferable(P)	(0.6, 0.7, 0.8), (-0.2, -0.4, -0.5)
Moderate(M)	(0.5, 0.6, 0.7), (-0.4, -0.5, -0.6)
Undesirable(U)	(0.2, 0.3, 0.4), (-0.5, -0.6, -0.8)
Strong undesirable (SU)	(0.1, 0.2, 0.3), (-0.7, -0.8, -0.9)
Extremely undesirable (EU)	(0, 0.1, 0.2), (-0.8, -0.9, -1.0)

Table 2. LTs for rating decision experts' significance degree

Ratings	**HBFNs**
Very poor	(0, 0.1, 0.2), (-0.8, -0.9, -1.0)
Poor	(0.3, 0.4, 0.5), (-0.6, -0.7, -0.8)
Average	(0.5, 0.65, 0.7), (-0.4, -0.45, -0.5)
Good	(0.7, 0.75, 0.8), (-0.3, -0.35, -0.4)
Very good	(0.8, 0.85, 0.9), (-0.2, -0.25, -0.3)
Excellent	(0.9, 0.95, 1.0), (-0, -0.1, -0.2)

Finally, we collected the required data from three decision experts. Consequently, based on the expert's comments, all the selected criteria for the evaluation of air quality improved technologies were considered in the analysis process. Based on the multiplicity of criteria taken during the preliminary survey, 10 criteria were evaluated and those are specified in table 3.

Table 3. Details of the criteria for the selection of Improved air quality

Dimension	**Criteria**	**Type of Criteria**
Environmental aspects	Contributing to climate change (R_1)	Benefit
	Loss of biological diversity (R_2)	Cost
	Control pollution (R_3)	Cost
Economic	Sustainability of microeconomic (R_4)	Benefit
	Sustainability of macroeconomic (R_5)	Benefit

Technology	Technology Maturity (R_6)	Benefit
	Continuity and liability of performance (R_7)	Benefit
Social aspects		Benefit
	Health and safety (R_8)	Benefit
	Job creation (R_9)	Benefit
	Environmental to Regional development (R_{10})	

The weight of the Decisions experts is calculated from Table .2 and by using Eq. (2) HBFNs are evaluated and specified in Table 4.

Table 4. Decision Experts weights

Decision Expert	**LTs**	**HBFNs**	**Weights**
E_1	Very Good	(0.8, 0.85, 0.9), (-0.2, -0.25, -0.3)	0.3241
E_2	Excellent	(0.9, 0.95, 1.0), (-0.1, -0.15, -0.2)	0.3764
E_3	Good	(0.7, 0.75, 0.8), (-0.3, -0.35, -0.4)	0.2995

Table.5 Describes the HBFNs for the air quality alternative selection and evaluation

