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A Sensitivity Analysis on a MCDM Problem Evaluated by ARAS Method

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Abstract - Multi-Criteria Decision Making, also known as MCDM, is a highly helpful technique for assessing numerous issues and conclusions as well as resolving conflicts in daily life. The choice of any technique, service, or product is fraught with difficulties. The choosing of any useful product, such as a scooter, is an important task that requires careful research into the selection criteria, where MCDM techniques play a significant role. But the results that are coming with different MCDM methods are has to be consistent enough. This particular study associated with the checking or verifying the results that are evaluated by the Additive Ratio Assessment (ARAS) method with AHP weights for each Criterion.

Keywords - **ARAS, MCDM, Scooter, Selection, Sensitivity Analysis.**

INTRODUCTION

When there are numerous and frequently competing criteria at play, MCDM acts as "An interface between DMs (Choice Managers) and analysts, assisting them in reaching a decision." The analyst and DMs typically focus on defining problems, their objectives, and how the ultimate choice should be made at the beginning of the process. The Methodology of evaluating a problem by using MCDM techniques can be describes briefly as,

a. At first the problem has to be identified and then after identifying the problem, structuring of the problem has been done.
b. Problem structuring can be done by taking consideration of the Stakeholders, Alternatives that are having, the uncertainties present, key issues of development, external environment of the organization, Constraints, Goals of the particular stated problem and values of the decision or the importance of the decisions that has to be taken by the decision managers.
c. Then the Modelling of the problem has been done by specifying the alternatives on the basis of which the decisions has to be made, defining the criterions that has to be used to evaluate the mathematical modelling of the work. Selecting weightage values for each alternative has been done also.
d. After the modulation of the problem, the decision that has been made by the DMs has to be challenged by challenging institutions and if there is any issue found out, new alternatives has to be chosen.
e. Analysis of the Robustness of the solution is done afterwards and sensitivity analysis also done for the problem in a parallel way.

This research work comprises with application of Sensitivity Analysis over a selection problem that has been carried out over 4 best-selling 125cc scooters available on Indian market up to 2021 and those scooters are: Suzuki Access 125 BS VI, Honda Activa 125 BS VI, Yamaha Fascino 125 BS VI & Hero Destini 125 BS VI by AHP-ARAS method. The study is mainly on the basis of some useful parameters and applies MCDM tools AHP and ARAS to obtain the best possible alternatives. A survey is done over Google form to analyze the customers experience and thinking over the products. Those who have own the above scooters are asked to solve several questions over Google form to observe the customers thinking over the criterions chosen for the problem solving pathway. On basis of the survey the Classical AHP process is carried out to find the relative importance of each and every criterion over other. The main specification or criterions that are chosen are Torque produced by the engine (Beneficial criteria), Engine Power output (Beneficial criteria), Fuel Economy (Beneficial criteria), Weight of the scooter (Non-Beneficial criteria), Service provided by the company and availabilities of parts (Beneficial criteria) & Price of the scooter in Indian market (Non-Beneficial criteria). On basis of this 6 criterion the best possible choice is to be made. After getting the results on the basis of this AHP-ARAS method, the sensitivity is checking by giving different weightage to the criterions and checking the deviation of the results or ranking of the alternatives.

LITERATURE REVIEW

MCDM has a vast area of research in the Engineering and Management field [1]. The Mukhametzyanov and Pamučar [2] tried to apply the sensitivity analysis for the findings of an investigation of the sensitivity of decision-making using the rank methods: SAW, MOORA, VIKOR, COPRAS, CODAS, TOPSIS, D'IDEAL, MABAC, PROMETHEE-I, II, and ORESTE-II with variations in the components in the decision matrix within a certain mistake (impreci-

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sion) in their paper on Sensitivity analysis in MCDM Problem. It is advised to utilize several simulations of the decision matrix's element estimates within a given error while determining the ranks of alternatives in order to acquire statistical estimates of the ranks. Anupamaet al. [3] in 2015 compared three MADM approaches SAW (Simple Additive Weighting), WPM (Weighted Product Method), and PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluations) in this research for their effectiveness in network selection. Zavadskas and Turskis [4] in their work try to use ARAS method over microclimate in office room. Hruška et al. [5] has been used the AHP method for solving a problem arises in a manufacturing farm regarding the supplier slecetion. Sihombing et al. [6] in their work used ARAS method to evaluate a branch location selection problem. Biswa et al. [7] conducted a study on quality of operations in seven newly established IITsinindia by SAW method and they made the weightage using the ENTROPY method. In their research, Srikrishna et al.[8] described how TOPSIS may be used to select new cars based on a variety of operational and technical criteria, including style, life expectancy, fuel efficiency, suspension, and price, among others. In the article, Evans [9] used Sensitivity analysis over decision problems of calculating the change in "confidence Sphere"in changes associated with the changes in probability vector. In their research, Srikrishna et al. [10] described how TOPSIS may be used to select new cars based on a variety of operational and technical criteria, including style, life expectancy, fuel efficiency, suspension, and price, among others.

THEORETICAL ANALYSIS

This section consists of all the theoretical details of ARAS and Sensitivity Analysis methodology.

