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AN UNBIASED COMPARISON OF THE MOORA TOPSIS AND WASPAS METHODS WITHIN THE MATLAB PROGRAMMING ENVIRONMENT, UTILIZING A FUZZY HYPERSOFT SETS FRAMEWORK

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Abstract The utilization of Multi-Criteria Decision Making methodologies facilitates the progression of decision-making within the complex arena of various alternatives and conflicting objectives. The strategies facilitate the resolution of complex decision-making problems by employing diverse criteria or objectives. In the real world, the presence of uncertainties, ambiguities, and fuzzy boundaries poses challenges for traditional MCDM methodologies in effectively capturing choice scenarios. The combination of fuzzy and hypersoft sets, known as fuzzy hypersoft sets, puts forward an innovative decision-making methodology predicated on uncertainty. The implementation of MCDM techniques in fuzzy hypersoft sets offers a comprehensive solution for the analysis of uncertain decisions. By incorporating ambiguous information, doing sensitivity analysis, and evaluating robustness into the decision-making process, decision-makers can effectively navigate complex option landscapes with confidence. Decision-makers have the potential to enhance their ability to respond to uncertainty by including fuzzy hypersoft sets into traditional frameworks.

1 Introduction

Within the dynamic fabric of metropolitan environments, some regions are confronted with the difficulties of disregard, deterioration, and lack of progress. These metropolitan areas, were bustling centers of activity, now serve as evidence of the progression of time, characterized by unoccupied structures, deteriorating infrastructure, and declining economic opportunities. Nevertheless, within the context of urban deterioration, there exists a potential for metamorphosis, rejuvenation, and invigoration.

Urban rehabilitation projects have emerged as promising solutions amidst the challenges posed by urban decay, providing a means to rejuvenate communities and invigorate their morale. These initiatives, which are based on strategic interventions and collaborative endeavours, aim to revitalize understand urban regions by tackling a wide range of issues and promoting long-term development. Urban regeneration programs aim to transform the urban landscape and establish vibrant and inclusive environments by adopting a comprehensive strategy that includes physical redevelopment, economic stimulation, social empowerment, environment stewardship, cultural preservation, and community participation.

The main aim is to examine the fundamental nature of urban rehabilitation initiatives, encompassing their importance, goals, essential elements, and the profound influence they exert on urban settings and the well-being of its residents. We analyse the complex network of strategies, alliances, and activities that support these projects, demonstrating their capacity to transform the urban story and stimulate beneficial transformations. Urban revitalization projects play a crucial role in revitalizing abandoned buildings, preserving cultural heritage, empowering marginalized communities, and developing sustainable infrastructure. These projects act as catalysts for urban renewal, leading to a more equitable and promising future.

The initial works in fuzzy set theory, authored by Zadeh demonstrate the author's desire to expand upon the traditional concept of a set and a proposition to account for fuzziness inherent in human language, specifically in judgements, evaluations and decisions [18]. Uncertain conceptual phenomena can be explored precisely and rigorously within the strict mathematical framework provided by fuzzy set theory (there is nothing fuzzy about fuzzy sets theory!). Additionally, it is fitting for scenarios involving ambiguous relations, criteria, and phenomena and can be regarded as a modelling language. Fuzzy sets, an indispensable instrument for managing insignificances and reluctances in DM (Decision-Making), were suggested by Zadeh for implementation [11]. Fuzzy sets and variants are inadequate for mathematical modelling due to the presence of more complex uncertainties in the data. This is the result of the parameters that comprise an attribute. To comprehensively manage parametric data, an alternative tool is required to resolve the issue. The result of this is the development of the Soft Set (SS) [8].

The philosophy of soft sets was primarily anticipated by Molodtsov in 1999. It provides greater rigor when the nebulous concept is parametrically modelled. Its framework is more general in nature in comparison to the fuzzy set and its variations. Later Smarandache [10] expanded upon the perception of the soft set by proposing the hypersoft set, which entails conversion of the function with multiple attributes. The primary rationale for utilizing Hypersoft Set (HSS) is that the Soft Set (SS) environment is incapable of handling situations involving attributes that consist of more than one and are further subdivided. Therefore, there is a significant necessity to establish a novel methodology in order to address these issues. Following this, the fundamentals of hypersoft set theory were investigated by Saeed et al., The goal of fuzzy hypersoft sets in decision-making is to provide a precise and advanced method for representing and analysing complex and uncertain information which was introduced by Yolcu and Ozturk [4].

Based on the aforementioned analysis of urban regeneration, Multi Criteria Decision Making emerges as most effective approach for identifying the optimal choice among a range of viable possibilities, considering diverse criteria. Numerous researchers worldwide have put up and recommended diverse strategies to address these types of unclear challenges through MCDM methods [7]. This study encompassed a range of methodologies for MCDM where the TOPSIS methodology developed by Hoon, and Hwang enable users to assign priority to orders by considering their similarity to target solutions [5]. The TOPSIS technique facilitates the identification of the final point leading to a favourable ideal solution, hence aiding in the selection of the most optimal course of action. The initial establishment of MOORA, also known as Multi-Criteria Optimization on the basis of ratio Analysis, can be attributed to Edmundas Kazimieras Zavadskas and Willem Karel M Brauers. This method involves applying ratios to a matrix of potential responses to aims.

The weighted aggregated sum product assessment approach is a multi-criteria decision making solution that can evaluate several options based on variety of criteria. The WASPAS approach is widely used to evaluate several alternatives based on various criteria. The utilization of the Weighted Aggregated Sum Product Assessment (WASPAS) technique can effectively minimize errors and enhance accuracy in the selection of both the maximum and minimum values. The WASPAS approach is highly effective in intricate decision-making scenarios and yields highly precise models [1].

In this study, the weight of each criterion is determined using the entropy weight determination method. The Entropy technique determines the objective weights for the attributes weights for the attributes by quantifying the significance of each reaction, without considering the subjective preferences of the decision-makers. It was deemed appropriate for any decision-making processes that necessitated the estimation of weight. Entropy can provide a numerical measure of the amount of information present, allowing for the comparison and analysis of the impact of utilizing various statistical models, algorithms, and their respective tuning parameters. The criterion's value of information increases as its entropy decreases. The Entropy approach quantifies the level of uncertainty in variables and assesses the impact of controlling factors on the outcome [14].

2 Basic Definitions

2.1 Linguistic Variable: It refers to the practice of detailing variables using words instead of their numerical value. Low, Medium, and High are linguistic variables commonly used in various industry contexts. Therefore, a linguistic variable for processing time can be represented as T, which includes the values of very low, low, medium, high, very high.[2]

Table 1.