	S_1	**S_2**	**S_3**	**S_4**	**S_5**	**S_6**
R_1	< (0.73,0.78,0.8), (-0.2,-0.25,-0.3)>	< (0.72,0.8,0.82), (-0.1,-0.13,-0.25)>	< (0.51,0.58,0.62), (-0.22,0.37,0.42)>	<(0.8,0.85,0.9), (0.42,0.47,0.55)>	< (0.45,0.5,0.7), (-0.22,-0.37,-0.42)>	< (0.7,0.75,0.8), (-0.15,-0.2,-0.3)>
R_2	< (0.54,0.7,0.8), (-0.2,-0.3,-0.4)>	< (0.43,0.66,0.79), (-0.15,-0.4,-0.5)>	<(0.45, 0.67, 0.8), (0.2,0.45,0.5)>	< (0.7,0.75,0.8), (-0.42,-0.5,-0.54)>	< (0.55,0.6,0.65), (-0.15,-0.35,-0.5)>	< (0.63,0.81,0.9), (-0.1,-0.28,-0.3)>
R_3	< (0.48,0.5,0.58), (-0.13,-0.15,-0.2)>	< (0.73,0.78,0.9), (-0.1,-0.12,-0.2)>	< (0.67,0.8,0.9), (-0.1,-0.25,-0.3)>	<(0.75,0.79,0.81), (0.34, 0.4, 0.6)>	< (0.71,0.88,0.9), (-0.34,-0.5,-0.61)>	< (0.8,0.9,0.95), (-0.12,-0.1,-0.2)>
R_4	< (0.67,0.72,0.87), (-0.5,-0.18,-0.2)>	< (0.48,0.67,0.8), (-0.19,-0.34,-0.5)>	< (0.51,0.63,0.7), (-0.14,-0.33,-0.5)>	< (0.5,0.72,0.8), (-0.2,-0.24,-0.45)>	< (0.4,0.55,0.62), (-0.35,-0.35,-0.44)>	< (0.71,0.81,0.9), (-0.1,-0.16,-0.3)>
R_5	< (0.48,0.5,0.58), (-0.32,-0.37,-0.4)>	< (0.7,0.75,0.8), (-0.18,-0.2,-0.2)>	<(0.52,0.59,0.63), (0.34,0.38,0.52)>	< (0.52,0.62,0.7), (-0.25,-0.35,-0.5)>	< (0.54,0.59,0.7), (-0.25,-0.28,-0.5)>	< (0.65,0.75,0.9), (-0.2,-0.25,-0.3)>
R_6	< (0.49,0.5,0.67), (-0.3,-0.4,-0.56)>	< (0.71,0.78,0.9), (-0.1,-0.2,-0.31)>	<(0.58,0.6,0.67), (0.17,0.36,0.5)>	< (0.48,0.52,0.62), (-0.3,-0.5,-0.55)>	< (0.6,0.67,0.8), (-0.38,-0.5,-0.6)>	< (0.6,0.87,0.9), (-0.15,-0.18,-0.2)>
R_7	< (0.7,0.81,0.9), (-0.11,-0.2,-0.32)>	< (0.6, 0.8, 0.9), (-0.39,-0.42,-0.6)>	< (0.66,0.8,0.9), (-0.1,-0.22,-0.3)>	< (0.35,0.51,0.6), (-0.28,-0.5,-0.6)>	< (0.43,0.5,0.6), (-0.3,-0.4,-0.52)>	< (0.64,0.8,0.9), (-0.1,-0.2,-0.34)>
R_8	< (0.72,0.8,0.9), (-0.1,-0.18,-0.3)>	< (0.59,0.71,0.9), (-0.1,-0.2,-0.35)>	< (0.38,0.5,0.67), (-0.1,-0.15,-0.2)>	< (0.72,0.8,0.9), (-0.1,-0.15,-0.3)>	< (0.44,0.6,0.75), (-0.25,-0.4,-0.5)>	< (0.44,0.54,0.6), (-0.2,-0.32,-0.5)>
R_9	< (0.74,0.8,0.8), (-0.13,-0.1,-0.2)>	< (0.75,0.88,0.95), (-0.1,-0.15,-0.2)>	<(0.74,0.8,0.9), (0.15,0.2,0.3)>	< (0.8,0.85,0.9), (-0.28,-0.3,-0.35)>	< (0.45,0.6,0.7), (-0.2,-0.33,-0.5)>	< (0.64,0.8,0.9), (-0.1,-0.2,-0.28)>
R_{10}	< (0.8,0.9,0.94), (-0.1,-0.25,-0.3)>	< (0.6,0.75,0.9), (-0.15,-0.2,-0.3)>	< (0.8,0.9,0.94), (-0.23,-0.1,-0.2)>	< (0.5,0.55,0.7), (-0.2,-0.38,-0.5)>	< (0.5,0.6,0.7), (-0.2,-0.4,-0.5)>	< (0.55,0.6,0.7), (-0.2,-0.44,-0.5)>

Table 5. Hesitant bipolar fuzzy ratings were given by DEs for improved air quality selection.

Using the conclusions of the decision experts by using Eq. (3) and Table .2, an aggregated decision matrix is formed and illustrated in Table 6.

Table 6. Aggregated decision matrix for improved air quality selection.

