

Classification of Renewable Energy Trends by Utilizing the Novel Entropy Measures under the Environment of q-rung Orthopair Fuzzy Soft Sets

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ABSTRACT

Energy generated from naturally replenishing sources such as the sun and wind, is said to be renewable energy (RE). The production of electricity water heating and cooling can all be done with renewable energy. Some recent trends in renewable energy are (1) Advanced photovoltaic (2) Distributed energy storage systems (3) Hydro Power (4) Bioenergy. The utilization of fuzzy set theory is very important for the classification of renewable energy trends. q-rung orthopair fuzzy soft set (q-ROFSS) is a parameterization tool and a more efficient apparatus to resolve unclear and vague data in general. As entropy is quantitated measure of disordered or randomness in a system and it can handle the uncertainty of data in fuzzy set theory for a disordered system. So, in this article, based on q-ROFSS, we have initiated some novel entropy measures under the environment of q-ROFSS to relate more complex data and to give more room to decision-makers for handling many decision-making problems. So, the entropy of q-ROFSS is the measure of ambiguity related to q-ROFSS. To show the authenticity of the established work further, we have established an algorithm for the introduced work along with a descriptive example to substantiate the reliability of initiated work. We have also initiated a comparative study of the introduced notion with some existing theories to demonstrate the usefulness and consistency of the given idea.

Keywords: q-rung orthopair fuzzy soft sets; Entropy Measures; Decision Making

(MSC2020) Codes: 03B52, 03E72, 28E10

1 | INTRODUCTION

A source of RE can never run out of fuel or is limitless, like the sun. Solar and wind energy are examples of sustainable energy sources that don't release carbon dioxide or various other greenhouse gases that cause global warming. To power everything, human beings are depending on coal oil and fossil fuels for the last 150 years. But these sources are creating an alarming situation for the atmosphere

due to the emission of harmful gasses. So due to this reason, there is a need to utilize those sources that are free from all those harmful gasses that create problems for the environment. Some recent trends in renewable energy are (1) Advanced photovoltaic (2) Distributed energy storage systems (3) Hydro Power (4) Bioenergy. Many researchers try to analyze RE sources to keep the environment safe from gaseous material. The analysis of global potential for RE was presented in [1]. [2] works on RE strategies for sustainable development energy. [3] study the role of RE sources in environmental protection.

In present days, when decision-makers have to handle uncertain data and they have to choose the optimum alternatives from the given ones, hurdles start to form in the collection of a large number of ambiguous data. Also, when there is too much complexity to measure the disordered for a given system, decision-makers face problems to tackle the data. In this case, entropy measures can help us to control this issue. So, the measure of fuzziness is often called entropy in literature initiated in [4]. A fuzzy set (FS) [5] is the fundamental tool that provides a new direction to researchers for handling ambiguous data. So many researchers find the concept of the FS in different directions like entropy measures, and they have applied this concept to the detection of breast cancer as given in [6]. We can see that the fuzzy entropy measure has an extensive range of approaches to different fields. As the idea of the intuitionistic fuzzy set (IFS) delivered in [7] is the more generalized version that can deal with a membership degree (MD) as well as a non-membership degree (NMD) in the same structure. So, due to the advanced notion of IFS, many researchers have started to see applications for these structures, and they have successfully applied it to many directions like medical diagnosis [8] and medicine [9]. Furthermore, many researchers find out the applications of entropy measures under the environment of IFSs and they have developed some new entropies and divergence measures using Archimedean t-conorm to apply them in supplier selection as given in [10]. Moreover, [11] develop some new entropy measures using the notion of IFSs for edge detection. Also, entropy measures for IFSs based on divergence have been initiated in [12]. As interval-valued IFS [13] is a more general way to present the data, based on this notion, some entropy measures have been introduced in [14]. Moreover, [15] proposed the correlation coefficient measure under the environment of a complex IFS and provide its application. Note that IFS is a limited idea to handle fuzzy information and based on these observations, the idea of Pythagorean fuzzy set (PyFS) [16] is introduced by Yager to cover the complexities faced by IFSs. Many researchers are actively engaged to develop some methods that can deal with PyF information like the VIKOR method based on entropies and divergence measures for PyF data given in [17]. Also, [18] find the importance of entropy measures based on the PyF probabilistic hesitant fuzzy decision-making technique. No doubt PyFS can discuss MD and NMD and it can handle more advanced data, but this notion faces difficulty to handle the data when decision-makers provide their information 0.7 for MD and 0.8 for the NMD. So, in this situation PyFS becomes limited and there is a need to develop a more advanced structure that can handle this type

of data. So, [19] develop the idea of q -rung orthopair fuzzy sets (q -ROFSs) that use the constraint that the sum of q th power of MD and NMD must belong to unit interval $[0, 1]$ for $q \geq 1$. It means q -ROFS is a more efficient tool to handle more complex data. After the notion of q -ROFS, many researchers have started to find out the application of this notion in pattern recognition and decision making [20, 21]. Also, knowledge measures for q -ROFS was developed in [22].

The traditional soft set (SS) is the function from a set of a parameter to a crisp subset of the universe. [23] introduces the idea of SS which deals with complex data involving uncertain and unclear objects. As a SS is more general apparatus to handle uncertainty, new developments have been made by researchers in this field. [24] initiated operations under the theory of SS. Also, [25] established the arithmetic constructions of SS associated with some operations. Later on, [26] find the applications of SS in topology and provide the idea of soft, rough topology. After the idea of SS, many researchers have tried to introduce the combined notion of SS and FS theories. Many hybrid notions like a fuzzy soft set (FSS) [27], IF soft set (IFSS) [28], PyF soft set (PyFSS) [29], and q -ROF soft set (q -ROFSS) [30] have been introduced. Many applications and theories have been developed on these notions like the study of FSS and its applications have been developed in [31]. Moreover, new aggregation operators (AOs) based on generalized IFSS was given in [32], and its application have been given in [33]. Furthermore, a novel approach toward generalized IFSS has been established in [34]. Also, [35] proved the new direction of generalized interval valued IFSS and established its applications to the decision support system. Moreover, based on these developed theories some entropy measures based on IFSS have been developed in [36]. Also, some entropy and distance measures for PyFSS have been developed in [37]. Also, [38] developed novel entropy measures for PyFSS. Also, [39] established the notion of Pythagorean m -polar FSS with its TOPSIS method for multi-criteria decision-making problems. Similar to the notion of q -ROFS, we can analyze that q -ROFSS is a more generalized structure than that of IFSS and PyFSS. Furthermore, q -ROFSS can consider the parameterization tool as well. So, based on q -ROFSS, in this article, we have developed novel entropy measures for q -ROFSS. Moreover, an algorithm based on these developed notions has been introduced. Also, these developed notions have been verified by introducing the descriptive example. A comparative study of the presented work has been developed that shows the reliability, effectiveness, and superiority of the introduced work. Moreover, the graphical introduction of the presented work has been given in Figure 1.