Additive Ratio Assessment (ARAS)

The Additive ratio assessment (ARAS) method is proposed by Edmundas Kazimieras Zavadskas in the year of 2010. Here the utility function value determining the complex relative efficiency of a feasible alternative is directly proportional to the relative effect of values and weights of the main criteria. It is one of the Compensatory method in which both beneficial and non-beneficial attributes are going to have a combination to get the feasible solution. The advantage of using this kind of MCDM method is, attributes remain independent and the method itself is simple in use and also required very less computational time.The following steps are involved to evaluate the ranking of alternatives:

Step-1: Establishing the Pair-wise comparison matrix

$$\mathbf{A} = \begin{matrix} C_1 & C_2 C_3 & \dots & \dots & C_n \end{matrix} \begin{bmatrix} \boldsymbol{x_{11}} & \boldsymbol{x_{12}} & \boldsymbol{x_{13}} & \dots & \boldsymbol{x_{1j}} \\ \boldsymbol{x_{21}} & \boldsymbol{x_{22}} & \boldsymbol{x_{23}} & \dots & \boldsymbol{x_{2j}} \\ \boldsymbol{x_{31}} & \boldsymbol{x_{32}} & \boldsymbol{x_{33}} & \dots & \boldsymbol{x_{3j}} \\ \vdots & \vdots & \vdots & : & \vdots \\ \boldsymbol{x_{i1}} & \boldsymbol{x_{i2}} & \boldsymbol{x_{i3}} & \dots & \boldsymbol{x_{ij}} \end{bmatrix} \quad (1)$$

Step-2: Normalization of the pair-wise comparison matrix has to be done to obtain the project outcome $\overline{X_{ij}}$.

For Beneficial attributes: $\overline{X_{ij}} = \frac{X_{ij}}{\sum_{i=0}^{m} {X_{ij}}^2}$ (2)

For Non-beneficial attributes: $\overline{X_{ij}} = \frac{{X_{ij}}^*}{\sum_{i=0}^{m} {X_{ij}}^2}$ (3)

Step-3: In this step estimation Weighted Normalized matrix is done by following expression:

$$\widehat{X_{ij}} = \overline{X_{ij}} w_j \quad (j=1, 2, \dots\dots\dots, n) \quad (4)$$

Step-4: After calculating '$\widehat{X_{ij}}$', S_i – optimality function for the ith alternatives has been calculated by:

$$S_i = \sum_{j=1}^{n} \widehat{X_{ij}} \text{ , i=0 to m} \quad (5)$$

Step-5: Calculation of Utility Degree

$$K_i = \frac{S_i}{S_0} \quad (6)$$

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where, S_i& S_0 are the Optimality criterion values.

Step-6: After calculation of K_i, based on that ranking of the alternatives has been done. For the given criteria, the alternative with the maximum value of K_i' is taken as the best compromise solution and is ranked 1 and similarly remaining alternatives are ranked.

SENSITIVITY ANALYSIS

MCDM tool is basically reducing the subjectivity in decision-making. Different MCDM methods have different mathematical modulation which makes the same problem with different yield solution. However the quality of the solution of the decision making process is known as Sensitivity Analysis. Sensitivity analysis is used for optimization as well as relation making.
It is mainly evaluate the quantitative behavior of the optimal solution or optimal value according to changes of parameter value included in the optimization and decision making. Sensitivity analysis is done to examine the robustness and stability of the ranking with respect to weights of the criterion is performed. The analysis deals with improving the outcomes of any specific model, qualitatively and quantitatively, and provides the sensitivity involves in decision making due to uncertain input values.

Step-1: Selecting the Pair-wise comparison matrix from the standard MCDM Process

$$\mathbf{A} = \begin{matrix} C_1 & C_2 & C_3 & \dots & \dots & C_n \end{matrix} \begin{bmatrix} x_{11} & x_{12} & x_{13} & \dots & x_{1j} \\ x_{21} & x_{22} & x_{23} & \dots & x_{2j} \\ x_{31} & x_{32} & x_{33} & \dots & x_{3j} \\ \vdots & \vdots & \vdots & : & \vdots \\ x_{i1} & x_{i2} & x_{i3} & \dots & x_{ij} \end{bmatrix} \quad (7)$$

Step-2: Weights of the criterions has been selected as:

- Equal weights to each criterions
- 50% weights for beneficial criterions and 50% weights for non-beneficial criterions.
- 60% weights for beneficial criterions and 40% weights for non-beneficial criterions.
- 70% weights for beneficial criterions and 30% weights for non-beneficial criterions.
- 80% weights for beneficial criterions and 20% weights for non-beneficial criterions.
- 90% weights for beneficial criterions and 10% weights for non-beneficial criterions.

For each cases of weight distribution among the criterions, the ranking of alternatives has been calculated by any MCDM method and then checking has been done that how sensitive our previously calculated or obtained ranks are over the sensitivity analysis. Here I have used the ARAS method to check the Sensitivity of the solution obtained.