	S_1	**S_2**	**S_3**	**S_4**	**S_5**	**S_6**
R_1	(0.770, -0.245)	(0.784, -0.145)	(0.572, -0.325)	(0.854, 0.475)	(0.557, -0.342)	(0.751 -0.206)
R_2	(0.694, -0.287)	(0.652, -0.311)	(0.664, -0.357)	(0.752, -0.483)	(0.601, -0.296)	(0.805, -0.205)
R_3	(0.519, -0.154)	(0.814, -0.132)	(0.808, -0.196)	(0.784, -0.428)	(0.848, -0.468)	(0.898, -0.131)
R_4	(0.765, -0.258)	(0.671, -0.316)	(0.619, -0.283)	(0.695, -0.273)	(0.530, -0.375)	(0.820, -0.166)
R_5	(0.519, -0.361)	(0.752, -0.193)	(0.582, -0.403)	(0.618, -0.349)	(0.623, -0.336)	(0.788, -0.245)
R_6	(0.556, -0.403)	(0.810, -0.182)	(0.616, -0.311)	(0.541, -0.436)	(0.698, -0.427)	(0.555, -0.402)
R_7	(0.818, -0.189)	(0.796, -0.456)	(0.807, -0.187)	(0.495, -0.355)	(0.512, -0.394)	(0.803, -0.187)
R_8	(0.818, -0.173)	(0.764, -0.188)	(0.526, -0.143)	(0.818, -0.162)	(0.612, -0.367)	(0.529, -0.314)
R_9	(0.782, -0.134)	(0.883, -0.143)	(0.823, -0.205)	(0.854, -0.307)	(0.593, -0.317)	(0.803, -0.176)
R_{10}	(0.893, -0.196)	(0.778, -0.205)	(0.893, -0.161)	(0.587, -0.335)	(0.605, -0.342)	(0.618, -0.354)

In the SWARA procedure, the role of decision-making experts plays an important role in the assessment of criterion weight. Each expert determines the importance of each criterion. Then, the experts provide a ranking of all the criteria according to their own indirect understanding and experience (Table 7). In table 8, the most important criterion is given as the first ranking and the least important criterion is given as the last one. Now by using the (step .4) the final criterion W_j with all estimates are represented in Table 8.

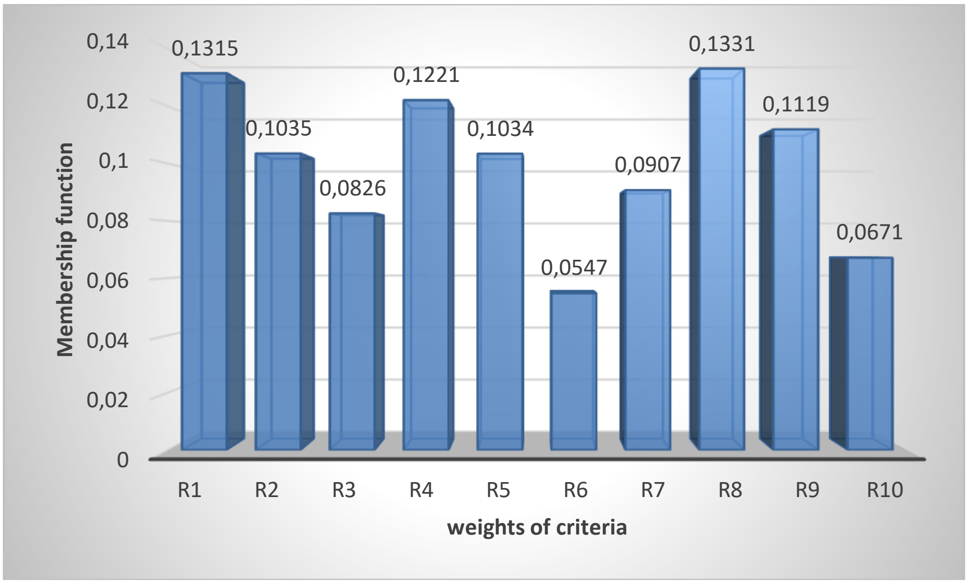


Fig 2. HBF weights of criteria value

From the graphical representation of figure.2 we have noticed that health risk (R_8) is one of the most important factors.