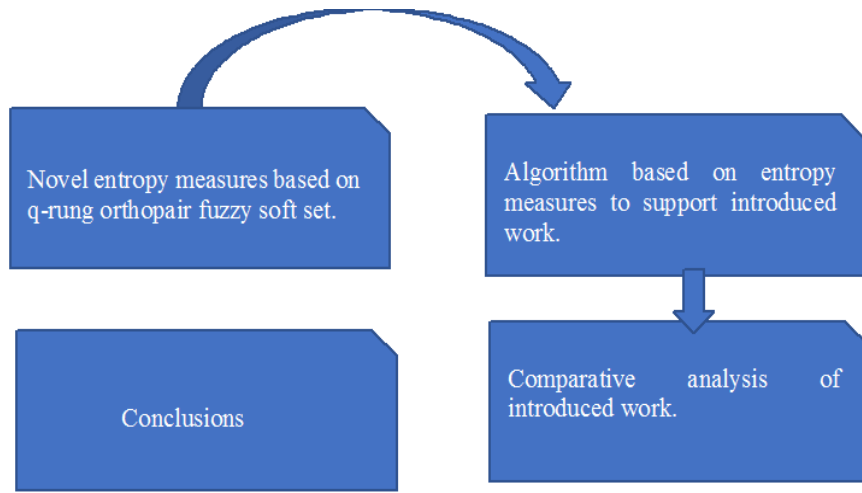


Figure 1. Frame Diagram for Proposed Work

The remainder of the manuscript is given as; In section 2, we have overviewed the basic definition of SS, IFSS, PyFSS and q-ROFSS. Moreover, Section 3 deals with a basic definition of introduced entropy measures under the environment of q-ROFSS. Also, section 4 deals with the developed algorithm along with an example to show the authenticity of the developed approach. Furthermore, in section 5, we have given the comparative study of the initiated work to show the effectiveness of the given idea. At the end of the article in section 6, we have developed conclusion remarks.

2 | PRELIMINARIES

In this part, we have discussed the predefined ideas of SS, IFSSs, PyFSS and q-ROFSS.

Definition 1: [23] Let $\mathcal{U}'$ be the universal set and P^* be the set of parameters. A SS is a pair $(\mathcal{F}, P^*)$.

Definition 2: [28] A pair $(\mathcal{F}, P^*)$ is called IFSS if the function $\mathcal{F} : P^* \rightarrow IFS^{\mathcal{U}'}$ is defined by

$$\mathcal{F}_{v_{i'}}(p_{j'}) = \{v_{i'}, \mathcal{M}^{\circ}_{j'}(v_{i'}), \mathbb{N}^{\circ}_{j'}(v_{i'}) \mid v_{i'} \in \mathcal{U}'\}$$

Where $IFS^{\mathcal{U}'}$ present the family of IFS over $\mathcal{U}'$ and $\mathcal{M}^{\circ}_{j'}(v_{i'}), \mathbb{N}^{\circ}_{j'}(v_{i'})$ present the MD and NMD respectively with a constraint that $0 \leq (\mathcal{M}^{\circ}_{j'}(v_{i'})) + (\mathbb{N}^{\circ}_{j'}(v_{i'})) \leq 1$.

Definition 3: [29] A pair $(\mathcal{F}, P^*)$ is called PyFSS if the function $\mathcal{F} : P^* \rightarrow PyFS^{\mathcal{U}'}$ is defined by

$$\mathcal{F}_{v_{i'}}(p_{j'}) = \{v_{i'}, \mathcal{M}^{\circ}_{j'}(v_{i'}), \mathbb{N}^{\circ}_{j'}(v_{i'}) \mid v_{i'} \in \mathcal{U}'\}$$

Where $PyFS^{\mathcal{U}'}$ present the family of PyFS over $\mathcal{U}'$ and $\mathcal{M}^{\circ}_{j'}(v_{i'}), \mathbb{N}^{\circ}_{j'}(v_{i'})$ present the MD and NMD respectively with a constraint that $0 \leq (\mathcal{M}^{\circ}_{j'}(v_{i'}))^2 + (\mathbb{N}^{\circ}_{j'}(v_{i'}))^2 \leq 1$.

Definition 4: [30] A pair $(\mathcal{F}, P^*)$ is called q-ROFSS if the function $\mathcal{F} : P^* \rightarrow q-ROFS^{\mathcal{U}'}$ is defined by

$$\mathcal{F}_{v_{i'}}(p_{j'}) = \{v_{i'}, \mathcal{M}^{\circ}_{j'}(v_{i'}), \mathbb{N}^{\circ}_{j'}(v_{i'}) \mid v_{i'} \in \mathcal{U}'\}$$

Where $q-ROFS^{\mathcal{U}'}$ present the family of q-ROFS over $\mathcal{U}'$ and $\mathcal{M}^{\circ}_{j'}(v_{i'}), \mathbb{N}^{\circ}_{j'}(v_{i'})$ present the MD and NMD respectively with a constraint that $0 \leq (\mathcal{M}^{\circ}_{j'}(v_{i'}))^q + (\mathbb{N}^{\circ}_{j'}(v_{i'}))^q \leq 1$ for all $v_{i'} \in \mathcal{U}'$. For simplicity, we call the pair $\mathcal{F}_{v_{i'}}(p_{j'}) = \{\mathcal{M}^{\circ}_{j'}(v_{i'}), \mathbb{N}^{\circ}_{j'}(v_{i'})\}$ as q-rung orthopair fuzzy soft number (q-ROFSN) for $\mathcal{M}^{\circ}_{j'}(v_{i'}), \mathbb{N}^{\circ}_{j'}(v_{i'}) \in [0, 1]$.

3 | ENTROPY MEASURE FOR Q-RUNG ORTHOPAIR FUZZY SOFT SETS (Q-ROFSS)

In this section, we have to introduce the definition of entropy measures for q-ROFSSs. For this consider two q-ROFSSs $\mathfrak{R}^q = (\mathfrak{F}, P^*)$ and $\tilde{\mathfrak{R}}^q = (\phi, P^*)$. Also, suppose that $\mathcal{U}' = \{v_1, v_2, \dots, v_{n_s}\}$ present the universal set and $P^* = \{p_1, p_2, \dots, p_{m_s}\}$ present parameter set (PS).