RESEARCH METHODOLOGY

Calculation with Additive Ratio Assessment (ARAS) method

Table 1 shows the pair-wise comparison matrix with all the criterion values corresponds to the alternatives. Here the Weights of each criterion have been taken as per the AHP processes, which have been carried out by using the survey data that are collected through Google form. In that paper we are directly taken the AHP weights values for the entire criterion.

Table 1. Criteria and Alternatives.

Criteria type →	BeneficialCriteria				Non-Beneficial Criteria	
Criteria	**Torque (N-m)**	**Power output (p.s)**	**Fuel Economy (kmpl)**	**Service provided by the company and parts availability**	**Weight of the scooter (kg)**	**Price of the scooter(INR)**
Suzuki Access 125	10	8.7	53.2727	4.36	104	87262
Honda Activa 125	10.3	8.2	47.6154	4.77	111	84056

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Yamaha Fascino 125	10.3	8.2	45.4444	4.44	99	82330
Hero Destini 125	10.4	9.0	45.0901	4.64	113	78400
AHP Weights	0.101214	0.073499	0.336171	0.307035	0.033399	0.148682

After that, the normalized decision matrix has been calculated in Table 2 by using the Eq. (2) and Eq. (3) according to the criteria type. Then the Weighted normalized decision matrix has been calculated in Table 3 by using the Eq. (4) according to the criteria type by multiplying each column value of Normalized decision matrix with the weightage assigned for each respective criterion.

Table 2. Normalized Decision Matrix in ARAS.

Criteria type →	**BeneficialCriteria**				**Non-Beneficial Criteria**	
	Torque (N-m)	**Power output (p.s)**	**Fuel Economy (kmpl)**	**Service provided by the company and parts availability**	**Weight of the scooter (kg)**	**Price of the scooter(INR)**
OptimalValue	0.202335	0.208817	0.21771	0.207572	0.211868	0.209055421
Suzuki Access 125	0.194553	0.201856	0.21771	0.18973	0.201682	0.18782454
Honda Activa 125	0.200389	0.190255	0.194591	0.207572	0.188963	0.194988401
Yamaha Fascino125	0.200389	0.190255	0.185718	0.193211	0.211868	0.199076218
Hero Destini 125	0.202335	0.208817	0.18427	0.201915	0.185619	0.209055421

Table 3. Weighted Normalized Decision matrix in ARAS.

Criteria type →	**BeneficialCriteria**				**Non-Beneficial Criteria**	
Criteria	**Torque (N-m)**	**Power output(p.s)**	**Fuel Economy (kmpl)**	**Service provided by the company and parts availability**	**Weight of the scooter (kg)**	**Price of the scooter (INR)**
Optimal Value	0.020479	0.015348	0.073188	0.063732	0.007076	0.031082778
Suzuki Access 125	0.019691	0.014836	0.073188	0.058254	0.006736	0.027926128
Honda Activa 125	0.020282	0.013984	0.065416	0.063732	0.006311	0.028991265
Yamaha Fascino125	0.020282	0.013984	0.062433	0.059323	0.007076	0.02959905
Hero Destini 125	0.020479	0.015348	0.061946	0.061995	0.006199	0.031082778

Then the Optimality Function S_i and Utility Degree Ki has been calculated in Table 4 by using the Eq. (5) and Eq. (6) for each and every alternative and based on the Utility Degree, the Ranking of Alternative has been done.

Table 4. Calculation of Optimality function, Utility Degree & Ranking of alternatives.

Alternatives	**S_i**	**K_i**	**Ranking of Alternatives**
Suzuki Access 125	0.200631	0.951286	**1**
Honda Activa 125	0.198716	0.942202	**2**
Yamaha Fascino 125	0.192697	0.913664	**4**
Hero Destini 125	0.19705	0.934306	**3**

Table 5. Criteria and Alternatives.

Criteria type →	**BeneficialCriteria**				**Non-Beneficial Criteria**	
	Torque (N-m)	**Power output (p.s)**	**Fuel Economy (kmpl)**	**Service provided by the company and parts availability**	**Weight of the scooter (kg)**	**Price of the scoo-ter (INR)**
Suzuki Access 125	10	8.7	53.2727	4.36	104	87262

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Honda Activa 125	10.3	8.2	47.6154	4.77	111	84056
Yamaha Fascino 125	10.3	8.2	45.4444	4.44	99	82330
Hero Destini 125	10.4	9.0	45.0901	4.64	113	78400
Weightage	0.166667	0.166667	0.166667	0.166667	0.166667	0.166667

CALCULATION WITH SENSITIVITY ANALYSIS

Case 01: Checking the sensitivity with Equal weightage method

Here in Table 5, equal weightage is given to the every criterion. As there is 6 criterions in total, each criterion are given 16.6667% of weightage. Now using ARAS method, ranking of alternatives has been done.

Table 6. Normalized Decision matrix.