Linguistic variable	**Numerical range**
Low	[0,0.3]
Medium	[0.4,0.6]
High	[0.7,1]

2.2 Fuzzy Set: $\mathfrak{X}$, described as compilation of things, typically characterized by $\mathfrak{x}$. Within $\mathfrak{X}$, $\breve{\mathfrak{A}}$ is regarded as a set of well-ordered pairs: $\breve{\mathfrak{A}} = \{\mathfrak{x}, \mu_{\breve{\mathfrak{A}}}(\mathfrak{x}) | \mathfrak{x} \in \mathfrak{X}\}$. $\mu_{\breve{\mathfrak{A}}}(\mathfrak{x})$ has been known as the membership function where $\mu_{\breve{\mathfrak{A}}}(\mathfrak{x}) = \begin{cases} 1 & \text{if } \mathfrak{x} \in \mathfrak{X} \\ 0 & \text{if } \mathfrak{x} \notin \mathfrak{X} \end{cases}$ [19]

2.3 Soft Sets: Consider $\mathfrak{X}$ to be the complete set, $\mathfrak{P}(\mathfrak{X})$ to be $\mathfrak{X}$/s power set, and $\mathfrak{E}$ to be the collection among all parameters. Denoting a soft set $(\varphi, \mathfrak{E})$ on $\mathfrak{X}$ is expressed as:
$(\varphi, \mathfrak{E}) = \{(\mathfrak{e}, \varphi(\mathfrak{e})), \mathfrak{e} \in \mathfrak{E}, \varphi(\mathfrak{e}) \in \mathfrak{P}(\mathfrak{X})\}$ where $\varphi : \mathfrak{E} \to \mathfrak{P}(\mathfrak{X})$ [9]

2.4 Fuzzy Soft Sets: $\mathfrak{X}$ a universal set, $\mathfrak{IP}(\mathfrak{X})$ comprise every fuzzy set of $\mathfrak{X}$ and $\mathfrak{E}$, the collection regardless of limitations. Then a duo $(\varphi, \mathfrak{E})$ is inferred as fuzzy soft set on $\mathfrak{X}, \varphi : \mathfrak{E} \to \mathfrak{IP}(\mathfrak{X})$. [?]

Example 1 (Soft Sets, Fuzzy Soft Sets): Consider an entire set $\mathfrak{Y}$ and parameter $\mathfrak{E}$
$\mathfrak{Y} = \{\mathfrak{y}_1 =$ Hilton, $\mathfrak{y}_2 =$ Marriott, $\mathfrak{y}_3 =$ HolidayInn$\}$ and
$\mathfrak{E} = \{\mathfrak{e}_1 =$ Room cleanliness, $\mathfrak{e}_2 =$ Staff friendliness, $\mathfrak{e}_3 =$ Amenities,
$\mathfrak{e}_4 =$ Location convenience, $\}$
Therefore, the soft set
$(\varphi, \mathfrak{E}) = \{((\mathfrak{e}_1, (\mathfrak{y}_1, \mathfrak{y}_3)), (\mathfrak{e}_2, (\mathfrak{Y})), (\mathfrak{e}_3, (\mathfrak{y}_1, \mathfrak{y}_2)), (\mathfrak{e}_4, (\mathfrak{y}_2, \mathfrak{y}_3)))\}$

Table 2.

Hotels	Parameters
$\mathfrak{y}_1 = Hilton$	$\mathfrak{e}_1 = Room\ Cleanliness$
$\mathfrak{y}_2 = Marriot$	$\mathfrak{e}_2 = Staff\ Friendliness$
$\mathfrak{y}_3 = HolidayInn$	$\mathfrak{e}_3 = Amenities$
	$\mathfrak{e}_4$ = Location Convenience

Now for fuzzy soft set $(\varphi, \mathfrak{E})$ is defined as

$$(\varphi, \mathfrak{E}) = \left\{ \left(\mathfrak{e}_1, \left(\frac{\mathfrak{y}_1}{0.5}, \frac{\mathfrak{y}_2}{0.34}, \frac{\mathfrak{y}_3}{0.1}\right)\right), \left(\mathfrak{e}_2, \left(\frac{\mathfrak{y}_1}{0.71}, \frac{\mathfrak{y}_2}{0.2}, \frac{\mathfrak{y}_3}{0.6}\right)\right) \right.$$
$$\left. \left(\mathfrak{y}_3, \left(\frac{\mathfrak{y}_1}{0.65}, \frac{\mathfrak{y}_2}{0.41}, \frac{\mathfrak{y}_3}{0.33}\right)\right), \left(\mathfrak{e}_4, \left(\frac{\mathfrak{y}_1}{0.8}, \frac{\mathfrak{y}_2}{0.15}, \frac{\mathfrak{y}_3}{0.52}\right)\right) \right\}$$

2.5 HyperSoft Sets: The set $\mathfrak{X}$ referred to as a universality while $\mathfrak{P}(\mathfrak{X})$ known as strongest set of $\mathfrak{X}$. Let $\mathfrak{e}_1, \mathfrak{e}_2, \ldots, \mathfrak{e}_\mathfrak{n}$ for $\mathfrak{n} \geq 1$ be $\mathfrak{n}$ clarified aspects, whose resulting sub-attributes of $\mathfrak{e}_\mathfrak{i}$ are in turn the sets $E_1, E_2, \ldots, E_n$ with $\mathfrak{E}_\mathfrak{i} \cap \mathfrak{E}_\mathfrak{i} = \emptyset$ for $\mathfrak{i} \neq \mathfrak{j}$ and $\mathfrak{i}, \mathfrak{j} \in \{1, 2, 3, \ldots, \mathfrak{n}\}$ then the combination $(\varphi, \mathfrak{E}_1 \times \mathfrak{E}_2 \times \ldots \mathfrak{E}_\mathfrak{n})$ represents hypersoft set over $\mathfrak{X}$ where $\varphi : \mathfrak{E}_1 \times \mathfrak{E}_2 \times \ldots \times \mathfrak{E}_\mathfrak{n} \to \mathfrak{P}(\mathfrak{X})$.[12]

2.6 Fuzzy HyperSoft Sets: Given $\mathfrak{X}$ as a global variable and $\mathfrak{E}_1, \mathfrak{E}_2, \mathfrak{E}_3, \ldots, \mathfrak{E}\mathfrak{n}$ as jointly separate sets of constraints, $\mathfrak{F}\mathfrak{P}(\mathfrak{X})$ is an ensemble of all fuzzy set over $\mathfrak{X}$. For apiece $\mathfrak{i} = 1, 2, 3, \ldots, \mathfrak{n}$, let $\mathfrak{A}_\mathfrak{i}$ denote the non-empty subset of $\mathfrak{E}_\mathfrak{i}$. The couple $(\varphi, \mathfrak{A}_1 \times \mathfrak{A}_2 \times \ldots \times \mathfrak{A}_\mathfrak{n})$ is used to indicate a fuzzy hypersoft set, where $\varphi : \mathfrak{U}_1 \times \mathfrak{A}_2 \times \ldots \times \mathfrak{A}_\mathfrak{n} \to \mathfrak{F}\mathfrak{P}(\mathfrak{X})$ is specified. [13]