Definition 5: A real function $\mathcal{E}_t: q-ROFSS(\mathcal{U}') \rightarrow [0, m_s n_s]$ is called entropy measure on $q-ROFSS(\mathcal{U}')$ if the following conditions hold.

$$C1) \mathcal{E}_t(\mathfrak{R}^q) = 0 \text{ iff } \mathfrak{R}^q \text{ is a soft set.}$$

$$C2) \mathcal{E}_t(\mathfrak{R}^q) = m_s n_s \text{ if } \mathcal{M}^{\circ}_{\mathfrak{F}_{p_{j'}}(v_{i'})} = N^{\circ}_{\mathfrak{F}_{p_{j'}}(v_{i'})} \forall p_{j'} \in P^* \text{ and } v_{i'} \in \mathcal{U}'.$$

$$C3) \mathcal{E}_t(\mathfrak{R}^q) = \mathcal{E}_t(\mathfrak{R}^q)^c$$

$$C4) \mathcal{E}_t(\mathfrak{R}^q) \geq \mathcal{E}_t(\tilde{\mathfrak{R}}^q) \text{ if } \mathcal{M}^{\circ}_{\mathfrak{F}_{p_{j'}}(v_{i'})} \leq \mathcal{M}^{\circ}_{\phi_{p_{j'}}(v_{i'})} \text{ and}$$

$$N^{\circ}_{\mathfrak{F}_{p_{j'}}(v_{i'})} \geq N^{\circ}_{\phi_{p_{j'}}(v_{i'})} \text{ for } \mathcal{M}^{\circ}_{\phi_{p_{j'}}(v_{i'})} \leq N^{\circ}_{\phi_{p_{j'}}(v_{i'})} \text{ or}$$

$$\mathcal{M}^{\circ}_{\mathfrak{F}_{p_{j'}}(v_{i'})} \geq \mathcal{M}^{\circ}_{\phi_{p_{j'}}(v_{i'})} \text{ and } N^{\circ}_{\mathfrak{F}_{p_{j'}}(v_{i'})} \leq N^{\circ}_{\phi_{p_{j'}}(v_{i'})} \text{ for } \mathcal{M}^{\circ}_{\phi_{p_{j'}}(v_{i'})} \geq N^{\circ}_{\phi_{p_{j'}}(v_{i'})}.$$

Now we will initiate two types of entropy measures for q-ROFSS to $R^+ \cup \{0\}$.

Definition 6: For $q-ROFSS \mathfrak{R}^q = \{\mathcal{M}^{\circ}_{\mathfrak{F}(p_{j'})}, N^{\circ}_{\mathfrak{F}(p_{j'})}\}$, two new types of entropy measures $\mathcal{E}_t^1, \mathcal{E}_t^2: q-ROFSS(\mathcal{U}') \rightarrow R^+ \cup \{0\}$ is given as

$$\mathcal{E}_t^1(\mathfrak{R}^q) = \frac{1}{\sqrt{2}-1} \sum_{j'=1}^{m_s} \sum_{i'=1}^{n_s} \left(\sin \left(\frac{\pi \left(1 + \mathcal{M}^{\circ q}_{\mathfrak{F}(p_{j'})}(v_{i'}) - N^{\circ q}_{\mathfrak{F}(p_{j'})}(v_{i'}) \right)}{4} \right) + \sin \left(\frac{\pi \left(1 - \mathcal{M}^{\circ q}_{\mathfrak{F}(p_{j'})}(v_{i'}) + N^{\circ q}_{\mathfrak{F}(p_{j'})}(v_{i'}) \right)}{4} \right) - 1 \right) \quad (1)$$

And

$$\mathcal{E}_t^2(\mathfrak{R}^q) = \frac{1}{\sqrt{2}-1} \sum_{j'=1}^{m_s} \sum_{i'=1}^{n_s} \left(\cos \left(\frac{\pi \left(1 + \mathcal{M}^{\circ q}_{\mathfrak{F}(p_{j'})}(v_{i'}) - N^{\circ q}_{\mathfrak{F}(p_{j'})}(v_{i'}) \right)}{4} \right) + \cos \left(\frac{\pi \left(1 - \mathcal{M}^{\circ q}_{\mathfrak{F}(p_{j'})}(v_{i'}) + N^{\circ q}_{\mathfrak{F}(p_{j'})}(v_{i'}) \right)}{4} \right) - 1 \right) \quad (2)$$

Example 1: Suppose $T = \{a_1, a_2, a_3, a_4, a_5\}$ be the set of five experts who wants to evaluate the capability of a student "Y" using the set of parameters $p = \{p_1 = \text{hard work}, p_2 = \text{punctualaiy}, p_3 = \text{Confident}, p_4 = \text{taking responsibility}\}$. Suppose experts deliver their data as q-ROFSS given in Table 1. Now we use suggested entropy measures for Table 1 and see the results for $q = 3$.

Table 1: q-rung orthopair fuzzy soft data

	a_1	a_2	a_3	a_4	a_5
p_1	(0.4, 0.6)	(0.8, 0.3)	(0.9, 0.1)	(0.2, 0.9)	(0.3, 0.2)
p_2	(0.5, 0.7)	(0.4, 0.7)	(0.3, 0.6)	(0.5, 0.5)	(0.6, 0.8)
p_3	(0.4, 0.4)	(0.7, 0.5)	(0.6, 0.5)	(0.6, 0.5)	(0.4, 0.6)
p_4	(0.6, 0.2)	(0.3, 0.8)	(0.6, 0.6)	(0.5, 0.6)	(0.5, 0.3)

Now by using equation (1), we get the result as given below

$$\mathcal{E}_t^1(\mathfrak{R}^q) = 17.9915.$$

And by using equation 2 we get

$$\mathcal{E}_t^2(\mathfrak{R}^q) = 17.9946$$

Theorem 1: The measure defined in Eq. (1) and Eq. (2) are valid entropy measures.

Proof: Let $\mathfrak{R}^q = \{\mathcal{M}^{\circ q}_{\mathfrak{F}}(p_{j'}), N^{\circ q}_{\mathfrak{F}}(p_{j'})\}$ be the collection of $q - ROFSS$. To prove that initiated measures are valid. For this, we have to prove the above given four properties.

C1) When $\mathfrak{R}^q$ is a soft set that is $\mathcal{M}^{\circ q}_{j'}(v_{i'}) = 0$ and $N^{\circ q}_{j'}(v_{i'}) = 1$ or $\mathcal{M}^{\circ q}_{j'}(v_{i'}) = 1$ and $N^{\circ q}_{j'}(v_{i'}) = 0$ where $i' = 1, 2, 3, \dots, n_s$ and $j' = 1, 2, 3, \dots, m_s$. Hence in both cases

$$\sin \left(\frac{\pi \left(\frac{1 + \mathcal{M}^{\circ q}_{\mathfrak{F}}(p_{j'})(v_{i'})}{-N^{\circ q}_{\mathfrak{F}}(p_{j'})(v_{i'})} \right)}{4} \right) + \sin \left(\frac{\pi \left(\frac{1 - \mathcal{M}^{\circ q}_{\mathfrak{F}}(p_{j'})(v_{i'})}{+N^{\circ q}_{\mathfrak{F}}(p_{j'})(v_{i'})} \right)}{4} \right) - 1 = 0$$

And

$$\cos \left(\frac{\pi \left(\frac{1 + \mathcal{M}^{\circ q}_{\mathfrak{F}}(p_{j'})(v_{i'})}{-N^{\circ q}_{\mathfrak{F}}(p_{j'})(v_{i'})} \right)}{4} \right) + \cos \left(\frac{\pi \left(\frac{1 - \mathcal{M}^{\circ q}_{\mathfrak{F}}(p_{j'})(v_{i'})}{+N^{\circ q}_{\mathfrak{F}}(p_{j'})(v_{i'})} \right)}{4} \right) - 1 = 0$$

Hence for Eq. (1) and (2), we get $\mathcal{E}_t^1(\mathfrak{R}^q) = \mathcal{E}_t^2(\mathfrak{R}^q) = 0$.