Criteria type →	**BeneficialCriteria**				**Non-Beneficial Criteria**	
Criteria	**Torque (N-m)**	**Power output (p.s)**	**Fuel Economy (kmpl)**	**Service provided by the company and parts availability**	**Weight of the scooter (kg)**	**Price of the scooter (INR)**
Optimal Value	0.202335	0.208817	0.21771	0.207572	0.211868	0.209055421
Suzuki Access 125	0.194553	0.201856	0.21771	0.18973	0.201682	0.18782454
Honda Activa 125	0.200389	0.190255	0.194591	0.207572	0.188963	0.194988401
Yamaha Fascino 125	0.200389	0.190255	0.185718	0.193211	0.211868	0.199076218
Hero Destini 125	0.202335	0.208817	0.18427	0.201915	0.185619	0.209055421

Table 7. Weighted Normalized Decision matrix.

Criteria type →	**BeneficialCriteria**				**Non-Beneficial Criteria**	
Criteria	**Torque (N-m)**	**Power output (p.s)**	**Fuel Economy (kmpl)**	**Service provided by the company and parts availability**	**Weight of the scooter (kg)**	**Price of the scooter (INR)**
Optimal Value	0.033722	0.034803	0.036285	0.034595	0.035311	0.03484257
Suzuki Access 125	0.032425	0.033643	0.036285	0.031622	0.033614	0.03130409
Honda Activa 125	0.033398	0.031709	0.032432	0.034595	0.031494	0.032498067
Yamaha Fascino 125	0.033398	0.031709	0.030953	0.032202	0.035311	0.03317937
Hero Destini 125	0.033722	0.034803	0.030712	0.033652	0.030936	0.03484257

Then the Optimality Function S_i and Utility Degree K_i has been calculated in Table 8 by using the Eq. (5) and Eq. (6) for each and every alternative and based on the Utility Degree, the Ranking of Alternative has been done.

Table 8. Calculation of Optimality function, Utility Degree & Ranking of alternatives.

Alternatives	**S_i**	**K_i**	**Ranking of Alternatives**
Suzuki Access 125	0.198893	0.949099	1
Honda Activa 125	0.196126	0.935899	4
Yamaha Fascino 125	0.196753	0.938889	3
Hero Destini 125	0.198668	0.948029	2

Case 02: Checking the sensitivity with 50%weightage to the Beneficial and 50% weightage to the non-beneficial attributes method.

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Table 9. Criteria and Alternatives.

Criteria type →	BeneficialCriteria				Non-Beneficial Criteria	
	Torque (N-m)	Power output (p.s)	Fuel Economy (kmpl)	Service provided by the company and parts availability	Weight of the scooter (kg)	Price of the scooter (INR)
Suzuki Access 125	10	8.7	53.2727	4.36	104	87262
Honda Activa 125	10.3	8.2	47.6154	4.77	111	84056
Yamaha Fascino 125	10.3	8.2	45.4444	4.44	99	82330
Hero Destini 125	10.4	9.0	45.0901	4.64	113	78400
Weightage	**0.125**	**0.125**	**0.125**	**0.125**	**0.25**	**0.25**

Table 10. Normalized Decision matrix.

Criteria type →	BeneficialCriteria				Non-Beneficial Criteria	
	Torque (N-m)	Power output (p.s)	Fuel Economy (kmpl)	Service provided by the company and parts availability	Weight of the scooter (kg)	Price of the scooter (INR)
Optimal Value	0.202335	0.208817	0.21771	0.207572	0.211868	0.209055421
Suzuki Access 125	0.194553	0.201856	0.21771	0.18973	0.201682	0.18782454
Honda Activa 125	0.200389	0.190255	0.194591	0.207572	0.188963	0.194988401
Yamaha Fascino 125	0.200389	0.190255	0.185718	0.193211	0.211868	0.199076218
Hero Destini 125	0.202335	0.208817	0.18427	0.201915	0.185619	0.209055421

Table 11. Weighted Normalized Decision matrix.

Criteria type →	BeneficialCriteria				Non-Beneficial Criteria	
Criteria	Torque (N-m)	Power output (p.s)	Fuel Economy (kmpl)	Service provided by the company and parts availability	Weight of the scooter (kg)	Price of the scooter (INR)
Optimal Value	0.025292	0.026102	0.027214	0.025946	0.052967	0.052263855
Suzuki Access 125	0.024319	0.025232	0.027214	0.023716	0.05042	0.046956135
Honda Activa 125	0.025049	0.023782	0.024324	0.025946	0.047241	0.0487471
Yamaha Fascino 125	0.025049	0.023782	0.023215	0.024151	0.052967	0.049769054
Hero Destini 125	0.025292	0.026102	0.023034	0.025239	0.046405	0.052263855

Then the Optimality Function S_i and Utility Degree Ki has been calculated in Table 12 by using the Eq. (5) and Eq. (6) for each and every alternative and based on the Utility Degree, the Ranking of Alternative has been done.

Table 12. Calculation of Optimality function, Utility Degree & Ranking of alternatives.

Alternatives	S_i	K_i	Ranking of Alternatives
Suzuki Access 125	0.197858	0.943145	3
Honda Activa 125	0.195089	0.929946	4
Yamaha Fascino 125	0.198933	0.94827	1
Hero Destini 125	0.198336	0.945423	2

Case 03: Checking the sensitivity with 60%weightage to the Beneficial and 40% weightage to the Non-Beneficial attributes method

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Table 13. Criteria and Alternatives.