Example 2 (Hypersoft sets, Fuzzy Hypersoft sets): Speculate on the expanse of opinions $\mathfrak{X} = \{\mathfrak{k}_1, \mathfrak{k}_2, \mathfrak{k}_3, \mathfrak{k}_4\}$ be the smart phones and $\{\mathfrak{c}_1 = \text{Performance}, \mathfrak{c}_2 = \text{Camera quality}, \mathfrak{c}_3 = \text{Price}\}$ consist of a set of characteristics whose values relate to the sub-attributes listed below:
Performance = $\mathfrak{E}_1 = \{\mathfrak{a}_{11} = \text{RAM}, \mathfrak{a}_{12} = \text{Storage Space}\}$,
Camera Quality = $\mathfrak{E}_2 = \{\mathfrak{a}_{21} = \text{Megapixel Count},$
$\mathfrak{a}_{22} = \text{Low Light performance}, \mathfrak{a}_{23} = \text{Image Stabilization}\}$
and Price = $\mathfrak{E}_3 = \{\mathfrak{a}_{31} = \text{Actual Price}, \mathfrak{a}_{32} = \text{Affordability}\}$.
Let $\hat{\mathfrak{A}} = \mathfrak{E}_1 \times \mathfrak{E}_2 \times \mathfrak{E}_3 = \{\mathfrak{a}_{11}, \mathfrak{a}_{12}\} \times \{\mathfrak{a}_{21}, \mathfrak{a}_{22}, \mathfrak{a}_{23}\} \times \{\mathfrak{a}_{31}, \mathfrak{a}_{32}\}$

$$\left\{\begin{array}{c} (\mathfrak{a}_{11}, \mathfrak{a}_{21}, \mathfrak{a}_{31}), (\mathfrak{a}_{11}, \mathfrak{a}_{21}, \mathfrak{a}_{32}), (\mathfrak{a}_{11}, \mathfrak{a}_{22}, \mathfrak{a}_{31}), \\ (\mathfrak{a}_{11}, \mathfrak{a}_{22}, \mathfrak{a}_{32}), (\mathfrak{a}_{11}, \mathfrak{a}_{23}, \mathfrak{a}_{31}), (\mathfrak{a}_{11}, \mathfrak{a}_{23}, \mathfrak{a}_{32}) \\ (\mathfrak{a}_{12}, \mathfrak{a}_{21}, \mathfrak{a}_{31}), (\mathfrak{a}_{12}, \mathfrak{a}_{21}, \mathfrak{a}_{32}), (\mathfrak{a}_{12}, \mathfrak{a}_{22}, \mathfrak{a}_{31}), \\ (\mathfrak{a}_{12}, \mathfrak{a}_{22}, \mathfrak{a}_{32}), (\mathfrak{a}_{12}, \mathfrak{a}_{23}, \mathfrak{a}_{31}), (\mathfrak{a}_{12}, \mathfrak{a}_{23}, \mathfrak{a}_{32}) \end{array}\right\}$$

where

$$\left\{\begin{array}{c} \widehat{\mathfrak{a}_1} = (\mathfrak{a}_{11}, \mathfrak{a}_{21}, \mathfrak{a}_{31}); \widehat{\mathfrak{a}_2} = (\mathfrak{a}_{11}, \mathfrak{a}_{21}, \mathfrak{a}_{32}); \widehat{\mathfrak{a}_3} = (\mathfrak{a}_{11}, \mathfrak{a}_{22}, \mathfrak{a}_{31}); \\ \widehat{\mathfrak{a}_4} = (\mathfrak{a}_{11}, \mathfrak{a}_{22}, \mathfrak{a}_{32}); \widehat{\mathfrak{a}_5} = (\mathfrak{a}_{11}, \mathfrak{a}_{23}, \mathfrak{a}_{31}); \widehat{\mathfrak{a}_6} = (\mathfrak{a}_{11}, \mathfrak{a}_{23}, \mathfrak{a}_{32}); \\ \widehat{\mathfrak{a}_7} = (\mathfrak{a}_{12}, \mathfrak{a}_{21}, \mathfrak{a}_{31}); \widehat{\mathfrak{a}_8} = (\mathfrak{a}_{12}, \mathfrak{a}_{21}, \mathfrak{a}_{32}); \widehat{\mathfrak{a}_9} = (\mathfrak{a}_{12}, \mathfrak{a}_{22}, \mathfrak{a}_{31}); \\ \widehat{\mathfrak{a}_{10}} = (\mathfrak{a}_{12}, \mathfrak{a}_{22}, \mathfrak{a}_{32}); \widehat{\mathfrak{a}_{11}} = (\mathfrak{a}_{12}, \mathfrak{a}_{23}, \mathfrak{a}_{31}); \widehat{\mathfrak{a}_{12}} = (\mathfrak{a}_{12}, \mathfrak{a}_{23}, \mathfrak{a}_{32}) \end{array}\right\}$$

$\hat{\mathfrak{A}} = \{\widehat{\mathfrak{a}_1}, \widehat{\mathfrak{a}_2}, \widehat{\mathfrak{a}_3}, \widehat{\mathfrak{a}_4}, \widehat{\mathfrak{a}_5}, \widehat{\mathfrak{a}_6}, \widehat{\mathfrak{a}_7}, \widehat{\mathfrak{a}_8}, \widehat{\mathfrak{a}_9}, \widehat{\mathfrak{a}_{10}}, \widehat{\mathfrak{a}_{11}}, \widehat{\mathfrak{a}_{12}}\}$ then the hypersoft sets is given by:

$$(\varphi, \hat{\mathfrak{A}}) = \left\{\begin{array}{c} (\widehat{\mathbf{a_1}}, (\widehat{\mathbf{k_1}}, \widehat{\mathbf{k_2}})), (\widehat{\mathbf{a_2}}, (\widehat{\mathbf{k_3}}, \widehat{\mathbf{k_4}})), (\widehat{\mathbf{a_3}}, (\widehat{\mathbf{k_1}}, \widehat{\mathbf{k_3}})), (\widehat{\mathbf{a_4}}, (\widehat{\mathbf{k_1}}, \widehat{\mathbf{k_4}})), \\ (\widehat{\mathbf{a_5}}, (\widehat{\mathbf{k_1}}, \widehat{\mathbf{k_3}})), (\widehat{\mathbf{a_6}}, (\widehat{\mathbf{k_2}}, \widehat{\mathbf{k_4}})), (\widehat{\mathbf{a_7}}, (\widehat{\mathbf{k_1}})), (\widehat{\mathbf{a_8}}, (\widehat{\mathbf{k_2}})), \\ (\widehat{\mathbf{a_9}}, (\widehat{\mathbf{k_3}})), (\widehat{\mathbf{a_{10}}}, (\widehat{\mathbf{k_4}})), (\widehat{\mathbf{a_{11}}}, (\widehat{\mathbf{k_1}}, \widehat{\mathbf{k_2}}, \widehat{\mathbf{k_3}})), (\widehat{\mathbf{a_{12}}}, (\widehat{\mathbf{k_1}}, \widehat{\mathbf{k_2}}, \widehat{\mathbf{k_4}})) \end{array}\right\}$$