Conversely, assume that $\mathcal{E}_t^1(\mathfrak{R}^q) = \mathcal{E}_t^2(\mathfrak{R}^q) = 0$ for $q - ROFSS \mathfrak{R}^q$, then by using definition 6, we get

$$\sin \left(\frac{\pi \left(\frac{1 + \mathcal{M}^{\circ q}_{\mathfrak{F}}(p_{j'})(v_{i'})}{-N^{\circ q}_{\mathfrak{F}}(p_{j'})(v_{i'})} \right)}{4} \right) + \sin \left(\frac{\pi \left(\frac{1 - \mathcal{M}^{\circ q}_{\mathfrak{F}}(p_{j'})(v_{i'})}{+N^{\circ q}_{\mathfrak{F}}(p_{j'})(v_{i'})} \right)}{4} \right) = 1$$

And

$$\cos\left(\frac{\pi\left(\frac{1+\mathcal{M}^{\circ q}\mathfrak{F}(p_{j'})}{4}\right)}{4}\right) + \cos\left(\frac{\pi\left(\frac{1-\mathcal{M}^{\circ q}\mathfrak{F}(p_{j'})}{4}\right)}{4}\right) = 1.$$

That implies that $N^{\circ q}\mathfrak{F}(p_{j'}) - \mathcal{M}^{\circ q}\mathfrak{F}(p_{j'}) = \pm 1$.

But for $q-ROFSS \mathfrak{R}^q$, the values $\{\mathcal{M}^{\circ q}\mathfrak{F}(p_{j'}), N^{\circ q}\mathfrak{F}(p_{j'})\}$ satisfying the constraint $N^{\circ q}\mathfrak{F}(p_{j'}) - \mathcal{M}^{\circ q}\mathfrak{F}(p_{j'}) = \pm 1$ with $0 \leq \mathcal{M}^{\circ q}\mathfrak{F}(p_{j'}), N^{\circ q}\mathfrak{F}(p_{j'}) \leq 1$ and $0 \leq \mathcal{M}^{\circ q}\mathfrak{F}(p_{j'}) + N^{\circ q}\mathfrak{F}(p_{j'}) \leq 1$ is $(1, 0)$ or $(0, 1)$.

Hence $\mathfrak{R}^q$ is a soft set.

C2) $\mathcal{M}^{\circ q}\mathfrak{F}(p_{j'}) = N^{\circ q}\mathfrak{F}(p_{j'})$ then,

$$\sin\left(\frac{\pi\left(\frac{1+\mathcal{M}^{\circ q}\mathfrak{F}(p_{j'})}{4}\right)}{4}\right) + \sin\left(\frac{\pi\left(\frac{1-\mathcal{M}^{\circ q}\mathfrak{F}(p_{j'})}{4}\right)}{4}\right) - 1 = \sqrt{2} - 1$$

And

$$\cos\left(\frac{\pi\left(\frac{1+\mathcal{M}^{\circ q}\mathfrak{F}(p_{j'})}{4}\right)}{4}\right) + \cos\left(\frac{\pi\left(\frac{1-\mathcal{M}^{\circ q}\mathfrak{F}(p_{j'})}{4}\right)}{4}\right) - 1 = \sqrt{2} - 1$$

Hence by using eq. (1) and (2), we get $\mathcal{E}_t^1(\mathfrak{R}^q) = \mathcal{E}_t^2(\mathfrak{R}^q) = m_{\circ}n_{\circ}$.

C3) For $q-ROFSS \mathfrak{R}^q = \{\mathcal{M}^{\circ q}\mathfrak{F}(p_{j'}), N^{\circ q}\mathfrak{F}(p_{j'})\}$ we have $(\mathfrak{R}^q)^c = \{N^{\circ q}\mathfrak{F}(p_{j'}), \mathcal{M}^{\circ q}\mathfrak{F}(p_{j'})\}$. Hence from eq.

(1) and (2) we get the required result.

C4) To prove the fourth property, suppose the functions $\mathfrak{f}_1^{\sim}(x, y)$ and $\mathfrak{f}_2^{\sim}(x, y)$ such that

$$\mathfrak{f}_1^{\sim}(x, y) = \sin\left(\frac{\pi(1+x^q-y^q)}{4}\right) + \sin\left(\frac{\pi(1-x^q+y^q)}{4}\right) - 1$$

And

$$\mathfrak{f}_2^{\sim}(x, y) = \cos\left(\frac{\pi(1+x^q-y^q)}{4}\right) + \cos\left(\frac{\pi(1-x^q+y^q)}{4}\right) - 1$$

$$x, y \in [0, 1] \text{ and } 0 \leq x^q + y^q \leq 1.$$

The partial derivative w.r.t x and y can be obtained as

$$\frac{\partial \mathfrak{f}_1^{\sim}(x, y)}{\partial x} = \frac{\pi x^{q-1}}{4} \left(\cos\left(\frac{\pi(1+x^q-y^q)}{4}\right) - \cos\left(\frac{\pi(1-x^q+y^q)}{4}\right) \right);$$

$$\frac{\partial \mathfrak{f}_1^{\sim}(x, y)}{\partial y} = \frac{\pi y^{q-1}}{4} \left(\cos\left(\frac{\pi(1-x^q+y^q)}{4}\right) - \cos\left(\frac{\pi(1+x^q-y^q)}{4}\right) \right);$$

$$\frac{\partial \mathbb{f}_2^{\approx}(x, y)}{\partial x} = \frac{\pi x^{q-1}}{4} \left(\sin \left(\frac{\pi(1-x^q+y^q)}{4} \right) - \sin \left(\frac{\pi(1+x^q-y^q)}{4} \right) \right);$$

$$\frac{\partial \mathbb{f}_2^{\approx}(x, y)}{\partial y} = \frac{\pi y^{q-1}}{4} \left(\sin \left(\frac{\pi(1+x^q-y^q)}{4} \right) - \sin \left(\frac{\pi(1-x^q+y^q)}{4} \right) \right);$$

We can get critical points when $x = y$ by solving the equations

$$\frac{\partial \mathbb{f}_1^{\approx}(x, y)}{\partial x} = 0, \frac{\partial \mathbb{f}_1^{\approx}(x, y)}{\partial y} = 0, \frac{\partial \mathbb{f}_2^{\approx}(x, y)}{\partial x} \text{ and } \frac{\partial \mathbb{f}_2^{\approx}(x, y)}{\partial y} = 0.$$

Also, we can get that $\frac{\partial \mathbb{f}_1^{\approx}(x, y)}{\partial x} \geq 0$ when $x \leq y$ and $\frac{\partial \mathbb{f}_1^{\approx}(x, y)}{\partial x} \leq 0$ when $x \geq y$, $\frac{\partial \mathbb{f}_1^{\approx}(x, y)}{\partial y} \leq 0$ when $x \leq y$ and $\frac{\partial \mathbb{f}_1^{\approx}(x, y)}{\partial y} \geq 0$ when $x \geq y$. Similarly, we can do for $\mathbb{f}_2^{\approx}$ also. Hence $\mathbb{f}_1^{\approx}$ and $\mathbb{f}_2^{\approx}$ are increasing w.r.t x when $x \leq y$ and decreasing when $x \geq y$. Also $\mathbb{f}_1^{\approx}$ and $\mathbb{f}_2^{\approx}$ are decreasing w.r.t y when $x \leq y$ and increasing when $x \geq y$.

