EXPLORING QUADRASOPHIC FUZZY SET: APPLICATIONS IN ASSESSING STRESS LEVELS AND SELF-ESTEEM CONNECTIONS

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Abstract

The ambiguous environment has been addressed with a variety of fuzzy sets and their extensions. The Quadrasophic Fuzzy Set is one of the generalization of Fuzzy set to handle imprecise information efficiently. It is defined with two new parameters. In this artifact, we defined the operations, theorems, and relations of the Quadrasophic Fuzzy Set with pertinent examples. We also established a comparison study with other existing models. Additionally, the integration of Quadrasophic Fuzzy data with the TOPSIS approach to solve the Multi Criteria Decision Making problem is proposed and illustrated by examining the relationship between employee stress levels and their self-esteem, which can trigger obsessive-compulsive disorder, using real-life data. The results are analyzed with SPSS software.

Keywords: Quadrasophic Fuzzy set, Quadrasophic Fuzzy Relation, Max-Min Composition, Decision making

1. Introduction

Fuzzy set and its extensions are helpful to handle the uncertain situations. One of the fuzzy set extensions is an Intuitionistic fuzzy set (IFS) .The framework of the conception Intuitionistic fuzzy set makes us to analyze the uncertain environment. IFS presents the sum of membership degree and the non-membership degree is less than one [5] ,[21]. The IFS has its wide range applications in many real life situations inbuilt with uncertainty. Also, the idea of IFS has been applied in different areas such as medication, business, decision making [9] [19].

For a case, if the sum of degrees of membership grade and non membership grade is not less than one,then the IFS cannot be applicable. To overcome the shortcoming exists in IFS, the concept of Pythagorean fuzzy set is established by R. Yager [21]. In Pythagorean fuzzy set, the sum of squares of membership degree and non membership degree lies between zero and one. Even though PFS is the extension of fuzzy set it has similar feature of IFS. Many researchers widened the theoretical concept of PFS [22] .PFS's special form to handle imprecise data provoked several authors to extend numerous operators in PFS and applied in various fields [1].

Bipolar fuzzy set represents the set with satisfaction level of property which ranges in [0, 1] and satisfaction level of implicit counter property ranges in [-1, 0] [23] [24].Bipolar can handle the situations characterized by positive and negative membership without hesitant. Several author extended the Bipolar idea [7] and applied in many fields to handle the bipolarity situation [14], [17],[15], [16] .The idea of neutrality was initially presented in Picture Fuzzy set. Picture fuzzy set represents positive, negative and neutral grade ranges in [0, 1] [8]. Picture fuzzy set has its vibrant applications in many fields including Artificial intelligence, medication, business, neutral networks and data coding. Neutrosophic fuzzy set presents the three aspects such as truthiness, falsity and the indeterminancy whose sum lies between one and three [6], [20] .There exist many extensions of fuzzy set and many blended fuzzy theoretical idea like bipolar picture fuzzy set [18] , neutrosophic- bipolar fuzzy set [13] to tackle the imprecision information. Along with polarity, indecisiveness and the influence of environment cannot be found with the existing extensions of fuzzy sets. The membership and non-membership divisions will not aid us in determining a definitive answer to the underlying issue. New parameters are needed to determine the absolute solution. The influential rate that altered the membership and non-membership ranges can result in new parameters. Further dimensions are produced by analyzing the influential rates that alter the membership and non-membership ranges. The modern analysis of membership grades results in two new memberships. Hence, Quadrasophic Fuzzy Set is defined with four membership functions [3], [4].

In this artifact, Section 2 provides some basic concepts of fuzzy sets. Section 3 presents the properties and definitions of QFS whereas in section 4 gives the operations, relations and advantages of Quadrasophic Fuzzy Model. To promote the validation results of QFS section 5 presents the comparative study with illustration in medical diagonsis.Using the Max-Min composition of QFS, Section 6 demonstrates how QFS may be applied to ascertain the relationship between self-esteem and stress levels that cause OCD. Section 7 emphasizes the significance of Quadrasophic Fuzzy Set (QFS) in analyzing the environmental impact through statistical analysis using SPSS. Finally, section 8 gives the conclusion of QFS with its scope for future research.

2. Preliminaries

Fuzzy sets [11]: A non-empty fuzzy set F in the universe U is defined as $F = \{(x, \mu(x)) : x \in X\}$ where $\mu(x) \in [0,1]$ is the degree of membership value of F.