Table 7. Linguistic terms for criteria weights of Air quality selection

Criteria	E_1	E_2	E_3	Aggregated HBFNs	Crisp values (S_j)
R_1	P	SP	P	(0.701,0.854,0.675), (0.352,0.146,0.38)	0.45
R_2	M	M	P	(0.598,0.653,0.675), (0.503,0.450,0.38)	0.202
R_3	M	U	M	(0.598, 0.33,0.569), (0.503,0.58, 0.529)	-0.038
R_4	M	P	SP	(0.598, 0.754, 0.784), (0.503,0.297, 0.216)	0.373
R_5	P	M	M	(0.701, 0.653,0.569), (0.352, 0.450, 0.529)	0.201
R_6	SU	U	SU	(0.205, 0.33, 0.144), (0.79, 0.58, 0.856)	-0.516
R_7	P	M	U	(0.701, 0.653, 0.27), (0.352, 0.450, 0.64)	0.06
R_8	SP	M	SP	(0.809,0.653, 0.784), (0.191, 0.45, 0.216)	0.462
R_9	P	M	P	(0.701, 0.653, 0.675), (0.352, 0.45, 0.38)	0.282
R_{10}	M	SU	U	(0.598, 0.23, 0.27), (0.503, 0.76, 0.64)	-0.268

Table 8. Criteria weights obtained by SWARA method for Air quality selection

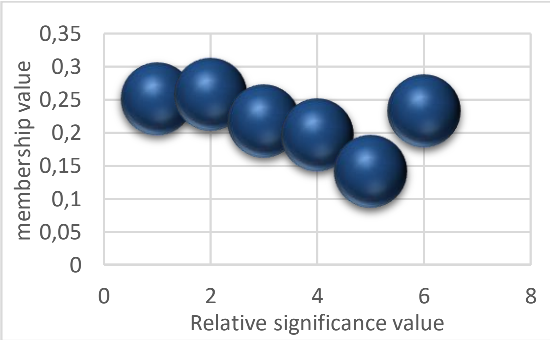
Criteria	Crisp values (S_j)	Comparative significance of criteria value	Coefficient (k_j)	Recalculated weight (P_j)	Criteria weight (w_j)
R_8	0.462	-	1.000	1.000	0.1331
R_1	0.45	0.012	1.012	0.988	0.1315
R_4	0.373	0.077	1.077	0.917	0.1221
R_9	0.282	0.091	1.091	0.841	0.1119
R_2	0.202	0.08	1.08	0.778	0.1035
R_5	0.201	0.001	1.001	0.777	0.1034
R_7	0.06	0.141	1.141	0.682	0.0907
R_3	-0.038	0.098	1.098	0.621	0.0826
R_{10}	-0.268	0.23	1.23	0.504	0.0671
R_6	-0.516	0.248	1.248	0.404	0.0547

Using equations (13-17), the calculated values of $S^*(x_i)$, $S^*(y_i)$, θ_i and λ_i of the alternatives $S_i(i = 1(1)6)$ concerning the criteria $R_i(i = 1(1)10)$ are given in Table 9.

Table 9. HBF- SWARA- COPRAS framework

AQT option	$S^*(x_i)$	$S^*(y_i)$	θ_i	λ_i	Ranking order
S₁	0.417	0.072	0.252	97.6%	2
S₂	0.447	0.091	0.258	100%	1
S₃	0.334	0.061	0.218	84.49%	4
S₄	0.313	0.078	0.197	76.35%	5
S₅	0.183	0.063	0.142	55.03%	6
S₆	0.415	0.125	0.233	90.3%	3

The best alternative is Electric vehicles from the table 9. This is the best and fastest way to control air pollution. This helps to improve air quality in Tamil Nadu, India. In India. Despite having the Covid-19 lockdown in India, the air quality is improving as vehicles are not being evacuated during the lockdown, so switching to alternative fuels and electric vehicles will help improve air quality. In India it is one of the best ways to improve air quality in Tamil Nadu. The final ranking for the COPRAS approach and utility degree are shown in the table .9 and the utility degree of the COPRAS method graphical representation is shown in Figure 3.