then the fuzzy hypersoft sets over $\mathfrak{X}$ is given as follows

$$(\varphi, \hat{\mathfrak{A}}) = \left\{\begin{array}{l} (\widehat{\mathfrak{a}_1}, (\widehat{\mathfrak{k}_1}, 0.63), (\widehat{\mathfrak{k}_2}, 0.27), (\widehat{\mathfrak{k}_3}, 0.7), (\widehat{\mathfrak{k}_4}, 0.43)), \\ (\widehat{\mathfrak{a}_2}, (\widehat{\mathfrak{k}_1}, 0.32), (\widehat{\mathfrak{k}_2}, 0.52), (\widehat{\mathfrak{k}_3}, 0.54), (\widehat{\mathfrak{k}_4}, 0.16)), \\ (\widehat{\mathfrak{a}_3}, (\widehat{\mathfrak{k}_1}, 0.7), (\widehat{\mathfrak{k}_2}, 0.22), (\widehat{\mathfrak{k}_3}, 0.81), (\widehat{\mathfrak{k}_4}, 0.9)), \\ (\widehat{\mathfrak{a}_4}, (\widehat{\mathfrak{k}_1}, 0.82), (\widehat{\mathfrak{k}_2}, 0.45), (\widehat{\mathfrak{k}_3}, 0.8), (\widehat{\mathfrak{k}_4}, 0.31)), \\ (\widehat{\mathfrak{a}_5}, (\widehat{\mathfrak{k}_1}, 0.19), (\widehat{\mathfrak{k}_2}, 0.9), (\widehat{\mathfrak{k}_3}, 0.6), (\widehat{\mathfrak{k}_4}, 0.54)), \\ (\widehat{\mathfrak{a}_6}, (\widehat{\mathfrak{k}_1}, 0.33), (\widehat{\mathfrak{k}_2}, 0.71), (\widehat{\mathfrak{k}_3}, 0.8), (\widehat{\mathfrak{k}_4}, 0.42)), \\ (\widehat{\mathfrak{a}_7}, (\widehat{\mathfrak{k}_1}, 0.32), (\widehat{\mathfrak{k}_2}, 0.7), (\widehat{\mathfrak{k}_3}, 0.9), (\widehat{\mathfrak{k}_4}, 0.18)), \\ (\widehat{\mathfrak{a}_8}, (\widehat{\mathfrak{k}_1}, 0.28), (\widehat{\mathfrak{k}_2}, 0.7), (\widehat{\mathfrak{k}_3}, 0.64), (\widehat{\mathfrak{k}_4}, 0.41)), \\ (\widehat{\mathfrak{a}_9}, (\widehat{\mathfrak{k}_1}, 0.2), (\widehat{\mathfrak{k}_2}, 0.81), (\widehat{\mathfrak{k}_3}, 0.4), (\widehat{\mathfrak{k}_4}, 0.14)), \\ (\widehat{\mathfrak{a}_{10}}, (\widehat{\mathfrak{k}_1}, 0.55), (\widehat{\mathfrak{k}_2}, 0.17), (\widehat{\mathfrak{k}_3}, 0.73), (\widehat{\mathfrak{k}_4}, 0.8)), \\ (\widehat{\mathfrak{a}_{11}}, (\widehat{\mathfrak{k}_1}, 0.24), (\widehat{\mathfrak{k}_2}, 0.54), (\widehat{\mathfrak{k}_3}, 0.45), (\widehat{\mathfrak{k}_4}, 0.9)), \\ (\widehat{\mathfrak{a}_{12}}, (\widehat{\mathfrak{k}_1}, 0.61), (\widehat{\mathfrak{k}_2}, 0.36), (\widehat{\mathfrak{k}_3}, 0.9), (\widehat{\mathfrak{k}_4}, 0.19)) \end{array}\right\}$$

3 MCDM Methods

3.1 Entropy weight determination method: The Entropy, which measures dispersion level of various information in decision making, is one of the weighting methods. It has been widely implemented in comprehensive evaluation studies in which the entropy value of the various evaluation indexes is used to determine the weights of different indexes [17].

Step 1: With respect to the selection framework $X = x_{ij}$

Step 2: Standardization of the matrix using the below mentioned formula

$$p_{ij} = \frac{x_{ij}}{\sum_{j=1}^{n} x_{ij}}$$

Step 3: Applying the values in the formula E_i of the Entropy weight method

$$E_i = \frac{\sum_{j=1}^{n} p_{ij}.ln\, p_{ij}}{ln\, n}$$

Step 4: Calculating the weight w_i when the scale of entropy value E_i is [0,1]

$$w_i = \frac{1 - E_i}{\sum_{i=1}^{m} (1 - E_i)}$$

3.2 MOORA: In order to optimize multiple competing objectives, potentially with a predetermined number of constraints considered, the MOORA method is applied to rank the available alternatives. Implementing the MCDM of the MOORA method entails the subsequent steps [10]

Step 1: Develop the decision matrix $X = x_{ij}$
Step 2: Compute normalization matrix $[x_{ij}]_{m \times n}$ based on the formula $K = [x_{ij}]_{m \times n}$, using the normalization method

$$K = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} {x_{ij}}^2}}$$

Step 3: Using the formula to normalize the weights and then calculate the decision matrix

$$W_{ij} = w_j \times k_{ij}$$

Step 4: Defining P_i & R_i on the basis of the following formulas.

$$P_i = \sum_{j=1}^{g} W_{ij}$$

$$R_i = \sum_{j=g+1}^{n} W_{ij}$$

where $\sum_{j=1}^{g} W_{ij}$ stands for the criterion with the lowest possible value and $\sum_{j=g+1}^{n} W_{ij}$ for the criterion with the greatest possible value.

Step 5: Identifying Q_i on the basis of the following formula

$$Q_i = P_i - R_i$$

3.3 TOPSIS: To address decision-making issues, Topsis method was devised by Yoon and Hwang. TOPSIS method simplifies the process of determining the shortest distance to an ideal solution, which aids in the selection of the best option. Soon after its launch, a plethora of researchers began using TOPSIS to decision-making and eventually expanded its scope to include all types of fuzzy settings [3].

Step 1: Build a decision-making model $X = x_{ij}$
Step 2: The normalizing procedure was used to construct the matrix $R = (x_{ij})_{m \times n}$, from the matrix $(x_{ij})_{m \times n}$

$$f_{ij} = \frac{x_{ij}}{\sqrt{\sum_{k=1}^{m} {x_{kj}}^2}}, i = 1, 2, \ldots, m, j = 1, 2, \ldots, n$$

Step 3: Determine the weighted normalized decision matrix

$$t_{ij} = f_{ij}.w_j,$$

where $w_j = \frac{w_j}{\sum_{k=1}^{n} w_k}, j = 1, 2, \ldots, n$

Step 4: Establish the worst and best alternative:

$$\begin{aligned} A_w &= \{\langle \max(t_{ij}|i=1,2,\ldots,m)|j \in J-\rangle, \langle \min(t_{ij}|i=1,2,\ldots,m)|j \in J+\rangle\} \\ &\equiv \{t_{wj}|j=1,2,\ldots,n\}, \\ A_b &= \{\langle \min(t_{ij}|i=1,2,\ldots,m)|j \in J-\rangle, \langle \max(t_{ij}|i=1,2,\ldots,m)|j \in J+\rangle\} \\ &\equiv \{t_{bj}|j=1,2,\ldots,n\} \end{aligned}$$

Step 5: Compute L^2 the distance

$$d_{iw} = \sqrt{\sum_{j=1}^{n}(t_{ij} - t_{wj})^2}, i = 1,2,\ldots m.$$

and among the alternative i & best condition A_b

$$d_{ib} = \sqrt{\sum_{j=1}^{n}(t_{ij} - t_{bj})^2}, i = 1,2,\ldots,m.$$

Step 6: Define how similar it is to the worst situation.

$$s_{iw} = \frac{d_{iw}}{(d_{iw} + d_{ib})}, 0 \leq s_{iw} \leq 1, i = 1,2,\ldots,m.$$

Step 7: Prioritize the alternatives as per s_{iw} $(i = 1,2,\ldots,m)$.