Intuitionistic Fuzzy sets [11]: An intuitionistic fuzzy set I in the non-empty set X is defined as $I = \{(x, \mu(x), \nu(x); x \in X)\}$ where the function $\mu(x), \nu(x) : X \to [0,1]$ represents the membership degree and the non- membership degree value with the condition $0 \leq \mu(x) + \nu(x) \leq 1$. The value $\pi(x) = 1 - \mu(x) - \nu(x)$ is named as the degree of indeterminacy $\forall x \in X$.

Pythagorean Fuzzy set [21]: A Pythagorean fuzzy set P, is defined as $P = \{(x, \mu(x), \nu(x); x \in X\}$ where the function $\mu(x), \nu(x)$:$X \to [0,1]$ represents the membership degree and the non- membership degree value with the condition $0 \leq \mu_P^2(x) + \nu_P^2(x) \leq 1$. The value $\pi_P(x) = \sqrt{1 - (\mu_P^2(x) - \nu_P^2(x))}$ is named as the degree of indeterminacy for $\forall x \in X$.

Quadrasophic fuzzy set [3]: The Quadrasophic fuzzy set q on the set U is defined as

$$q = \{(x, \eta_q(x), \lambda_{\eta_q}(x), \lambda_{\mu_q}(x), \mu_q(x)) | x \in U\}$$

where the degree of positive membership grade is $\mu_q(x) : U \to [0,1]$, the degree of negative membership is $\eta_q(x) : U \to [-1,0]$ the degree of restricted positive membership is $\lambda_{\mu_q}(x) : U \to [0,0.5]$ the degree of restricted negative membership is $\lambda_{\eta_q}(x) : U \to [-0.5,0]$ And the condition follows: $-1 \leq \mu_q(x) + \eta_q(x) \leq 1$, $-0.5 \leq \lambda_q \leq 0.5$ and $0 \leq \mu_q^2 + \eta_q^2 + \lambda_q^2 \leq 3$ for all $x \in U$, such that $\lambda_q =$ Length of $(\lambda_{\mu_q}, \lambda_{\eta_q})$.

Max-Min-Max composition [9]: Let $A(x \to y)$ and $B(y \to z)$ be any to IF relations. Then the Max-min- Max composition of as $A \circ B$ from x to z, whose membership functions and non membership functions are represented as follows: $\nu_{B \circ A}(x,z) = \wedge_y[\nu_A(x,y), \nu_B(y,z)]$, $\mu_{B \circ A}(x,z) = \vee_y[\mu_A(x,y), \mu_B(y,z)]$ for all $x \in X, y \in Y, (x,y) \in X \times Y$ where $\wedge = min$, $\vee = max$.

Score Function [12]: Let $P = (x, \mu_P(x), \nu_P(x); x \in X)$ be the PFS in the non-empty set X. Then, the score- valued function of PFS is defined as score $(P) = (\mu_P(x))^2 - (\nu_P(x))^2$, where score$(P) \in [-1, 1]$.

3. Quadrasophic Fuzzy Sets

A Quadrasophic fuzzy set (QFS) is a fuzzy set intended to address environmental impact rates. It aims to attain the "restricted level" in both positive and negative polarity, where the rate at which a condition or implicit counter condition is partially satisfied is known as the "reluctant value."

The complex structure of the set will not be disclosed by the degree of satisfaction property and its implicit counter-property. Furthermore, it must be evident which subgroups exhibit varying degrees of reluctance on both the positive and negative sides. The partial counter implicit property has a level of tentative fixation of [-0.5, 0], whereas the partial satisfaction property has a level of [0, 0.5]. The subset explains how the level of ambiguity or influence impacts the satisfaction rate in the property and explicit counter-property.

The refusal of the positive and negative membership grades is referred to as "restrictive positive membership" and "restrictive negative membership," respectively. Restricted positive and restricted negative membership are two additional memberships that we examine in addition to positive and negative membership to obtain more accurate findings [3]. The margin for restricted membership is located at the crossover point. Restricted membership allows us to provide more precise results by determining the impact range.

Quadrasophic Fuzzy Set: [3] The Quadrasophic fuzzy set (QFS) defined on X is represented as

$$Q = \{(x, \eta(x), \lambda_\eta(x), \lambda_\mu(x), \mu(x)) \,|\, x \in X\}$$

In Q, $\mu(x) : X \to [0, 1]$ represents the degree of positive membership of x , $\eta(x) : X \to [-1, 0]$ represents the degree of negative membership of x, $\lambda_\mu(x) : X \to [0, 0.5]$ represents the degree of restricted positive membership of x ,$\lambda_\eta(x) : X \to [-0.5, 0]$ represents the degree of restricted negative membership of x. The inequality $-1 \leq \mu(x) + \eta(x) \leq 1$, $-0.5 \leq \lambda \leq 0.5$ and $0 \leq \mu^2 + \eta^2 + \lambda^2 \leq 3$ holds for every $x \in X$, where $\lambda =$ Length of $(\lambda_\mu, \lambda_\eta)$.
The term $QFS(x)$ refers to the set of all Quadrasophic Fuzzy Set on X.