Now for q -ROFSS $\mathbb{R}^q = (\mathbb{F}, P^*)$ and $\tilde{\mathbb{R}}^q = (\phi, P^*)$ and by using the property of the function $\mathbb{f}_1^{\approx}$ and $\mathbb{f}_2^{\approx}$ in eq. (1) and eq. (2), we can observe that $\mathcal{E}_t^1(\mathbb{R}^q) \geq \mathcal{E}_t^1(\tilde{\mathbb{R}}^q)$ and $\mathcal{E}_t^2(\mathbb{R}^q) \geq \mathcal{E}_t^2(\tilde{\mathbb{R}}^q)$ if $\mathcal{M}^\circ_{\mathbb{F}(p_{j'})}(v_{i'}) \leq \mathcal{M}^\circ_{\phi(p_{j'})}(v_{i'})$ and $N^\circ_{\mathbb{F}(p_{j'})}(v_{i'}) \geq N^\circ_{\phi(p_{j'})}(v_{i'})$ for $\mathcal{M}^\circ_{\phi(p_{j'})}(v_{i'}) \leq N^\circ_{\phi(p_{j'})}(v_{i'})$ or $\mathcal{M}^\circ_{\mathbb{F}(p_{j'})}(v_{i'}) \geq \mathcal{M}^\circ_{\phi(p_{j'})}(v_{i'})$ and $N^\circ_{\mathbb{F}(p_{j'})}(v_{i'}) \leq N^\circ_{\phi(p_{j'})}(v_{i'})$ for $\mathcal{M}^\circ_{\phi(p_{j'})}(v_{i'}) \geq N^\circ_{\phi(p_{j'})}(v_{i'})$.

Hence $\mathcal{E}_t^1, \mathcal{E}_t^2$ are valid entropy measures.

Remark 1:

From Eq. (1) and Eq. (2) we observe that when the value of MD and NMD corresponding to each parameter are closer to each other than entropy increases.

When both MD and NMD are equal then the maximum value can be achieved.

4 | PROPOSED ALGORITHM FOR ENTROPY MEASURES BASED ON Q-ROFSS

In part, we will present an algorithm for entropy measure measures based on q-ROFSS to solve decision-making (DM) problems. Also, a numerical example is initiated to holdup the introduced notion.

4.1 | Algorithm

As we observe that q-ROFSS is a more general apparatus than the existing notions like IFSS and PyFSS. Moreover, this notion provides more room for decision-makers to resolve their DM issues. So, it is a beneficial apparatus to depict information in a more precise way during DM problems. To discuss this completely, let $\mathcal{A}^\ell = \{\mathcal{A}_1^\ell, \mathcal{A}_2^\ell, \mathcal{A}_3^\ell, \dots, \mathcal{A}_J^\ell\}$ be the set of $\mathfrak{d}$ alternatives. Also, suppose that $\xi^\triangleright = \{\xi_1^\triangleright, \xi_2^\triangleright, \xi_3^\triangleright, \dots, \xi_{n_\circ}^\triangleright\}$ present the set of $n_\circ$ experts to evaluate the $\mathcal{I}$ alternatives and $P^* = \{p_1, p_2, \dots, p_{m_\circ}\}$ present the set of parameters. Now consider that each expert $\xi_{j'}^\triangleright$ provide his assessment corresponding to each alternative in terms of q-ROFSNs as $\mathbb{R}^q = \{\mathcal{M}^\circ_{i'j'}^{(\mathfrak{d})}, N^\circ_{i'j'}^{(\mathfrak{d})}\}$ such that $\mathcal{M}^\circ_{i'j'}^{(\mathfrak{d})}, N^\circ_{i'j'}^{(\mathfrak{d})} \in [0, 1]$ where $1 \leq i' \leq n_\circ, 1 \leq j' \leq m_\circ$ and $1 \leq \mathfrak{d} \leq \mathcal{I}$. Now we present the algorithm to solve the above-given problems using the proposed entropy measure under the notion of q-ROFSS as below

Step 1: Collect the overall information on alternatives $(\mathcal{A}^\ell)^\mathfrak{d}$ where $\mathfrak{d} = 1, 2, 3, \dots, \mathcal{J}$ proposed by experts in a matrix as follows

$$((\mathcal{A}^\ell)^\mathfrak{d}, P^*) = \begin{bmatrix} \mathfrak{R}_{11}^{q(\mathfrak{d})} & \mathfrak{R}_{12}^{q(\mathfrak{d})} & \dots & \mathfrak{R}_{1m_o}^{q(\mathfrak{d})} \\ \mathfrak{R}_{21}^{q(\mathfrak{d})} & \mathfrak{R}_{22}^{q(\mathfrak{d})} & \dots & \mathfrak{R}_{2m_o}^{q(\mathfrak{d})} \\ \vdots & \vdots & \ddots & \vdots \\ \mathfrak{R}_{n_o1}^{q(\mathfrak{d})} & \mathfrak{R}_{n_o2}^{q(\mathfrak{d})} & \dots & \mathfrak{R}_{n_o m_o}^{q(\mathfrak{d})} \end{bmatrix} \quad (3)$$

Step 2: By using eq. (1) and (2) calculate the values $\mathfrak{R}_\mathfrak{d}^q$ ($\mathfrak{d} = 1, 2, 3, \dots, \mathcal{J}$) for each alternative. For instant using the initiated entropy measure $\mathcal{E}_t^1$, the values of $\mathfrak{R}_\mathfrak{d}^q = \mathcal{E}_t^1((\mathcal{A}^\ell)^\mathfrak{d})$ are calculated by

$$\mathfrak{R}_\mathfrak{d}^q = \frac{1}{\sqrt{2}-1} \sum_{j'=1}^{m_o} \sum_{i'=1}^{n_o} \left(\sin \left(\frac{\pi \left(1 + (\mathcal{M}_{i'j'}^\circ)^q - (\mathcal{N}_{i'j'}^\circ)^q \right)}{4} \right) + \sin \left(\frac{\pi \left(1 - (\mathcal{M}_{i'j'}^\circ)^q + (\mathcal{N}_{i'j'}^\circ)^q \right)}{4} \right) - 1 \right) \quad (4)$$

Step 3: The larger the value of entropy implies that the lesser the ambiguity and hence provide a better option. Thus calculate $\mathfrak{R}_s^q = \max_{\mathfrak{d}=1,2,3,\dots,\mathcal{J}}(\mathfrak{R}_\mathfrak{d}^q)$ and choose the index value.