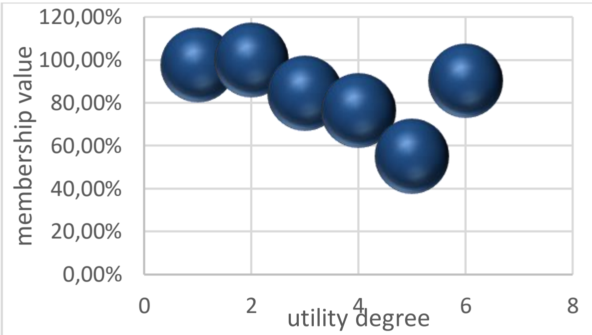


Fig 3. Values of relative significance and utility degree.

Based on the Table 9 and from figure (3) the preference order of the improved air quality technologies is found out. (i.e) $S_2 > S_1 > S_6 > S_3 > S_4 > S_5$ and thus we notice that, S_2 is the most preferred one.

Comparison and Sensitivity Analysis

A comparison between the results obtained from the proposed framework with the existing approaches is discussed. It is also discussed to compare them with the WASPAS method to show their effectiveness and HBF-SWARA-COPRAS benefits.

HBF-WASPAS method

Steps 1-4: As with the previous section 3.2 steps (1-4) framework.

Step 5: Determine the total relative importance of the weighted sum model (WSM) for each option is provided by,

$$Q_i^1 = \sum_{i=1}^{n} w_j \mu_{ij}$$

Step 6: Determine the total relative importance of the weighted product model (WPM) for each option is provided by,

$$Q_i^2 = \prod_{i=1}^{n} \mu_{ij}^{\ w_j}$$

Step 7: Calculate the WASPAS measure of each option, is given by,

$$Q_i = \gamma Q_i^1 + (1-\gamma) Q_i^2$$

where γ denotes the coefficient of decision mechanism that estimates the precision of WASPAS according to the initial criteria exactness and $\gamma \in [0, 1]$ (when $\vartheta = 0$ and $\vartheta = 1$, then WASPAS is converted to the WSM and WPM, correspondingly).
Step 8: Rank the options, based on the crisp score values of Q_i.
Step 9: End.

Now, the overall computational procedure of HBF-WASPAS method is presented in Table 10 and the final ranking list of WASPAS method graphical representation is shown in figure 4. Then, the ranking order is given by, $S_2 > S_6 > S_1 > S_3 > S_4 > S_5$.

Table 10. The outcome result by the HBF- SWARA- WASPAS approach

IAQ option	WSM (Q_i^1)	WPM (Q_i^2)	WPS$_i$	Ranking order
S_1	0.489	0.444	0.467	3
S_2	0.539	0.518	0.529	1
S_3	0.395	0.363	0.379	4
S_4	0.391	0.345	0.368	5
S_5	0.246	0.235	0.241	6
S_6	0.541	0.505	0.523	2

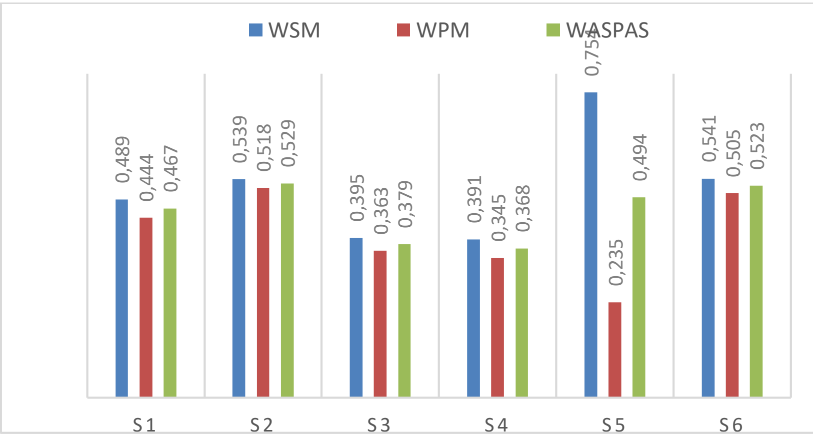


Fig 4. HBF-WASPAS results

From Tables 9 and 10, the priority sequence order of air quality technology obtained by the developed HBF-SWARA-COPRAS approach shows the best compatibility with the HBF-WASPAS approach. In the present case study, we observe that the alternative **S_2** is the most appropriate air quality technology. There are some differences in the alternate final ratings. The efficient use of the WASPAS method in fuzzy COPRAS provides the final rankings of this study. Here, alternatives S_1 and S_6 have different ranks. Nevertheless, by the proposed method, the remaining alternatives have the same ranks and the graphical representation of the ranking orders are also shown in figure 5.