Criteria type →	BeneficialCriteria				Non-Beneficial Criteria	
	Torque (N-m)	Power output (p.s)	Fuel Economy (kmpl)	Service provided by the company and parts availability	Weight of the scooter (kg)	Price of the scooter (INR)
Suzuki Access 125	10	8.7	53.2727	4.36	104	87262
Honda Activa 125	10.3	8.2	47.6154	4.77	111	84056
Yamaha Fascino 125	10.3	8.2	45.4444	4.44	99	82330
Hero Destini 125	10.4	9.0	45.0901	4.64	113	78400
Weightage	0.15	0.15	0.15	0.15	0.2	0.2

Table 14. Normalized Decision matrix in ARAS with 60%-40% weightage.

Criteria type →	Beneficial Criteria				Non-Beneficial Criteria	
	Torque (N-m)	Power output (p.s)	Fuel Economy (kmpl)	Service provided by the company and parts availability	Weight of the scooter (kg)	Price of the scooter (INR)
Optimal Value	0.202335	0.208817	0.21771	0.207572	0.211868	0.209055421
Suzuki Access 125	0.194553	0.201856	0.21771	0.18973	0.201682	0.18782454
Honda Activa 125	0.200389	0.190255	0.194591	0.207572	0.188963	0.194988401
Yamaha Fascino 125	0.200389	0.190255	0.185718	0.193211	0.211868	0.199076218
Hero Destini 125	0.202335	0.208817	0.18427	0.201915	0.185619	0.209055421

Table 15. Weighted Normalized Decision matrix in ARAS with 60%-40% weightage.

Criteria type →	BeneficialCriteria				Non-Beneficial Criteria	
Criteria	Torque (N-m)	Power output (p.s)	Fuel Economy (kmpl)	Service provided by the company and parts availability	Weight of the scooter (kg)	Price of the scooter (INR)
Optimal Value	0.03035	0.031323	0.032657	0.031136	0.042374	0.041811084
Suzuki Access 125	0.029183	0.030278	0.032657	0.02846	0.040336	0.037564908
Honda Activa 125	0.030058	0.028538	0.029189	0.031136	0.037793	0.03899768
Yamaha Fascino 125	0.030058	0.028538	0.027858	0.028982	0.042374	0.039815244
Hero Destini 125	0.03035	0.031323	0.027641	0.030287	0.037124	0.041811084

Then the Optimality Function S_i and Utility Degree Ki has been calculated in Table 16 by using the Eq. (5) and Eq. (6) for each and every alternative and based on the Utility Degree, the Ranking of Alternative has been done.

Table 16. Calculation of Optimality function, Utility Degree & Ranking of alternatives.

Alternatives	S_i	K_i	Ranking of Alternatives
Suzuki Access 125	0.198479	0.946716	2
Honda Activa 125	0.195711	0.933516	4
Yamaha Fascino 125	0.197625	0.942644	3
Hero Destini 125	0.198535	0.946986	1

Case 04: Checking the sensitivity with 70% weightage to the Beneficial and 30% weightage to the Non-Beneficial attributes method

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Table 17. Criteria and Alternatives.

Criteria type →	BeneficialCriteria				Non-Beneficial Criteria	
	Torque (N-m)	Power output (p.s)	Fuel Economy (kmpl)	Service provided by the company and parts availability	Weight of the scooter (kg)	Price of the scooter (INR)
Suzuki Access 125	10	8.7	53.2727	4.36	104	87262
Honda Activa 125	10.3	8.2	47.6154	4.77	111	84056
Yamaha Fascino 125	10.3	8.2	45.4444	4.44	99	82330
Hero Destini 125	10.4	9.0	45.0901	4.64	113	78400
Weightage	**0.175**	**0.175**	**0.175**	**0.175**	**0.15**	**0.15**

Table 18. Normalized Decision matrix in ARAS with 70%-30% weightage.

Criteria type →	BeneficialCriteria				Non-Beneficial Criteria	
	Torque (N-m)	Power output (p.s)	Fuel Economy (kmpl)	Service provided by the company and parts availability	Weight of the scooter (kg)	Price of the scooter (INR)
Optimal Value	0.202335	0.208817	0.21771	0.207572	0.211868	0.209055421
Suzuki Access 125	0.194553	0.201856	0.21771	0.18973	0.201682	0.18782454
Honda Activa 125	0.200389	0.190255	0.194591	0.207572	0.188963	0.194988401
Yamaha Fascino 125	0.200389	0.190255	0.185718	0.193211	0.211868	0.199076218
Hero Destini 125	0.202335	0.208817	0.18427	0.201915	0.185619	0.209055421

Table 19. Weighted Normalized Decision matrix in ARAS with 70%-30% weightage.