3.4 WASPAS: The utility of this instrument for decision-making has gained widespread recognition owing to its mathematical easiness and ability to produce more precise results in comparison to the WSM and WPM methodologies. [1]

Step 1: Initiate the matrix required to resolve the selection problem.
Step 2: Now using normalizing formula:

$$x_{ij} = \frac{x_{ij}}{\max(x_{ij})}(BeneficialCriteria) \tag{3.1}$$

$$x_{ij} = \frac{\min(x_{ij})}{x_{ij}}\ (Non - BeneficialCriteria) \tag{3.2}$$

Step 3: The total relative importance is calculated based on WSM method

$$Q_i{}^{(1)} = \sum_{j=1}^{n} x_{ij}w_j \tag{3.3}$$

Step 4: Again, for WPM method it is calculated as

$$Q_i{}^{(2)} = \prod_{j=1}^{n} x_{ij}{}^{w_j} \tag{3.4}$$

Step 5: An expanded equation is derived through the utilization of this methodology to approximate the overall relative significance of alternatives:

$$Q_i = \lambda.Q_i{}^{(1)} + (1-\lambda).Q_i{}^{(2)} \tag{3.5}$$

By doing so, the precision of evaluations is enhanced, and the decision-making process is rendered more beneficial.

4 Numerical Example

A municipal planning committee member is responsible for choosing the best appropriate urban regeneration project for a specific area experiencing economic decline and social issues. The objective is to select a project that will rejuvenate the region, enhance the standard of living, stimulate economic growth, and establish a lively and sustainable community. In order to accomplish this goal, the committee members must assess multiple urban regeneration initiatives according to the specified criteria and their related sub-criteria. Below are the mentioned urban revitalization projects:

$$U = \left\{ \begin{array}{c} \text{Mixed-Use development with Affordable Housing } (U_1) \\ \text{Green Infrastructure and Urban Parks Enhancement } (U_2), \\ \text{Historic Preservation and Adaptive reuse } (U_3), \\ \text{Transit-Oriented Development TOD } (U_4), \\ \text{Community Co-ops and Local Entrepreneurship Hubs } (U_5), \\ \text{Smart City Technology Integration } (U_6), \\ \text{Arts and Cultural Districts Revitalization } (U_7), \\ \text{Sustainable Urban Agriculture and Foof Hubs } (U_8), \\ \text{Pedestrian-Friendly Streetscapes and Complete Streets Implementation } (U_9), \\ \text{Waterfront redevelopment and Blue Economy Intiatives } (U_{10}) \end{array} \right\}$$

$$\begin{array}{c} u_1 = \text{economic development}, u_2 = \text{social equity}, \\ u_3 = \text{environmental sustainability}, u_4 = \text{infrastructure improvement}, \\ u_5 = \text{community engagement}, u_6 = \text{cultural preservations}, \\ u_7 = \text{public safety}, u_8 = \text{health and well-being}, \\ u_9 = \text{housing affordability}, u_{10} = \text{long-term viability}. \end{array}$$

$$u_1 = \left\{ \begin{array}{c} u_{11} = \text{job creation}, \\ u_{12} = \text{business growth} \\ u_{13} = \text{increase in property values}; \end{array} \right\}$$

$$u_2 = \left\{ \begin{array}{c} u_{21} = \text{marginalised community access} \\ u_{22} = \text{low-cost housing} \\ u_{33} = \text{lowering gentrification}; \end{array} \right\}$$

$$u_3 = \left\{ \begin{array}{c} u_{31} = \text{reduction in carbon emission}, \\ u_{32} = \text{preservation of green spaces} \\ u_{33} = \text{use of renewable energy sources}; \end{array} \right\}$$

$$u_4 = \left\{ \begin{array}{c} u_{41} = \text{transportation accessibility}, \\ u_{42} = \text{utilities upgrade} \\ u_{43} = \text{public amenities enhancement}; \end{array} \right\}$$

$$u_5 = \left\{ \begin{array}{c} u_{51} = \text{stakeholder particiaption in decision-making}, \\ u_{52} = \text{public outreach and awareness}, \\ u_{53} = \text{transparency and accountability}; \end{array} \right\}$$

$$u_6 = \left\{ \begin{array}{c} u_{61} = \text{historic building preservation}, \\ u_{62} = \text{promotion of cultural events}, \\ u_{63} = \text{support for local artists aand artisans}; \end{array} \right\}$$

$$u_7 = \left\{ \begin{array}{c} u_{71} = \text{crime prevention measures,} \\ u_{72} = \text{safe public spaces creation} \\ u_{73} = \text{emergency response preparedness;} \end{array} \right\}$$

$$u_8 = \left\{ \begin{array}{c} u_{81} = \text{access to healthcare services,} \\ u_{82} = \text{recreational opportunities,} \\ u_{83} = \text{reduction of environmental health risks;} \end{array} \right\}$$

$$u_9 = \left\{ \begin{array}{c} u_{91} = \text{percentage of income spent on housing,} \\ u_{92} = \text{availability of affordable housing units,} \\ u_{93} = \text{protection against displacement;} \end{array} \right\}$$

$$u_{10} = \left\{ \begin{array}{c} u_{101} = \text{resilience to climate change impacts,} \\ u_{102} = \text{adaptability to economic fluctuations,} \\ u_{103} = \text{sustainable management practices;} \end{array} \right\}$$

Here the manual calculation of MOORA, TOPSIS, and WASPAS methods using the above mentioned algorithm have been shown.

Entropy weight determination method: The entropy weight determination method is a quantitative technique for objectively establishing the weights of criteria in decision-making processes. It is built on the principle of entropy from information theory, which quantifies the level of disorder or uncertainty within a system. In decision-making, reduced entropy values signify the heightened significance of a criterion owing to diminished uncertainty or enhanced discriminative capability.

Table 3.

Projects	U_1	U_2	U_3	U_4	U_5	U_6	U_7	U_8	U_9	U_{10}
E_j	0.977	0.962	0.991	0.937	0.955	0.965	0.972	0.983	0.955	0.963
$1 - E_j$	0.023	0.038	0.009	0.063	0.045	0.035	0.028	0.017	0.045	0.037
w_i	0.069	0.112	0.026	0.186	0.133	0.102	0.083	0.049	0.131	0.109

MOORA: The square roots of the total squared replies serve as the denominators of the set of ratios in MOORA. These ratios appear to be the best option among many ratios because they are dimensionless. Located between zero and one, these dimensionless ratios are added when maximizing or deleted when minimizing. In the end, the ratios that were obtained are used to rank each choice. [2]

Table 4.