Table 11. Results of comparison

IAQ option	COPRAS	Ranking order	WASPAS	Ranking order
S_1	0.252	2	0.467	3
S_2	0.258	1	0.529	1
S_3	0.218	4	0.379	4
S_4	0.197	5	0.368	5
S_5	0.142	6	0.241	6
S_6	0.233	3	0.523	2

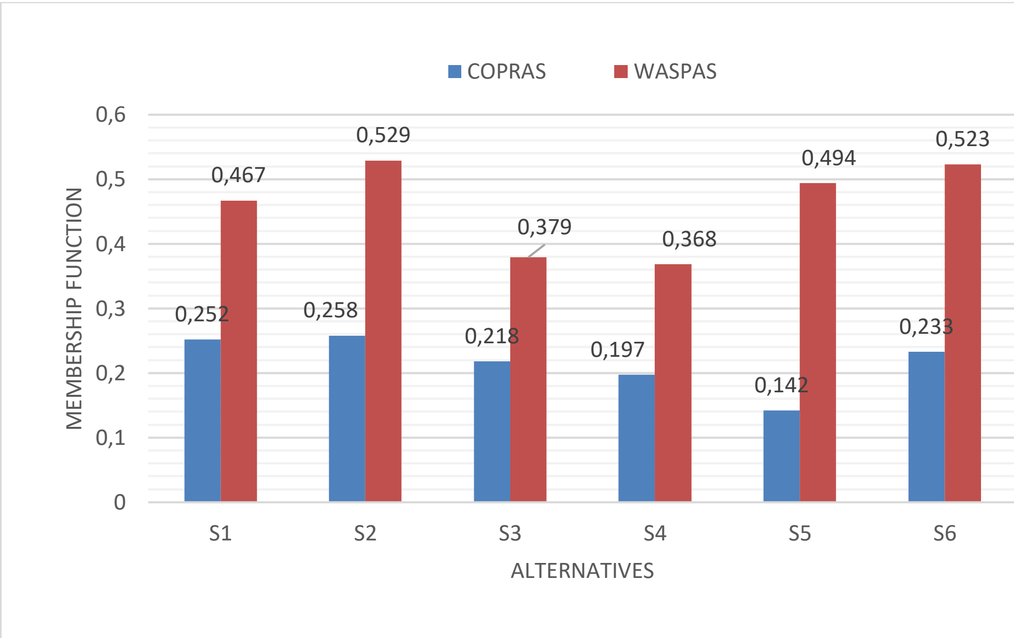


Fig 5. The comparison results between HBF-COPRAS and HBF-WASPAS

From the figure .5, we noticed that comparing the HBF-COPRAS method with the HBF-WASPAS methods, we could see changes in the ranking order.

Ranking order
HBF-COPRAS: $S_2 > S_1 > S_6 > S_3 > S_4 > S_5$
HBF-WASPAS: $S_2 > S_6 > S_1 > S_3 > S_4 > S_5$.

Sensitivity Analysis
In the present section, we discuss the sensitivity analysis according to the different values that promotes the equality of the proposed method. To do this, different values of parameter γ are taken into investigation, and different values of γ help to assess the sensitivity of the COPRAS approach. The ranking sequences of options related to different parameter values are shown in the table .12 and in the figure.6. We can see in all the sets given in the table. the option S_3 has the highest rank, when γ=0.0 to 0.1, while S_1 has highest rank when γ=0.2 to 0.3 Further the alternative S_2 has the best solution when γ =0.4 to 1.0 as well as S_6

has the worst rank when γ=0 to 0.1 Whereas S_5 has the last rank when $\gamma = 0.2\ to\ 1$. Recently, it can be observed that the HBF-SWARA-COPRAS approach to different values of the parameter γ has better consistency. Furthermore, the subjective criteria weights evaluated by the SWARA technique protect to improve the sensitivity of the proposed structure. From the discussion above, we realize that using different values of the γ parameters will increase the stability of the introduced framework. It is shown in figure 6.