Step 4: Find out the best alternative based on the index term obtain from Step 3.

4.2 | Numerical Example

In this subsection, we have to elaborate on the numerical explanation of established work to support the introduced work.

Example 2: Due to its potential to lower the production of greenhouse gases, prevent climate change, and reduce dependency on fossil fuels, RE sources have attracted significant interest and acceptance. For their wider and more effective adoption into energy systems, however, problems like storage, growth of infrastructure, and initial expenses have yet to be solved. To provide a dependable and consistent energy supply from these sources, initiatives are being made to increase productivity as well as the affordability of RE technology. Additionally, innovative solutions for energy storage and grid management tactics are being developed.

Different advantages can be seen in the context of RE that are given below

1. There could be a lot of career prospects in the RE industry. RE technology deployment, operation, maintenance, and repair demand a wide spectrum of expertise, from architecture and engineering to analysis and technology.
2. Minimizing dependence on foreign fuels and unpredictable markets improves the security of energy.
3. There are numerous and practically infinite sources of renewable energy. Natural assets such as direct sunlight, water, air, and heat from geothermal sources can all be used to generate energy. These sources will keep replenishing themselves for as long as the Earth is in existence.

Some recent trends in RE are (1) Distributed energy storage systems (2) Advanced photovoltaic (3) Hydro Power.

1. Distributed Energy Storage Systems

The energy system can benefit greatly from distributed energy storage, especially as we switch to renewable energy sources. It can facilitate the deployment of RE by minimizing supply and demand timing variations. Only very small-scale distributed energy storage is currently used. Expensive batteries are frequently the foundation of the systems. Additionally, many regions lack legislative incentives like time-of-use electricity pricing. However, this has lately started to change as battery prices fall and utilities look to avoid expensive infrastructure upgrades in response to rising demand. Utilizing distributed energy storage has been made more appealing by the growth of distributed generating. The energy system is prepared to incorporate distributed storage as a key component.

2. Advanced Photovoltaic

Modern developments in solar energy conversion using photovoltaic (PV) cells are referred to as "advanced photovoltaic." These innovations are meant to increase solar energy production's performance, affordability, and adaptability. Advanced photovoltaic technologies include (1) Multifunction solar cells (2) Concentrated Photovoltaic cells (CPV) (3) Organic Photovoltaic (OPV) (4) Nanostructured solar cells etc.

Compared to conventional solar cell tools, advanced photovoltaic technologies have several benefits. These benefits encourage competence, affordability, and general acceptability as a primary energy source.

1. More sunlight can be converted into electricity thanks to advancements in photovoltaic technology, which increases the amount of energy that can be produced by a given area of solar panels.

Some modern photovoltaic tools, such as perovskite solar cells, can produce energy even in low-light environments. This can be especially helpful when the sky is cloudy or overcast.

3. Hydro Power

Hydropower, commonly referred to as hydroelectric power, is a RE source that uses the power of moving water to produce electricity. It is one of the most traditional and popular forms of RE. The fundamental idea behind hydropower is to operate turbines utilizing the kinetic energy of water that is moving, which subsequently transforms mechanical power into electrical power. Hydropower is a significant source of RE since it provides several advantages. The following are some of the major benefits of hydropower:

1. It emits less greenhouse gasses, assisting in reducing air pollution as well as global warming.

2. A continuous and dependable source of electricity is offered by hydropower which helps to stabilize the system and fulfill base load needs.
3. In many cases, hydropower plants can operate for more than 50 years provided they are designed effectively and managed. This span helps maintain steady energy output throughout time.

Consider the above three RE sources as an alternative given as $\{\mathcal{A}_1^\ell, \mathcal{A}_2^\ell, \mathcal{A}_3^\ell\}$ and we want to classify these RE sources. Suppose five experts $\xi_1^\triangleright, \xi_2^\triangleright, \xi_3^\triangleright, \xi_4^\triangleright$, and $\xi_5^\triangleright$ provide their assessment data in the shape of q-ROFSS about each alternative corresponding to parameters $p_1 =$ *Ultimated power sources*, $p_2 =$ *They come from natural sources*, $p_3 =$ *Donot produce greenhouse gas emission* and $p_4 =$ *Doesnot generate waste*. Now the stepwise algorithm is used here to find out the best alternatives.

Step 1: The assessment of each expert for alternatives corresponding to each parameter is given in following Table 2-4.

Table 2 $\left((\mathcal{A}^\ell)^1, P^*\right)$

	$\xi_1^\triangleright$	$\xi_2^\triangleright$	$\xi_3^\triangleright$	$\xi_4^\triangleright$	$\xi_5^\triangleright$
p_1	(0.5, 0.6)	(0.3, 0.5)	(0.2, 0.9)	(0.4, 0.3)	(0.8, 0.3)
p_2	(0.3, 0.5)	(0.2, 0.8)	(0.5, 0.6)	(0.5, 0.5)	(0.7, 0.6)
p_3	(0.4, 0.3)	(0.5, 0.7)	(0.3, 0.5)	(0.6, 0.3)	(0.4, 0.7)
p_4	(0.6, 0.7)	(0.4, 0.4)	(0.2, 0.4)	(0.2, 0.8)	(0.3, 0.5)

Table 3 $\left((\mathcal{A}^\ell)^2, P^*\right)$

	$\xi_1^\triangleright$	$\xi_2^\triangleright$	$\xi_3^\triangleright$	$\xi_4^\triangleright$	$\xi_5^\triangleright$
p_1	(0.3, 0.6)	(0.5, 0.6)	(0.3, 0.9)	(0.2, 0.2)	(0.4, 0.3)
p_2	(0.5, 0.5)	(0.3, 0.3)	(0.4, 0.2)	(0.5, 0.1)	(0.3, 0.6)
p_3	(0.2, 0.3)	(0.4, 0.4)	(0.5, 0.3)	(0.7, 0.4)	(0.6, 0.4)
p_4	(0.4, 0.7)	(0.6, 0.3)	(0.6, 0.1)	(0.9, 0.3)	(0.7, 0.2)

Table 4 $\left((\mathcal{A}^\ell)^3, P^*\right)$

	$\xi_1^\triangleright$	$\xi_2^\triangleright$	$\xi_3^\triangleright$	$\xi_4^\triangleright$	$\xi_5^\triangleright$
p_1	(0.4, 0.2)	(0.6, 0.2)	(0.5, 0.1)	(0.3, 0.4)	(0.3, 0.9)
p_2	(0.5, 0.4)	(0.4, 0.5)	(0.2, 0.3)	(0.5, 0.7)	(0.6, 0.4)
p_3	(0.4, 0.3)	(0.2, 0.7)	(0.1, 0.8)	(0.4, 0.4)	(0.1, 0.8)
p_4	(0.6, 0.1)	(0.2, 0.7)	(0.7, 0.1)	(0.6, 0.6)	(0.1, 0.4)