Criteria type →	BeneficialCriteria				Non-Beneficial Criteria	
Criteria	Torque (N-m)	Power output (p.s)	Fuel Economy (kmpl)	Service provided by the company and parts availability	Weight of the scooter (kg)	Price of the scooter (INR)
Optimal Value	0.035409	0.036543	0.038099	0.036325	0.03178	0.031358313
Suzuki Access 125	0.034047	0.035325	0.038099	0.033203	0.030252	0.028173681
Honda Activa 125	0.035068	0.033295	0.034053	0.036325	0.028344	0.02924826
Yamaha Fascino 125	0.035068	0.033295	0.032501	0.033812	0.03178	0.029861433
Hero Destini 125	0.035409	0.036543	0.032247	0.035335	0.027843	0.031358313

Then the Optimality Function S_i and Utility Degree Ki has been calculated in Table 20 by using the Eq. (5) and Eq. (6) for each and every alternative and based on the Utility Degree, the Ranking of Alternative has been done.

Table 20. Calculation of Optimality function, Utility Degree & Ranking of alternatives.

Alternatives	S_i	K_i	Ranking of Alternatives
Suzuki Access 125	0.1991	0.950291	1
Honda Activa 125	0.196334	0.937091	3
Yamaha Fascino 125	0.196317	0.93701	4
Hero Destini 125	0.198735	0.948551	2

Case 05: Checking the sensitivity with 80% weightage to the Beneficial and 20% weightage to the Non-Beneficial attributes method

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Table 21. Criteria and Alternatives.

Criteria type →	BeneficialCriteria				Non-Beneficial Criteria	
	Torque (N-m)	Power output (p.s)	Fuel Economy (kmpl)	Service provided by the company and parts availability	Weight of the scooter (kg)	Price of the scooter (INR)
Suzuki Access 125	10	8.7	53.2727	4.36	104	87262
Honda Activa 125	10.3	8.2	47.6154	4.77	111	84056
Yamaha Fascino 125	10.3	8.2	45.4444	4.44	99	82330
Hero Destini 125	10.4	9.0	45.0901	4.64	113	78400
Weightage	**0.20**	**0.20**	**0.20**	**0.20**	**0.10**	**0.10**

Table 22. Normalized Decision matrix in ARAS with 80%-20% weightage.

Criteria type →	BeneficialCriteria				Non-Beneficial Criteria	
	Torque (N-m)	Power output (p.s)	Fuel Economy (kmpl)	Service provided by the company and parts availability	Weight of the scooter (kg)	Price of the scooter (INR)
Optimal Value	0.202335	0.208817	0.21771	0.207572	0.211868	0.209055421
Suzuki Access 125	0.194553	0.201856	0.21771	0.18973	0.201682	0.18782454
Honda Activa 125	0.200389	0.190255	0.194591	0.207572	0.188963	0.194988401
Yamaha Fascino 125	0.200389	0.190255	0.185718	0.193211	0.211868	0.199076218
Hero Destini 125	0.202335	0.208817	0.18427	0.201915	0.185619	0.209055421

Table 23. Weighted Normalized Decision matrix in ARAS with 80%-20% weightage.

Criteria type →	BeneficialCriteria				Non-Beneficial Criteria	
Criteria	Torque (N-m)	Power output (p.s)	Fuel Economy (kmpl)	Service provided by the company and parts availability	Weight of the scooter (kg)	Price of the scooter (INR)
Optimal Value	0.040467	0.041763	0.043542	0.041514	0.021187	0.020905542
Suzuki Access 125	0.038911	0.040371	0.043542	0.037946	0.020168	0.018782454
Honda Activa 125	0.040078	0.038051	0.038918	0.041514	0.018896	0.01949884
Yamaha Fascino 125	0.040078	0.038051	0.037144	0.038642	0.021187	0.019907622
Hero Destini 125	0.040467	0.041763	0.036854	0.040383	0.018562	0.020905542

Then the Optimality Function S_i and Utility Degree Ki has been calculated in Table 24by using the Eq. (5) and Eq. (6) for each and every alternative and based on the Utility Degree, the Ranking of Alternative has been done.

Table 24. Calculation of Optimality function, Utility Degree & Ranking of alternatives.

Alternatives	S_i	K_i	Ranking of Alternatives
Suzuki Access 125	0.19972	0.953871	1
Honda Activa 125	0.196957	0.94067	3
Yamaha Fascino 125	0.195009	0.931369	4
Hero Destini 125	0.198935	0.950118	2

Case 06: Checking the sensitivity with 90% weightage to the Beneficial and 10% weightage to the Non-Beneficial attributes method

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Table 25. Criteria and Alternatives.

Criteria type →	BeneficialCriteria				Non-Beneficial Criteria	
	Torque (N-m)	Power output (p.s)	Fuel Economy (kmpl)	Service provided by the company and parts availability	Weight of the scooter (kg)	Price of the scooter (INR)
Suzuki Access 125	10	8.7	53.2727	4.36	104	87262
Honda Activa 125	10.3	8.2	47.6154	4.77	111	84056
Yamaha Fascino 125	10.3	8.2	45.4444	4.44	99	82330
Hero Destini 125	10.4	9.0	45.0901	4.64	113	78400
Weightage	**0.225**	**0.225**	**0.225**	**0.225**	**0.050**	**0.050**

Table 26. Normalized Decision matrix in ARAS with 90%-10% weightage.