Table 12. Different values of compromise solution w.r.t $\gamma\epsilon[0,1]$

γ	S_1	S_2	S_3	S_4	S_5	S_6
0	0.087	0.069	0.103	0.081	0.1	0.057
0.1	0.120	0.106	0.126	0.104	0.108	0.087
0.2	0.153	0.144	0.149	0.127	0.116	0.123
0.3	0.186	0.182	0.172	0.150	0.125	0.160
0.4	0.219	0.220	0.195	0.173	0.133	0.196
0.5	**0.252**	**0.258**	**0.218**	**0.197**	**0.141**	**0.233**
0.6	0.285	0.296	0.241	0.220	0.150	0.269
0.7	0.318	0.334	0.264	0.243	0.158	0.306
0.8	0.351	0.372	0.288	0.266	0.167	0.342
0.9	0.384	0.410	0.311	0.289	0.175	0.379
1	0.417	0.447	0.334	0.313	0.183	0.415

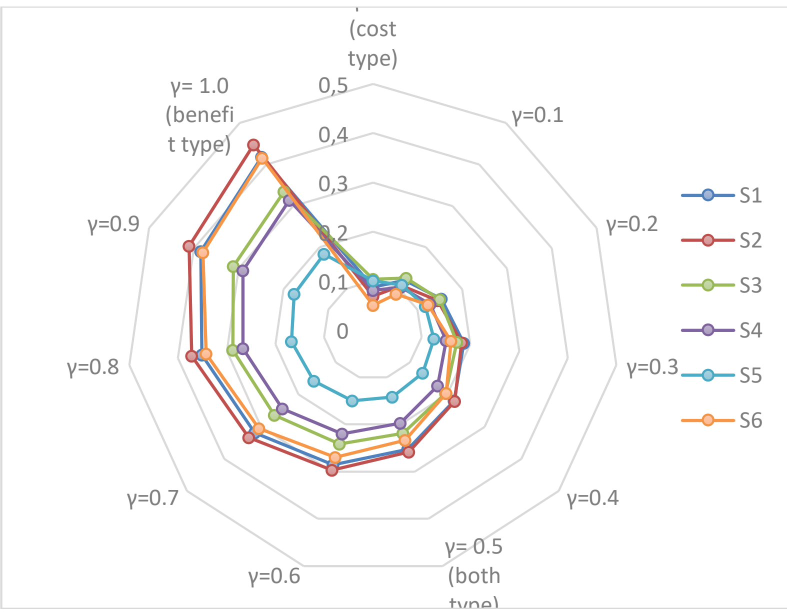


Fig .6 Representation of utility degree of AQT option over different parameter γ value

Conclusion

Recently, the selection of the most suitable Air quality technology (AQT) for sustainable management has become a significant concern. Due to several conflicting criteria, the AQT selection problem is a complex MCDM problem. To address this issue, an integrated framework based on SWARA and COPRAS approaches has been introduced in the context of HBFs. In this study, an evaluation index process for AQT options was developed. It has four dimensions: environmental aspects, economic, technology and social aspects. These criteria consist of three, two, two and three sub-criteria respectively, which are widely considered in terms of literature, research reports and expertise in various fields. The main advantages of the proposed approach are the ease of calculation under the HBFs environment and the use of a high resilience detection process of criteria that enhances the sustainability of the developed method. The proposed approach can be applied to any problems with a general structure of MCDM problems and to use Hesitant bipolar fuzzy information. Studies of the results confirm that the proposed method has a high efficiency compared to the existing one. The results prove that the AQT option S_2 (increasing Electric vehicles) should be selected as the best AQT option by finding the maximum utility degree.

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