	Non-Beneficial Weights	Beneficial Weights	(Beneficial & Non-Beneficial)	Rank
U_1	0.043	0.298	0.255	2
U_2	0.074	0.255	0.181	10
U_3	0.074	0.275	0.201	6
U_4	0.068	0.281	0.213	5
U_5	0.040	0.231	0.191	7
U_6	0.034	0.291	0.257	1
U_7	0.071	0.308	0.237	4
U_8	0.040	0.261	0.191	8
U_9	0.028	0.212	0.185	9
U_{10}	0.049	0.287	0.238	3

TOPSIS: It assesses a group of options according to a predetermined standard. The technique is applied to companies across a range of industries. Each, time we must base an analytical choice on the information gathered. By finding the best along with the worst alternative and calculating the similarity worst condition through the formula the ranking of the alternatives is done. [11]

Table 5.

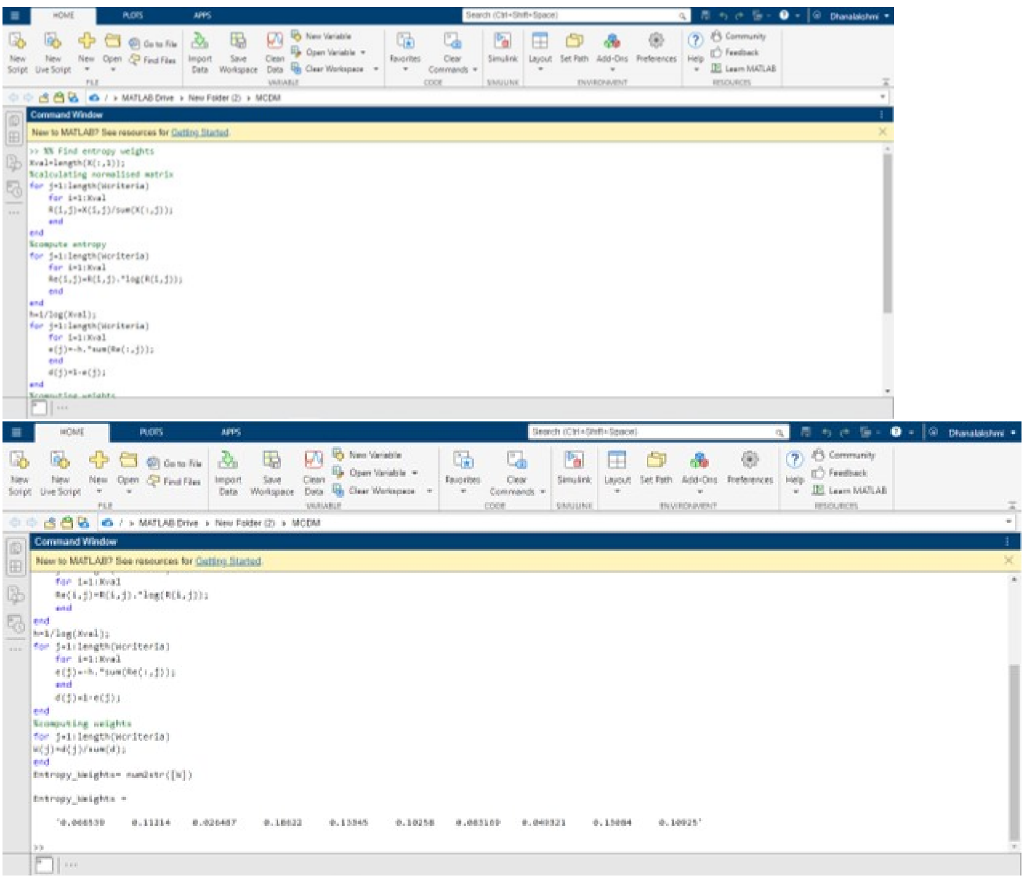
	S_{ib}	S_{iw}	P_i	Position
U_1	0.055	0.097	0.639	2
U_2	0.082	0.064	0.439	9
U_3	0.072	0.063	0.467	8
U_4	0.086	0.078	0.477	6
U_5	0.080	0.085	0.517	5
U_6	0.049	0.093	0.655	1
U_7	0.078	0.091	0.538	4
U_8	0.073	0.064	0.467	7
U_9	0.089	0.060	0.404	10
U_{10}	0.054	0.094	0.635	3

WASPAS: Whenever the value of λ is equal to zero, the WASPAS approach undergoes a conversion to the Weighted Product Model, and when equal to one, it is transformed to the weighted Sum Model. The lamda (λ) parameter has been employed to address multi-criteria decision making problems to improve ranking precision. A situational study is utilized and applied in WASPAS multi criteria decision making method, drawing inspiration from a referenced application of WASPAS and subsequently simplifying it.

Table 6.

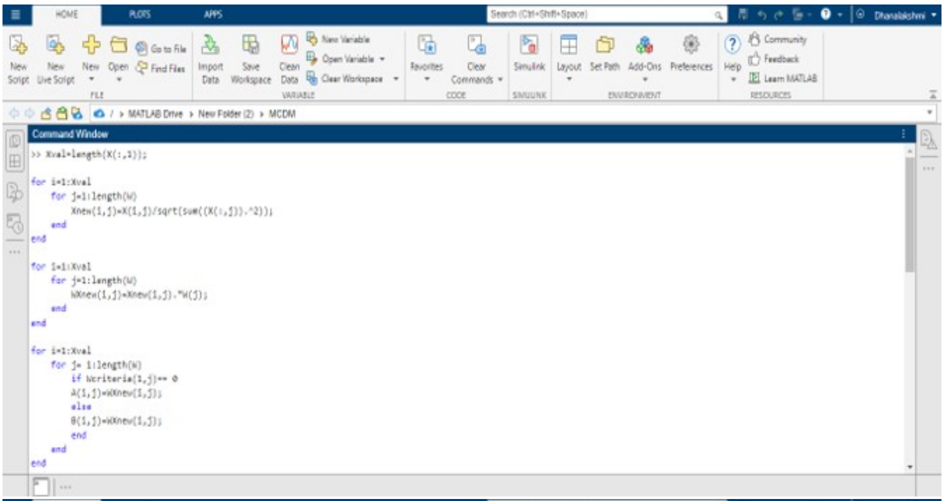
	WSM	WPM	WASPAS	Classification
U_1	0.741	0.693	0.717	2
U_2	0.504	0.472	0.488	10
U_3	0.556	0.541	0.549	6
U_4	0.585	0.480	0.532	8
U_5	0.566	0.463	0.515	9
U_6	0.745	0.713	0.729	1
U_7	0.636	0.515	0.576	5
U_8	0.598	0.566	0.582	4
U_9	0.596	0.495	0.545	7
U_{10}	0.677	0.629	0.653	3