Remark 1. If $\mu(x) \neq 0$, $\eta(x) = \lambda_\mu(x) = \lambda_\eta(x) = 0$ then Q is a fuzzy set of the form $< x, \mu(x) >$.

3.1. Properties of Quadrasophic Fuzzy Sets

Properties:

1. If $\mu(x) \neq 0, \eta(x) \neq 0, \lambda_\mu(x) = \lambda_\eta(x) = 0$ then Q reduces to a bipolar fuzzy set.
2. If $\mu(x) \neq 0, \eta(x) = 0, \lambda_\mu(x) = \lambda_\eta(x) = 0$ then Q is a high positive membership.
3. If $\mu(x) = 0, \eta(x) \neq 0, \lambda_\mu(x) = \lambda_\eta(x) = 0$ then Q is a high negative membership.
4. If $\mu(x) \neq 0, \lambda_\mu(x) \neq 0, \eta(x) = \lambda_\eta(x) = 0$ then Q is a restricted positive membership.
5. If $\mu(x) = 0, \lambda_\mu(x) = 0, \eta(x) \neq, \lambda_\eta(x) \neq 0$ then Q is a restricted negative membership.
6. If $\mu(x) \neq 0, \eta(x) \neq 0, \lambda_\mu(x) \neq 0, \lambda_\eta(x) \neq 0$ then it is Quadrasophic fuzzy set.

Remark 2. The empty Quadrasophic fuzzy set is defined as $Q_0 = (0, 0, 0, 0)$ and complete Quadrasophic fuzzy set is defined as $Q_1 = (-1, -0.5, 0.5, 1)$ for each $x \in X$.

Subset [3]: Let $Q_1, Q_2 \in Q$ defined on the non - empty set X then Q_1 is the subset of Q_2 denoted by $Q_1 \subseteq Q_2$, if for each $x \in X$; $\eta_{Q_1}(x) \geq \eta_{Q_2}(x)$, $\lambda_{\eta Q_1}(x) \geq \lambda_{\eta Q_2}(x)$, $\lambda_{\mu Q_1}(x) \leq \lambda_{\mu Q_2}(x)$, $\mu_{Q_1}(x) \leq \mu_{Q_2}(x)$.

Complement of Quadrasophic Fuzzy Set[3]: The complement of the set $Q_1 \in Q$ in X is represented as Q_1^C and is defined as $Q_1^C = (\eta^C, \lambda_\eta^C, \lambda_\mu^C, \mu^C)$, where $\eta^C = -1 - \eta$, $\lambda_\eta^C = -0.5 - \lambda_\eta$, $\lambda_\mu^C = 0.5 - \lambda_\mu$ and $\mu^C = 1 - \mu$.

Intersection and Union of QFS [3]: The intersection of Q_1 and Q_2 in Quadrasophic Fuzzy Set is defined as:

$$Q_1 \cap Q_2 = (\eta_{Q_1}(x) \vee \eta_{Q_2}(x), \lambda_{\eta_{Q_1}}(x) \vee \lambda_{\eta_{Q_2}}(x), \lambda_{\mu_{Q_1}}(x) \wedge \lambda_{\mu_{Q_2}}(x), \mu_{Q_1}(x) \wedge \mu_{Q_2}(x)), \forall x \in X.$$

The union of Q_1 and Q_2 in Quadrasophic fuzzy set is defined as:

$$Q_1 \cup Q_2 = (\eta_{Q_1}(x) \wedge \eta_{Q_2}(x), \lambda_{\eta_{Q_1}}(x) \wedge \lambda_{\eta_{Q_2}}(x), \lambda_{\mu_{Q_1}}(x) \vee \lambda_{\mu_{Q_2}}(x), \mu_{Q_1}(x) \vee \mu_{Q_2}(x)), \forall x \in X.$$