Step 2: For simplicity, we use equation 1, $q = 3$ and compute results as

$$\mathcal{E}_t^1((\mathcal{A}^\ell)^{(1)}) = \frac{1}{\sqrt{2}-1} \left(\sin \left(\frac{\pi \left(1 + \mathcal{M}^{\circ q} \mathbb{F}(p_{j'}) (v_{i'}) - N^{\circ q} \mathbb{F}(p_{j'}) (v_{i'}) \right)}{4} \right) + \sin \left(\frac{\pi \left(1 - \mathcal{M}^{\circ q} \mathbb{F}(p_{j'}) (v_{i'}) + N^{\circ q} \mathbb{F}(p_{j'}) (v_{i'}) \right)}{4} \right) - 1 \right)$$

$$= \frac{1}{\sqrt{2}-1} \left(\sin \left(\frac{\pi(1+(0.5)^3-(0.6)^3)}{4} \right) + \sin \left(\frac{\pi(1-(0.5)^3+(0.6)^3)}{4} \right) - 1 \right) + \frac{1}{\sqrt{2}-1} \left(\sin \left(\frac{\pi(1+(0.3)^3-(0.5)^3)}{4} \right) + \sin \left(\frac{\pi(1-(0.3)^3+(0.5)^3)}{4} \right) - 1 \right) + \dots + \frac{1}{\sqrt{2}-1} \left(\sin \left(\frac{\pi(1+(0.3)^3-(0.5)^3)}{4} \right) + \sin \left(\frac{\pi(1-(0.3)^3+(0.5)^3)}{4} \right) - 1 \right).$$

$$\mathcal{E}_t^1((\mathcal{A}^\ell)^{(1)}) = (18.4257)$$

Similarly, we can get, $\mathcal{E}_t^1((\mathcal{A}^\ell)^{(2)}) = 18.4802$ and $\mathcal{E}_t^1((\mathcal{A}^\ell)^{(3)}) = 18.3896$

Step 3: From the above results we can arrange them as $\mathcal{E}_t^1((\mathcal{A}^\ell)^{(3)}) < \mathcal{E}_t^1((\mathcal{A}^\ell)^{(1)}) < \mathcal{E}_t^1((\mathcal{A}^\ell)^{(2)})$.

Step 4: We can observe that $(\mathcal{A}^\ell)^{(2)}$ is the best alternative.

5 | COMPARATIVE ANALYSIS

This part of the manuscript is devoted to delivering the comparison of the initiated structure with some existing literature to show the helpfulness and trustworthiness of the introduced ideas. We will contrast the delivered ideas with [36], [37], and [38].

Example 3: Let $(\mathcal{A}^\ell)^{(1)}$, $(\mathcal{A}^\ell)^{(2)}$ and $(\mathcal{A}^\ell)^{(3)}$ be the three PyFSS. Suppose these three sets have been elaborated by three experts corresponding to three parameters whose rating values are summed up in the shape of IFSS as follows

$$((\mathcal{A}^\ell)^1, P^*) = \begin{pmatrix} (0.2, 0.4) & (0.1, 0.5) & (0.1, 0.1) \\ (0.1, 0.3) & (0.6, 0.2) & (0.3, 0.4) \\ (0.3, 0.3) & (0.3, 0.5) & (0.5, 0.3) \end{pmatrix}$$

$$((\mathcal{A}^\ell)^2, P^*) = \begin{pmatrix} (0.3, 0.2) & (0.2, 0.5) & (0.7, 0.1) \\ (0.2, 0.2) & (0.4, 0.2) & (0.6, 0.3) \\ (0.4, 0.1) & (0.4, 0.5) & (0.3, 0.4) \end{pmatrix}$$

$$((\mathcal{A}^\ell)^3, P^*) = \begin{pmatrix} (0.1, 0.4) & (0.1, 0.6) & (0.4, 0.4) \\ (0.2, 0.3) & (0.6, 0.3) & (0.5, 0.4) \\ (0.4, 0.3) & (0.7, 0.2) & (0.1, 0.3) \end{pmatrix}$$

As we know that PyFSS is a more general notion than that of IFSS. Now we use the introduced entropy measure on the above-given data and calculate their results. We also compare these results with existing measures given in [36], [37], and [38]. These existing measures are given as follows.

$$\mathcal{E}_t^1(\mathcal{A}^\ell)[36] = \sum_{j'=1}^{m_s} \sum_{i'=1}^{n_s} \left(1 - \mathcal{M}^{\circ} \mathbb{F}(p_{j'}) (v_{i'}) - N^{\circ} \mathbb{F}(p_{j'}) (v_{i'}) \right),$$

$$\begin{aligned}\mathcal{E}_t^2(\mathcal{A}^\ell)[36] &= \sum_{j'=1}^{m_\circ} \sum_{i'=1}^{n_\circ} \left(1 - \mathcal{M}^\circ_{\mathfrak{F}(p_{j'})}(v_{i'}) - N^\circ_{\mathfrak{F}(p_{j'})}(v_{i'}) \right) e^{\left(1 - \mathcal{M}^\circ_{\mathfrak{F}(p_{j'})}(v_{i'}) - N^\circ_{\mathfrak{F}(p_{j'})}(v_{i'}) \right)}, \\ \mathcal{E}_t^3(\mathcal{A}^\ell)[37] &= \sum_{j'=1}^{m_\circ} \sum_{i'=1}^{n_\circ} \left(1 - \mathcal{M}^{\circ 3}_{\mathfrak{F}(p_{j'})}(v_{i'}) - N^{\circ 3}_{\mathfrak{F}(p_{j'})}(v_{i'}) \right), \\ \mathcal{E}_t^4(\mathcal{A}^\ell)[37] &= \sum_{j'=1}^{m_\circ} \sum_{i'=1}^{n_\circ} \left(1 - \mathcal{M}^{\circ 4}_{\mathfrak{F}(p_{j'})}(v_{i'}) - N^{\circ 4}_{\mathfrak{F}(p_{j'})}(v_{i'}) \right), \\ \mathcal{E}_t^5(\mathcal{A}^\ell)[38] &= \frac{1}{\sqrt{2}-1} \sum_{j'=1}^{m_\circ} \sum_{i'=1}^{n_\circ} \left(\sin \left(\frac{\pi \left(1 + \mathcal{M}^{\circ 2}_{\mathfrak{F}(p_{j'})}(v_{i'}) - N^{\circ 2}_{\mathfrak{F}(p_{j'})}(v_{i'}) \right)}{4} \right) \right. \\ &\quad \left. + \sin \left(\frac{\pi \left(1 - \mathcal{M}^{\circ 2}_{\mathfrak{F}(p_{j'})}(v_{i'}) + N^{\circ 2}_{\mathfrak{F}(p_{j'})}(v_{i'}) \right)}{4} \right) - 1 \right).\end{aligned}$$

The overall results of these theories have been proposed in Table 5.