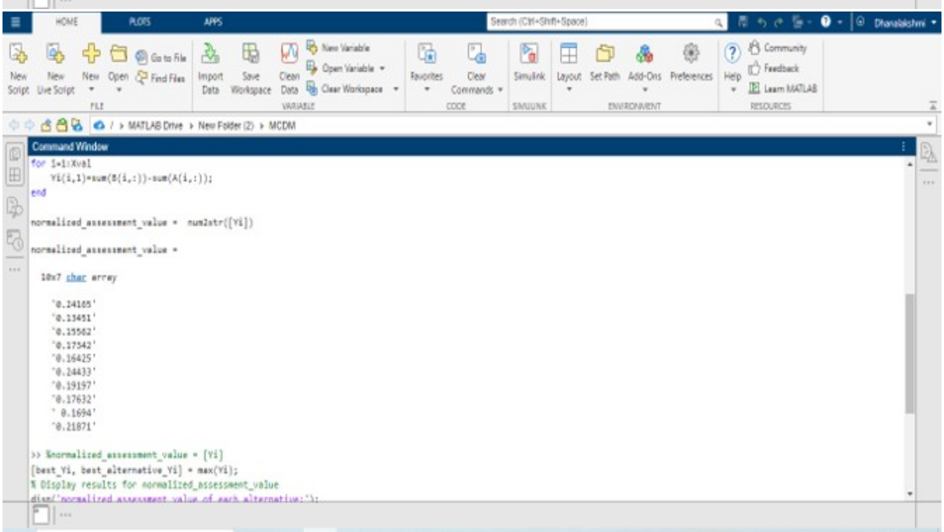
MATLAB CODING for Entropy Weight Determination Method:

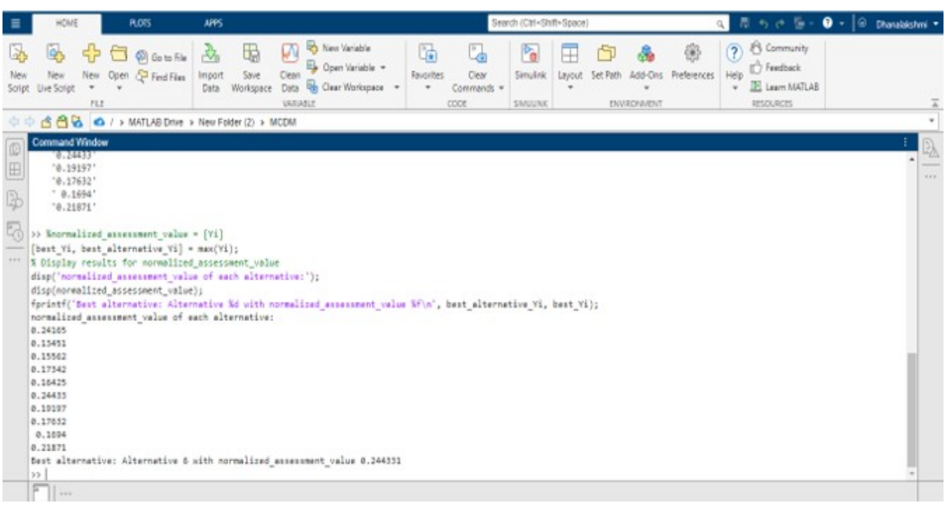


MATLAB CODING OF MOORA TOPSIS AND WASPAS METHOD: Here the coding and the output of all the three MCDM methods have been shown along with the best alternative.

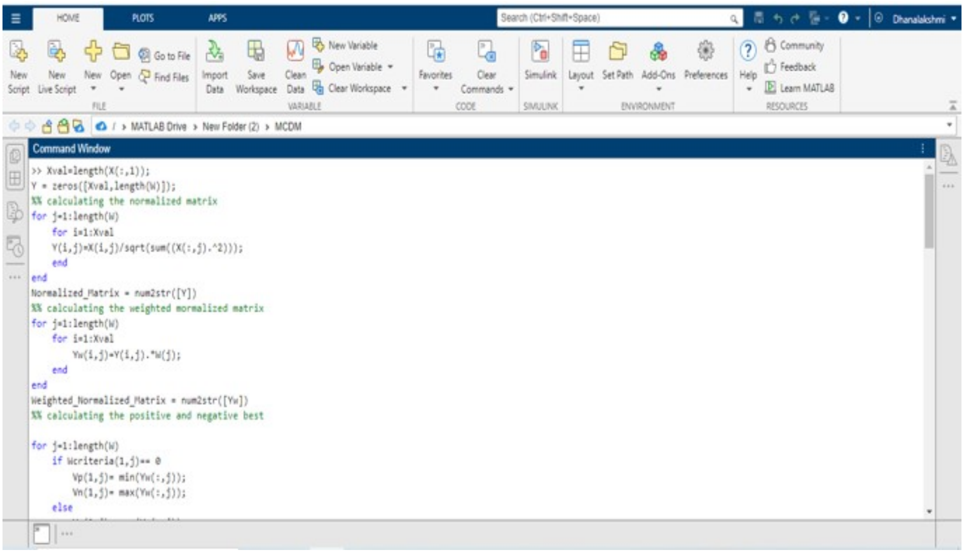
MOORA method: MOORA permits alternatives with intermediate attributes to attain the top ranking, an outcome that is unattainable using weighted linearity of the various objectives. Despite the simulations being theoretical constructs, it is possible to deduce that MOORA is operational and prepared for practical implementation once data becomes accessible. In addition to each of these when utilized in conjunction with MATLAB code, MOORA is designed to reduce human labor and increase the outcome while decreasing the computational period.