Equal Set[3]: Let $Q_1, Q_2 \in Q$ defined on the non empty set X then Q_1 is equal to Q_2 denoted by $Q_1 = Q_2$ if for each $x \in X$;

$$\eta_{Q_1}(x) = \eta_{Q_2}(x), \lambda_{\eta_{Q_1}}(x) = \lambda_{\eta_{Q_2}}(x), \lambda_{\mu_{Q_1}}(x) = \lambda_{\mu_{Q_2}}(x), \mu_{Q_1}(x) = \mu_{Q_2}(x).$$

4. Certain operations on Quadrasophic Fuzzy Sets

Theorem 1. Let $Q_1, Q_2, Q_3 \in Q$ then it satisfy the following properties.
i) $Q_1 \subseteq Q_2$, $Q_2 \subseteq Q_3$ then $Q_1 \subseteq Q_3$.
ii) The operations intersection and union are commutative.
iii) The operations intersection and union are distributive.
iv) The operations intersection and union are associative.
v) The operations intersection and union satisfies the De-Morgan's rule.

Proof. i) By using the Subset definition , $Q_1 \subseteq Q_2$ if $\eta_{Q_1}(x) \geq \eta_{Q_2}(x)$, $\lambda_{\eta_{Q_1}}(x) \geq \lambda_{\eta_{Q_2}}(x)$, $\lambda_{\mu_{Q_1}}(x) \leq \lambda_{\mu_{Q_2}}(x)$, $\mu_{Q_1}(x) \leq \mu_{Q_2}(x)$. If $Q_2 \subseteq Q_3$ then $\eta_{Q_2}(x) \geq \eta_{Q_3}(x)$, $\lambda_{\eta_{Q_2}}(x) \geq \lambda_{\eta_{Q_3}}(x)$, $\lambda_{\mu_{Q_2}}(x) \leq \lambda_{\mu_{Q_3}}(x)$, $\mu_{Q_2}(x) \leq \mu_{Q_3}(x)$.
Then, obviously $Q_1 \subseteq Q_3$.

ii) By the definition of Intersection,

$$Q_1 \cap Q_2 = \{max(\eta_{Q_1}(x), \eta_{Q_2}(x)), max(\lambda_{\eta_{Q_1}}(x), \lambda_{\eta_{Q_2}}(x)), min(\lambda_{\mu_{Q_1}}(x), \lambda_{\mu_{Q_2}}(x)), min(\mu_{Q_1}(x), \mu_{Q_2}(x))\}$$

$$Q_2 \cap Q_1 = \{max(\eta_{Q_2}(x), \eta_{Q_1}(x)), max(\lambda_{\eta_{Q_2}}(x), \lambda_{\eta_{Q_1}}(x)), min(\lambda_{\mu_{Q_2}}(x), \lambda_{\mu_{Q_1}}(x)), min(\mu_{Q_2}(x), \mu_{Q_1}(x))\}$$

Therefore, $Q_1 \cap Q_2 = Q_2 \cap Q_1$.
In similar way, we show $Q_1 \cup Q_2 = Q_2 \cup Q_1$.
iii)

$$Q_2 \cap Q_3 = \{max(\eta_{Q_2}(x), \eta_{Q_3}(x)), max(\lambda_{\eta_{Q_2}}(x), \lambda_{\eta_{Q_3}}(x)), min(\lambda_{\mu_{Q_2}}(x), \lambda_{\mu_{Q_3}}(x)), min(\mu_{Q_2}(x), \mu_{Q_3}(x))\}$$

$$\begin{aligned} Q_1 \cup (Q_2 \cap Q_3) = (& [min\{\eta_{Q_1}(x), max(\eta_{Q_2}(x), \eta_{Q_3}(x))\}], \\ & [min\{\lambda_{\eta_{Q_1}}(x), max(\lambda_{\eta_{Q_2}}(x), \lambda_{\eta_{Q_3}}(x))\}], \\ & [max\{\lambda_{\mu_{Q_1}}(x), min(\lambda_{\mu_{Q_2}}(x), \lambda_{\mu_{Q_3}}(x))\}], \\ & [max\{\mu_{Q_1}(x), min(\mu_{Q_2}(x), \mu_{Q_3}(x))\}]). \end{aligned}$$

$$\begin{aligned} Q_1 \cup Q_2 = \{ & min(\eta_{Q_1}(x), \eta_{Q_2}(x)), min(\lambda_{\eta_{Q_1}}(x), \lambda_{\eta_{Q_2}}(x)), \\ & max(\lambda_{\mu_{Q_1}}(x), \lambda_{\mu_{Q_2}}(x)), max(\mu_{Q_1}(x), \mu_{Q_2}(x))\} \end{aligned}$$