Table 5. Comparative analysis of proposed work

Methods	$(\mathcal{A}^\ell)^1$	$(\mathcal{A}^\ell)^2$	$(\mathcal{A}^\ell)^3$
$\mathcal{E}_t^1[36]$	3.5	3.0	2.7
$\mathcal{E}_t^2[36]$	5.8013	4.6137	4.1275
$\mathcal{E}_t^3[37]$	8.099	7.812	7.653
$\mathcal{E}_t^4[37]$	8.5795	8.3704	8.2743
$\mathcal{E}_t^5[38]$	8.7506	8.5816	8.5369
Introduced work	8.9119	8.8117	8.7850

From the analysis of above Table 5, we see that existing notions along with introduced work can deal with intuitionistic fuzzy soft data that show the generality of initiated work. Moreover, the geometrical presentation of data given in Table 5 is given in Figure 2.

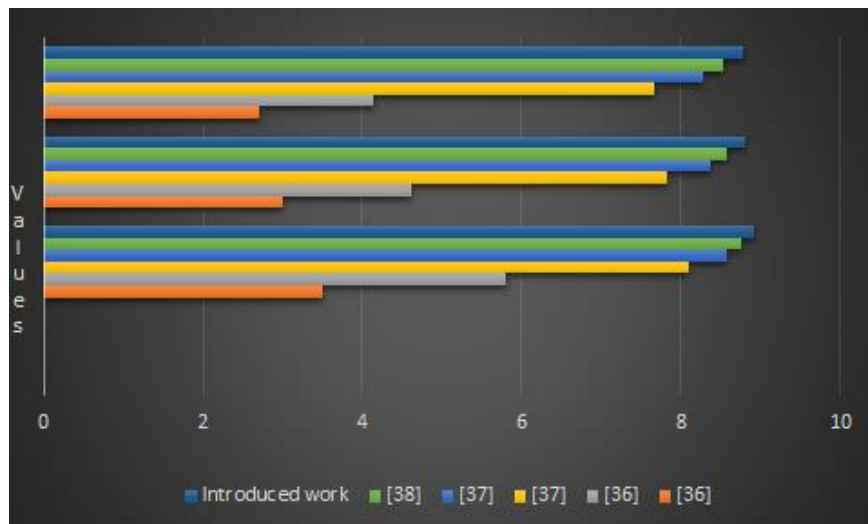


Figure 2. Graphical presentation of data given in Table 5

Example 4: Let $(\mathcal{A}^\ell)^{(1)}$, $(\mathcal{A}^\ell)^{(2)}$ and $(\mathcal{A}^\ell)^{(3)}$ be the three PyFSS. Suppose these three sets have been elaborated by three experts corresponding to three parameters whose rating values are summed up in the shape of PyFSS as follows

$$\begin{aligned} ((\mathcal{A}^\ell)^1, P^*) &= \begin{pmatrix} (0.6, 0.4) & (0.3, 0.8) & (0.5, 0.6) \\ (0.7, 0.5) & (0.9, 0.4) & (0.3, 0.6) \\ (0.6, 0.6) & (0.7, 0.5) & (0.5, 0.7) \end{pmatrix} \\ ((\mathcal{A}^\ell)^2, P^*) &= \begin{pmatrix} (0.9, 0.4) & (0.2, 0.5) & (0.2, 0.9) \\ (0.5, 0.6) & (0.6, 0.2) & (0.1, 0.8) \\ (0.6, 0.5) & (0.6, 0.7) & (0.8, 0.4) \end{pmatrix} \\ ((\mathcal{A}^\ell)^3, P^*) &= \begin{pmatrix} (0.3, 0.4) & (0.6, 0.6) & (0.5, 0.3) \\ (0.8, 0.3) & (0.6, 0.7) & (0.7, 0.2) \\ (0.4, 0.7) & (0.7, 0.5) & (0.9, 0.1) \end{pmatrix} \end{aligned}$$

The overall results of these theories have been proposed in Table 6.

Table 6. Comparative analysis of proposed work

Methods	$(\mathcal{A}^\ell)^1$	$(\mathcal{A}^\ell)^2$	$(\mathcal{A}^\ell)^3$
$\mathcal{E}_t^1[36]$	Failed	Failed	Failed
$\mathcal{E}_t^2[36]$	Failed	Failed	Failed
$\mathcal{E}_t^3[37]$	4.363	4.783	5.271
$\mathcal{E}_t^4[37]$	5.723	5.866	6.382
$\mathcal{E}_t^5[38]$	7.928	7.112	7.598
Introduced work	8.045	7.436	7.934

From Table 6 we can note that entropy measures proposed in [36] can only deal with IFS data while data presented in Table 6 is based on PyFS numbers so developed entropy measures given in [36] cannot PyFS information. While existing notions given in [37] and [38] can deal with the data presented in Table 6 along with the introduced work. So proposed work is more efficient than existing techniques. The graphical presentation of data proposed in Table 6 is given in Figure 3.

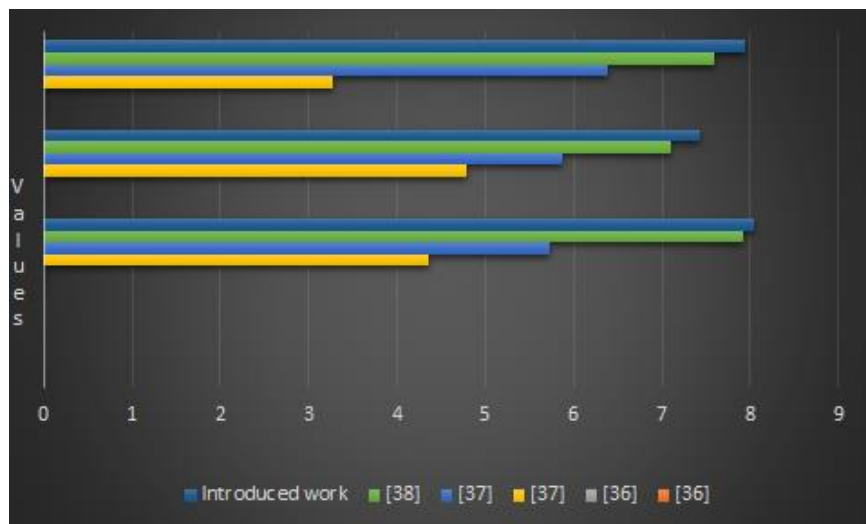


Figure 3. Graphical presentation of data given in Table 6

6 | CONCLUSION

As q-ROFSS is a more dominant notion than that of IFSS and PyFSS. Also, it provides more room for decision-makers for the presentation of data in many DM problems. So relying on q-ROFSS, in this article, we have introduced some new entropy measures. Moreover, the properties of these developed notions have been discussed. To produce the application of this newly initiated work, we have established an algorithm based on the initiated entropy measures. Moreover, to show the working of the developed notion we have discussed the numerical examples to support the initiated work. Moreover, a contrast study of the delivered work with some other existing literature shows the authenticity and usefulness of the developed notion.

In future directions, we can extend these theories to the bipolar soft set introduced in [40]. Also, we can extend this theory to a T-spherical fuzzy set [41]. Moreover, some new theories can be developed like aggregation operators as given in [42, 43]. Also, we can extend these notions to bipolar complex fuzzy sets [44].

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