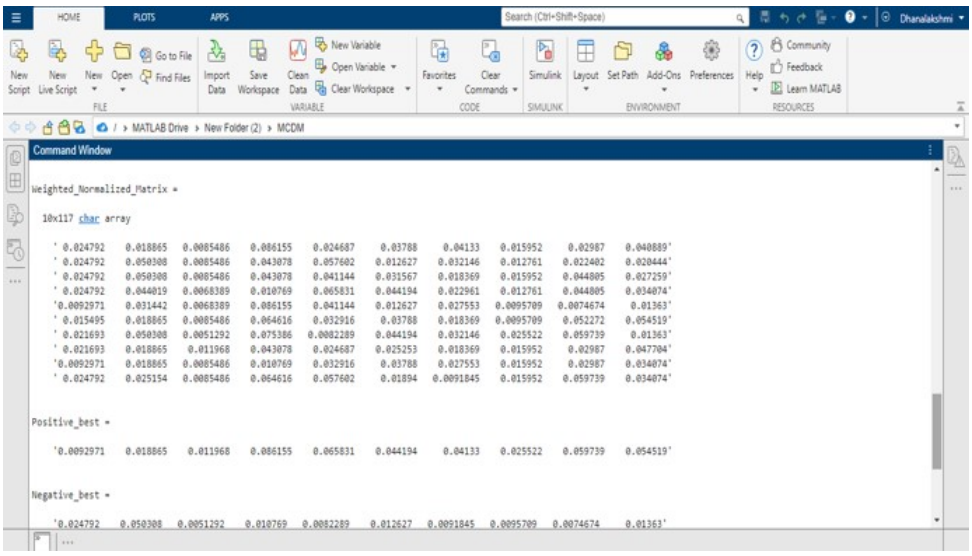


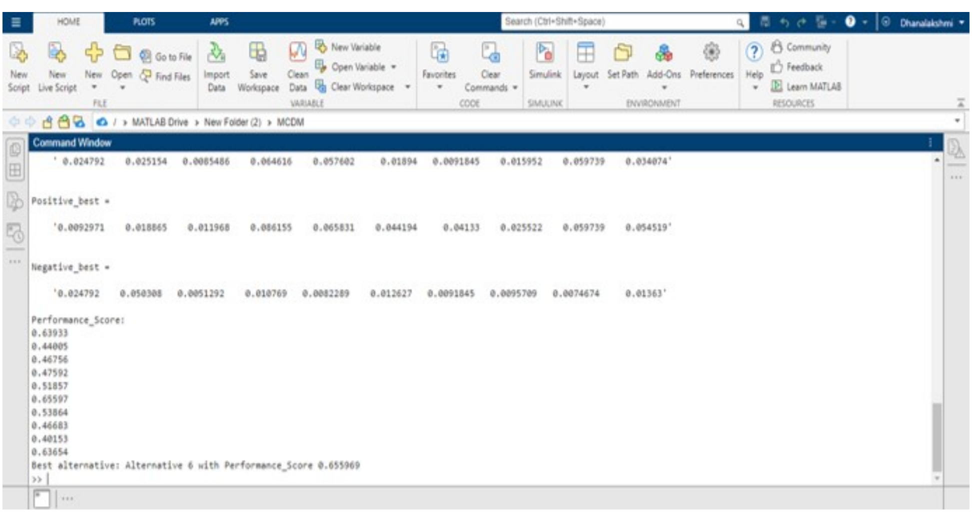




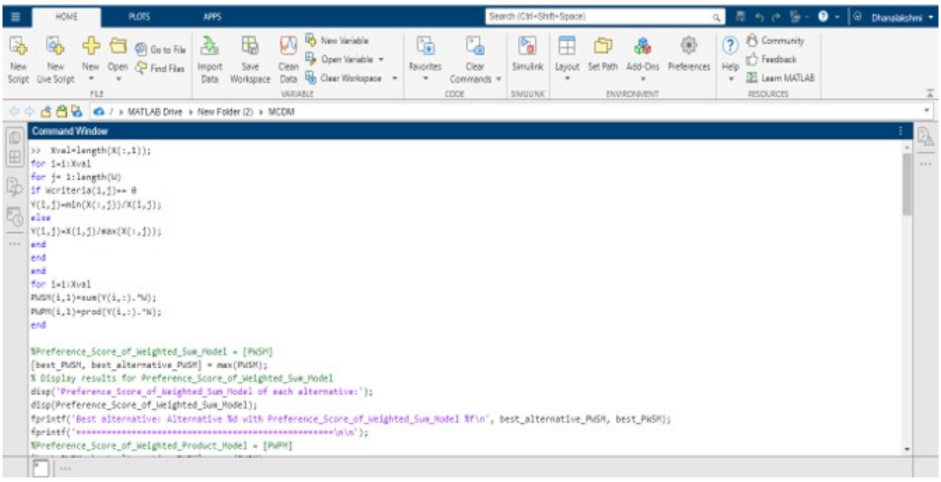
TOPSIS method: The TOPSIS method facilitates the determination of the least space from a optimistic perfect solution, thereby enabling to select the absolute ideal option. Because of its compatibility, the technique is widely employed by researchers across the globe. Intriguingly, MATLAB programming increases the algorithm's strength by decreasing the time and effort required to determine the preferred alternative.

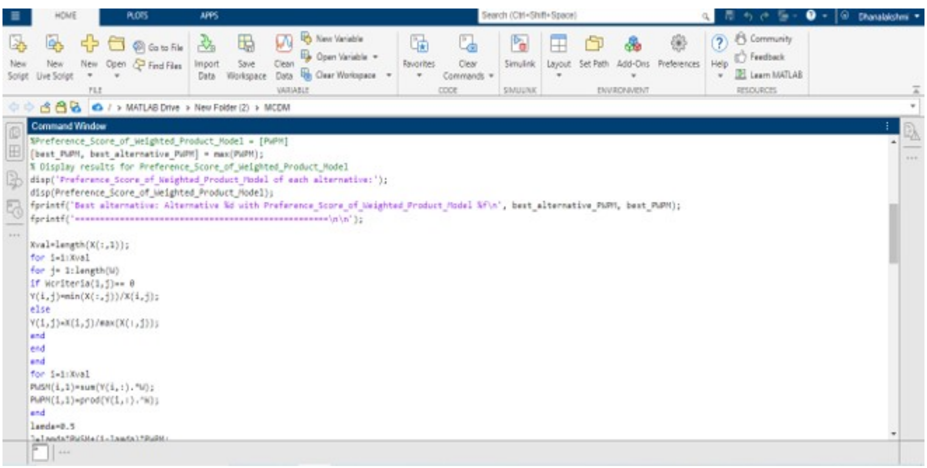


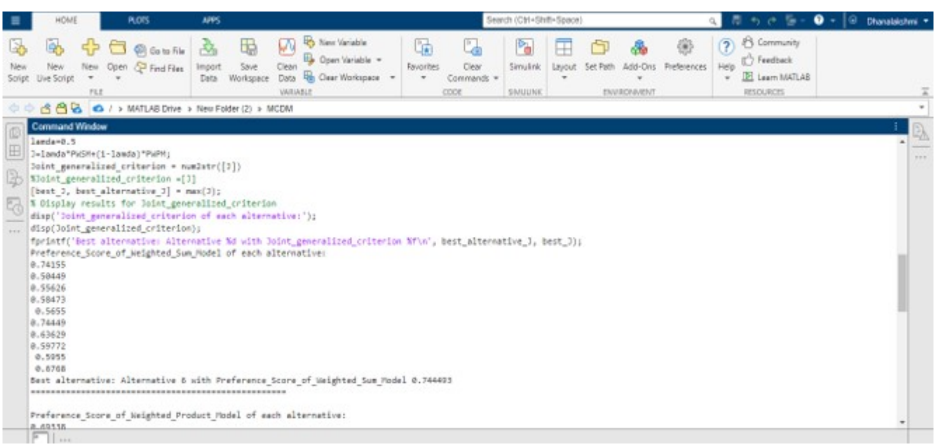




WASPAS: The WASPAS methodology is straightforward and provides decision makers with the most precise alternative for reaching a conclusion, in comparison to the standard WSM and WPM procedures. Furthermore, when implemented using MATLA B programming, it proves to be more refined and straightforward, allowing for quicker conclusions with less processing time.







Result: After comparing the three MCDM methods, whether done manually or via MATLAB code, it is evident that the Smart City technology Integration is the optimal choice.

5 Conclusion

The best urban regeneration project that satisfies all parameters is analysed using different MCDM methods. Here fuzzy hypersoft sets is used, where the parameters can be divided into numerous possibilities. Entropy weight determination method is utilized to obtain the weights for calculating the MCDM methods. The weight calculation is based on the weightage or importance of each of the projects considered. A table that compares the MOORA, TOPSIS and WAPAS approaches is created here. When it comes to giving each choice the best ranking, the MCDM technique stands out as the finest. Furthermore, this is the first instance of MATLAB coding being created utilizing the MCDM methods' algorithm and deployed under these three ways to obtain a precise solution for a problem with a real-world focus. Also, the ranking of manual calculation and MATLAB coding calculation go hand in hand providing a feasible solution according to the scenario. Through ranking of these three methods and among all the urban regeneration programs smart city technology integration stands out to be the best with the necessary parameters.

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