$$\begin{aligned} Q_1 \cup Q_3 = \{ & min(\eta_{Q_1}(x), \eta_{Q_3}(x)), min(\lambda_{\eta_{Q_1}}(x), \lambda_{\eta_{Q_3}}(x)), \\ & max(\lambda_{\mu_{Q_1}}(x), \lambda_{\mu_{Q_3}}(x)), max(\mu_{Q_1}(x), \mu_{Q_3}(x))\} \end{aligned}$$

$$\begin{aligned} (Q_1 \cup Q_2) \cap (Q_1 \cup Q_3) = (& [max\{min(\eta_{Q_1}(x), \eta_{Q_2}(x)), min(\eta_{Q_1}(x), \eta_{Q_3}(x))\}], \\ & [max\{min(\lambda_{\eta_{Q_1}}(x), \lambda_{\eta_{Q_2}}(x)), min(\lambda_{\eta_{Q_1}}(x), \lambda_{\eta_{Q_3}}(x))\}], \\ & [min\{max(\lambda_{\mu_{Q_1}}(x), \lambda_{\mu_{Q_2}}(x)), max(\lambda_{\mu_{Q_1}}(x), \lambda_{\mu_{Q_3}}(x))\}], \\ & [min\{max(\mu_{Q_1}(x), \mu_{Q_2}(x)), max(\mu_{Q_1}(x), \mu_{Q_3}(x))\}]). \end{aligned}$$

Hence, $Q_1 \cup (Q\neg_2 \cap Q_3) = (Q_1 \cup Q_2) \cap (Q_1 \cup Q_3)$.
In similar way we can prove, $Q_1 \cap (Q\neg_2 \cup Q_3) = (Q_1 \cap Q_2) \cup (Q_1 \cap Q_3)$.
iv)

$$\begin{aligned} Q_1 \cup Q_2 = \{ & min(\eta_{Q_1}(x), \eta_{Q_2}(x)), min(\lambda_{\eta_{Q_1}}(x), \lambda_{\eta_{Q_2}}(x)), \\ & max(\lambda_{\mu_{Q_1}}(x), \lambda_{\mu_{Q_2}}(x)), max(\mu_{Q_1}(x), \mu_{Q_2}(x))\} \end{aligned}$$

$$\begin{aligned} Q_1 \cup (Q_2 \cup Q_3) = (& [min\{min(\eta_{Q_1}(x), \eta_{Q_2}(x)), \eta_{Q_3}(x)\}], \\ & [min\{min(\lambda_{\eta_{Q_1}}(x), \lambda_{\eta_{Q_2}}(x)), \lambda_{\eta_{Q_3}}(x)\}], \\ & [max\{max(\lambda_{\mu_{Q_1}}(x), \lambda_{\mu_{Q_2}}(x)), \lambda_{\mu_{Q_3}}(x)\}], \\ & [max\{max(\mu_{Q_1}(x), \mu_{Q_2}(x)), \mu_{Q_3}(x)\}]). \end{aligned}$$

$$\begin{aligned} Q_2 \cup Q_3 = \{ & min(\eta_{Q_2}(x), \eta_{Q_3}(x)), min(\lambda_{\eta_{Q_2}}(x), \lambda_{\eta_{Q_3}}(x)), \\ & max(\lambda_{\mu_{Q_2}}(x), \lambda_{\mu_{Q_3}}(x)), max(\mu_{Q_2}(x), \mu_{Q_3}(x))\} \end{aligned}$$

$$\begin{aligned} Q_1 \cup (Q_2 \cup Q_3) = (& [min\{\eta_{Q_1}(x), min(\eta_{Q_2}(x), \eta_{Q_3}(x))\}], \\ & [min\{\lambda_{\eta_{Q_1}}(x), min(\lambda_{\eta_{Q_2}}(x), \lambda_{\eta_{Q_3}}(x))\}], \\ & [max\{\lambda_{\mu_{Q_1}}(x), max(\lambda_{\mu_{Q_2}}(x), \lambda_{\mu_{Q_3}}(x))\}], \\ & [max\{\mu_{Q_1}(x), max(\mu_{Q_2}(x), \mu_{Q_3}(x))\}]). \end{aligned}$$

Hence, $(Q_1 \cup Q_2) \cup Q_3 = Q_1 \cup (Q_2 \cup Q_3)$.
In this way, we can prove $(Q_1 \cap Q_2) \cap Q_3 = Q_1 \cap (Q_2 \cap Q_3)$.

iv) By using definition, we can prove
$\overline{Q_1 \cup Q_2} = \overline{Q_1} \cap \overline{Q_1}$ and $\overline{Q_1 \cap Q_2} = \overline{Q_1} \cup \overline{Q_2}$. ■