Criteria type →	BeneficialCriteria				Non-Beneficial Criteria	
Criteria	Torque (N-m)	Power output (p.s)	Fuel Economy (kmpl)	Service provided by the company and parts availability	Weight of the scooter (kg)	Price of the scooter (INR)
Optimal Value	0.202335	0.208817	0.21771	0.207572	0.211868	0.209055421
Suzuki Access 125	0.194553	0.201856	0.21771	0.18973	0.201682	0.18782454
Honda Activa 125	0.200389	0.190255	0.194591	0.207572	0.188963	0.194988401
Yamaha Fascino 125	0.200389	0.190255	0.185718	0.193211	0.211868	0.199076218
Hero Destini 125	0.202335	0.208817	0.18427	0.201915	0.185619	0.209055421

Table 27. Weighted Normalized Decision matrix in ARAS with 90%-10% weightage.

Criteria type →	BeneficialCriteria				Non-Beneficial Criteria	
Criteria	Torque (N-m)	Power output (p.s)	Fuel Economy (kmpl)	Service provided by the company and parts availability	Weight of the scooter (kg)	Price of the scooter (INR)
Optimal Value	0.045525	0.046984	0.048985	0.046704	0.010593	0.010452771
Suzuki Access 125	0.043774	0.045418	0.048985	0.042689	0.010084	0.009391227
Honda Activa 125	0.045088	0.042807	0.043783	0.046704	0.009448	0.00974942
Yamaha Fascino 125	0.045088	0.042807	0.041787	0.043473	0.010593	0.009953811
Hero Destini 125	0.045525	0.046984	0.041461	0.045431	0.009281	0.010452771

Then the Optimality Function S_i and Utility Degree Ki has been calculated in Table 28by using the Eq. (5) and Eq. (6) for each and every alternative and based on the Utility Degree, the Ranking of Alternative has been done.

Table 28. Calculation of Optimality function, Utility Degree & Ranking of alternatives.

Alternatives	S_i	K_i	Ranking of Alternatives
Suzuki Access 125	0.200341	0.957455	1
Honda Activa 125	0.197579	0.944253	3
Yamaha Fascino 125	0.193701	0.925721	4
Hero Destini 125	0.199134	0.951687	2

Table 29. Summarize the Alternative Rankings of the Sensitivity analysis.

	Methods Followed	Rank 1	Rank 2	Rank 3	Rank 4
Case 1	ARAS method with AHP weights	Suzuki Access 125	Honda activa125	Hero Destini 125	Yamaha Fascino 125

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Case 2	ARAS method with Equal weightage	Suzuki Access 125	Hero Destini 125	Yamaha Fascino 125	Honda activa 125
Case 3	ARAS method with 50% weightage assigned with Beneficial criterion and 50% for Non-beneficial criterion	Yamaha Fascino 125	Hero Destini 125	Suzuki Access 125	Honda activa125
Case 4	ARAS method with 60% weightage assigned with Beneficial criterion and 40% for Non-beneficial criterion	Hero Destini 125	Suzuki Access 125	Yamaha Fascino 125	Honda activa 125
Case 5	ARAS method with 70% weightage assigned with Beneficial criterion and 30% for Non-beneficial criterion	Suzuki Access 125	Hero Destini 125	Honda activa 125	Yamaha Fascino 125
Case 6	ARAS method with 80% weightage assigned with Beneficial criterion and 20% for Non-beneficial criterion	Suzuki Access 125	Hero Destini 125	Honda activa 125	Yamaha Fascino 125
Case 7	ARAS method with 90% weightage assigned with Beneficial criterion and 10% for Non-beneficial criterion	Suzuki Access 125	Hero Destini 125	Honda activa 125	Yamaha Fascino 125

RESULT AND DISCUSSION

From the Table 29, we can clearly see that among 7 cases in the Sensitivity analysis using ARAS, the Suzuki Access 125 is having the Rank 1 in highest no of cases (5 out of 7). Then around 71% case the Hero Destini 125 takes the rank of 2. After which the Honda Activa 125 takes the Rank 3 in most of the cases and Yamaha Fascino 125 holds the rank 4 in 57% cases. Fig. 1 gives spot light over the fact that how many times an alternative has got a particular rank. By this Fig. 27 we can see