Theorem 2. Let $Q_1, Q_2, Q_3 \in Q$ then the result would be as follows:

1. Law of Idempotent: $Q_1 \cup Q_1 = Q_1 \cap Q_1 = Q_1$.
2. Law of Absorption: $Q_1 \cup (Q_1 \cap Q_2) = Q_1, Q_1 \cap (Q_1 \cup Q_2) = Q_1$.
3. $(Q_1^C)^C = Q_1$.
4. $Q_1 \cap Q_2 \subset Q_1 \, and \, Q_1 \cap Q_2 \subset Q_2$.
5. $Q_1 \subset Q_1 \cup Q_2 \, and \, Q_2 \subset Q_1 \cup Q_2$.
6. $If \, Q_1 \subset Q_2 \, and \, Q_2 \subset Q_3 \, then \, Q_1 \subset Q_3$.
7. $If \, Q_1 \subset Q_2 \, then \, Q_1 \cap Q_3 \subset Q_2 \cap Q_3 \, and \, Q_1 \cup Q_3 \subset Q_2 \cup Q_3$.

Proof. By using Theorem 1 and definitions of Quadrasophic Fuzzy Set, the results are obvious. ■

Generalization of Intersection and Union: Let X be a non- empty set and let $(Q_s)_{s\in Q} \subset Q$.
i) The intersection of $(Q_s)_{s\in Q}$ denoted by $(\cap_{s\in Q} Q_s)$ in a Quadrasophic fuzzy set is defined as,

$$(\cap_{s\in Q} Q_s)(x) = \{max_{s\in Q}\, \eta_s(x), max_{s\in Q}\, \lambda_{\eta s}(x), \\ min_{s\in Q}\, \lambda_{\mu s}(x), min_{s\in Q}\, \mu_s(x)\}, \forall x \in X.$$

ii) The union of $(Q_s)_{s\in Q}$ denoted by $(\cap_{s\in Q} Q_s)$ in a Quadrasophic fuzzy set is defined as,

$$(\cup_{s\in Q} Q_s)(x) = \{min_{s\in Q}\, \eta_s(x), min_{s\in Q}\, \lambda_{\eta s}(x), \\ max_{s\in Q} \lambda_{\mu s}(x), max_{s\in Q}\, \mu_s(x)\}, \forall x \in X.$$

Generalization of Laws: Let $(Q_s)_{s\in Q} \subset Q$ be defined in the non empty set X,
i) Generalization of Distributive laws:

$$Q \cap (\cup_{s\in Q} Q_s)(x) = \cup_{s\in Q}(Q \cap Q_s)$$

ii) Generalization of De-Morgan's law:

$$(\cup_{s\in Q} Q_s)^C(x) = (\cap_{s\in Q} Q_s^C)$$
$$(\cap_{s\in Q} Q_s)^C(x) = (\cup_{s\in Q} Q_s^C).$$

Measures of Distance: 1. The normalized Hamming distance between any QFS set $Q_1, Q_2 \in Q(x)$ is defined as,

$$d_{Qh}(Q_1, Q_2) = \frac{1}{2n}\sum_{i=1}^{n}[\left|\eta_{Q_1}(x_i))^2 - (\eta_{Q_2}(x_i))^2\right| + \left|(\lambda_{\eta_{Q_1}}(x_i))^2 - (\lambda_{\eta_{Q_2}}(x_i))^2\right| \\ + \left|(\lambda_{\mu_{Q_1}}(x_i))^2 - (\lambda_{\mu_{Q_2}}(x_i)))^2\right| + \left|(\mu_{Q_1}(x_i))^2 - \mu_{Q_2}(x_i))^2\right|].$$

2. The normalized Euclidean distance between any QFS set $Q_1, Q_2 \in Q(x)$ is defined as,

$$d_{Qh}(Q_1, Q_2) = \sqrt{\frac{1}{2n}\sum_{i=1}^{n}[\eta_{Q_1}(x_i))^2 - (\eta_{Q_2}(x_i))^2]^2 + [](\lambda_{\eta_{Q_1}}(x_i))^2 - (\lambda_{\eta_{Q_2}}(x_i))^2]^2 \\ +[(\lambda_{\mu_{Q_1}}(x_i))^2 - (\lambda_{\mu_{Q_2}}(x_i)))^2]^2 + [(\mu_{Q_1}(x_i))^2 - \mu_{Q_2}(x_i))^2]^2}$$

Quadrasophic Fuzzy Relation: A subset of the Quadrasophic fuzzy set $X \times Y$ is the Quadrasophic fuzzy relation R represented by $R = \{(x, y,), \eta_R(x, y), \lambda_{\eta_R}(x, y), \lambda_{\mu_R}(x, y), \mu_R(x, y) | x \in X, y \in Y\}$ where,

$$\eta_R(x) : X \to [-1,0]$$
$$\lambda_{\eta R}(x) : X \to [-0.5,0]$$
$$\lambda_{\mu R}(x) : X \to [0,0.5]$$
$$\mu_R(x) : X \to [0,1]$$

satisfy the conditions for all $(x,y) \in (X \times Y)$, $-1 \leq \mu_R(x) + \eta_R(x) \leq 1$, $-0.5 \leq \lambda_R \leq 0.5$ and $0 \leq \mu_R^2 + \eta_R^2 + \lambda_R^2 \leq 3$ where $\lambda_R =$ Length of $(\lambda_{\mu R}, \lambda_{\eta R})$. Let $QFR(X \times Y)$ denotes the set of all Quadrasophic fuzzy relation on X.

Max-Min-Max Function: If $Q_1, Q_2 \in QFS(X)$ are two QFR and $Q_1(x \to y)$, $Q_2(y \to z)$. Then, max-min-max composition as $Q_1 \circ Q_2$ from x to z, whose membership functions are represented as follows:
$\eta_{Q_2 \circ Q_1}(x,z) = \wedge_y max[\eta_{Q_1}(x,y), \eta_{Q_2}(y,z)]$
$\lambda_{\eta_{Q_2 \circ Q_1}}(x,z) = \wedge_y max[\lambda_{\eta_{Q_1}}(x,y), \lambda_{\eta_{Q_2}}(y,z)]$
$\lambda_{\mu_{Q_2 \circ Q_1}}(x,z) = \vee_y min[\lambda_{\mu Q_1}(x,y), \lambda_{\mu_{Q_2}}(y,z)]$
$\eta_{Q_2 \circ Q_1}(x,z) = \vee_y min[\mu_{Q_1}(x,y), \mu_{Q_2}(y,z)]$
$\forall x \in X, y \in Y$, $(x,y) \in X \times Y$ where $\wedge = min$, $\vee = max$.

Score value function: Let $Q = (x, \eta(x), \lambda_\eta(x), \lambda_\mu(x), \mu(x))$ be the QFS in$X$. Then, the score- valued function $sv(Q)$ of Q is defined as $sv(Q) = \frac{\mu(x) + \lambda_\mu(x) + \eta(x) + \lambda_\eta(x)}{3}$, where $sv(Q) \in [-1,1]$.

4.1. Advantages of the Quadrasophic Fuzzy model

The following Table 1 shows the assessment and advancement of the proposed model with respect to the existing models of fuzzy set.

Table 1: *Extensions of Fuzzy theoretical set with QFS assessment level*

Grade\Theoretical Set	Satisfaction	Neutral	Dissatisfaction	Bipolarity	Restricted Bipolarity
Fuzzy set	Yes	-	-	-	-
Bipolar Fuzzy set	Yes	-	-	Yes	-
Picture Fuzzy set	Yes	Yes	Yes	-	-
Quadrasophic Fuzzy set	Yes	-	Yes	Yes	Yes

Table 2: *Patient and symptom relational values in terms of QFS*

Q_1	δ_1	δ_2	δ_3	δ_4	δ_5
a_1	(-0.1,-0.1, 0.4,0.8)	(-0.1,-0.1, 0.3,0.6)	(-0.8,-0.4,0.1,0.2)	(-0.1,-0.1,0.3,0.6)	(-0.6,-0.3,0.1,0.1)
a_2	(-0.8,-0.4,0,0)	(-0.4,-0.2,0.2,0.4)	(-0.1,-0.1,0.3,0.6)	(-0.7,-0.4,0.1,0.1)	(-0.8,-0.4,0.1,0.1)
a_3	(-0.1,-0.1,0.4,0.8)	(-0.1,-0.1,0.4,0.8)	(-0.6,-0.3,0,0)	(-0.7,-0.4,0.1,0.2)	(-0.5,-0.3,0,0)
a_4	(-0.1,-0.1,0.3,0.6)	(-0.4,-0.2,0.3,0.5)	(-0.4,-0.2,0.2,0.3)	(-0.4,-0.2,0.2,0.3)	(-0.4,-0.2,0.2,0.3)