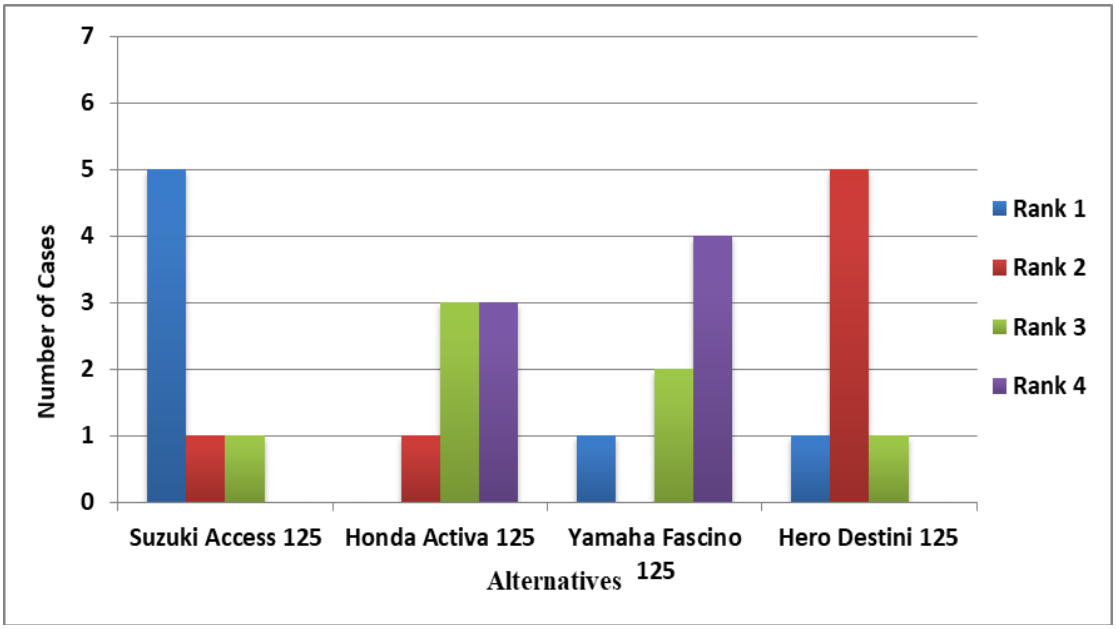

Fig. 1. Sensitivity Analysis Result.

that Suzuki Access 125 holds Rank 1 in 6 methods among 10. Honda Activa 125 holds Rank 2 in 8 methods among 10. Yamaha Fascino 125 holds Rank 4 in 9 cases among 10 and Hero Destini 125 holds Rank 3 in 6 cases. The Fig. 2 clearly describes graphically about the ranks that are evaluated for each alternatives with Standard ARAS and Sensitivity analysis. The Fig also clarifies that which alternative ranks what with different weightage cases.

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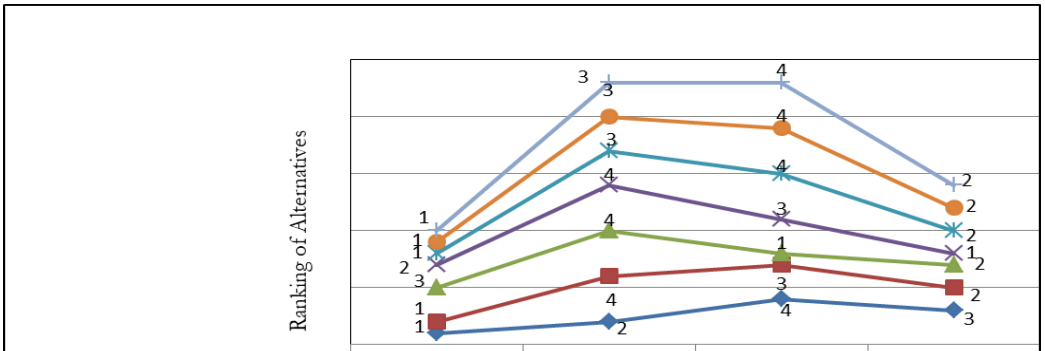

	Suzuki Access 125	Honda Activa 125	Yamaha Fascino 125	Hero Destini 125
90%-10%	1	3	4	2
80%-20%	1	3	4	2
70%-30%	1	3	4	2
60%-40%	2	4	3	1
50%-50%	3	4	1	2
Equal weightage	1	4	3	2
ASRS with AHP weight	1	2	4	3

Fig. 2. Ranking comparison between Standard ARAS result and Sensitivity Analysis Result

It can be seen from the comparison figure that the results that are obtained from standard case are somehow varies for 60%-40% and 50%-50% weightage techniques. As we increase the weightage percentile for the beneficial criterions, it increases the closeness of the results with the standard one. Suzuki Access 125 holds rank 1 in most of the cases and which holds rank 1 earlier in the standard ARAS method also. On the other hand, rank 4 hold by Yamaha Fascino 125 in Standard ARAS as well as most of the Sensitivity Analysis cases. Deviation is seen for the rank 2 and rank 3. In AHP-ARAS method, the rank 2 is got by Honda Activa 125 and rank 3 is holds by Hero Destini 125. But in sensitivity analysis result, rank 2 holds by Hero Destini 125 and rank 3 holds by Honda Activa 125 for majority of cases.

CONCLUSION

The Sensitivity Analysis mainly makes a judgmental overview about the results that are obtained from the standard process of MCDM by using the variable weightage method. It helps the decision makers to become confident about the judgment that he/she has to be made. In our work we are trying to make an overview about how a variable weightage sensitivity analysis can be used to check consistency of the Standard MCDM results. We can conclude from the work that there is not much deviation of results for Rank 1 and Rank 4 positions which are obtained from AHP-ARAS and Sensitivity Analysis. Suzuki Access 125 holds Rank 1 and which is the best alternative among all 4 alternatives. Yamaha Fascino 125 holds Rank 4 in most of the cases. For Rank 3 and Rank 4 position some deviation is seen in the standard and sensitivity analysis process and which can be taken care of by the decision makers easily with subjective judgment.

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