5. Test and comparison analysis

This segment provides an application of the Quadrasophic fuzzy set in medical diagnosis. Several authors have done their research work in medical diagnosis with various extensions of the fuzzy set. The medication deals with the environment of ambiguity. In addition, the Quadrasophic Fuzzy Set includes the impact of the environment as one of its membership values,

Table 3: *Symptoms and diseases relational values in terms of QFS*

Q_2	t_1	t_2	t_3	t_4	t_5
δ_1	(0, 0, 0.2,0.4)	(0,0,0.4,0.7)	(-0.3,-0.2, 0.2,0.3)	(-0.7,-0.4 ,0.1,0.1)	(-0.8,-0.4 ,0.1,0.1)
δ_2	(-0.7,-0.4, 0.1,0.1)	(-0.9,-0.5, 0,0)	(-0.7,-0.4,0.1,0.2)	(0,0,0.4,0.8)	(-0.8,-0.4, 0.1,0.2)
δ_3	(-0.3,-0.2, 0.2,0.4)	(0,0,0.4,0.7)	(-0.6,-0.3,0.1,0.2)	(-0.7,-0.4,0.1,0.2)	(-0.8,-0.4,0.1,0.2)
δ_4	(-0.7,-0.4,0.1,0.1)	(-0.8,-0.4, 0.1,0.1)	(-0.9,-0.5, 0.1,0.1)	(-0.7, -0.4, 0.1, 0.2)	(-0.1,-0.1, 0.4,0.8)

Table 4: *Relational values of patient and diseases in terms of QFS*

Q_3	t_1	t_2	t_3	t_4	t_5
a_1	(-0.7,- 0.4, 0.2,0.4)	(-0.8,-0.4, 0.4,0.7)	(-0.7,-0.4, 0.3,0.6)	(-0.6,-0.3 ,0.1,0.2)	(-0.8,-0.4 ,0.1,0.2)
a_2	(-0.7,-0.4, 0.2,0.3)	(-0.8,-0.4,0.2,0.2)	(-0.8,-0.4, 0.2,0.4)	(-0.7,-0.4, 0.3,0.6)	(-0.8,-0.4, 0.1,0.1)
a_3	(-0.6,-0.3, 0.2,0.4)	(-0.6,-0.3, 0.4,0.7)	(-0.6,-0.3,0.3,0.6)	(-0.7,-0.4, 0.1,0.2)	(-0.7,-0.4, 0.1,0.2)
a_4	(-0.4,-0.2, 0.2,0.4)	(-0.4,-0.2, 0.4,0.7)	(-0.4,-0.2, 0.3,0.5)	(-0.4,-0.2, 0.2,0.3)	(-0.4,-0.2,0.2,0.3)

which will aid in determining the best result.

Now, consider the database in medical analysis [9], [10] and will solve using the Quadrasophic Fuzzy set. Suppose four patients $a_i = \{Sanjeev - a_1, Sam - a_2, Sarjesh - a_3, Sarath - a_4\}$ affected with the disease, whose symptoms are $\delta_i = \{Temperature - \delta_i, Headache - \delta_2, StomachPain - \delta_3, Cough - \delta_4, ChestPain - \delta_5\}$. Consequently, the collection of ailments that the medical advisor specified is $t_i = \{Viralfever - t_1, Malaria - t_2, Typhoid - t_3, StomachProblem - t_4, Heartproblems - t_5\}$. The relation $Q_1(a_i \to \delta_i)$ between patients and symptoms and the relation $Q_2(\delta_i \to t_i)$ between symptoms and illness is represented in Table 2 and 3. The Quadrasophic fuzzy relation

Table 5: *Ranking value of patient and diseases*

Q_3	t_1	t_2	t_3	t_4	t_5
a_1	0.0667	**0.2667**	0.1667	-0.1	0
a_2	0.033	0.033	0.1	**0.1667**	0.033
a_3	0	**0.1667**	0.1	-0.033	-0.033
a_4	-0.1	**0.0667**	-0.033	-0.133	-0.133

of compositional value $Q_1 \circ Q_2$ is represented in Table 4. The Quadrasophic fuzzy relation of compositional value is represented in Table 4.

$$\Re = \frac{(-1 - \eta_Q(a_i, t)) + (-0.5 - \lambda_{\eta Q}(a_i, t)) + \mu_Q(a_i, t) + \lambda_{\mu Q}(a_i, t)}{3}$$

is the formulation to find the rank value, which is presented in Table 5.

It is clear that Sajeev, Sarjesh and Sarath are suffering from Malaria and Sam is suffering from Stomach problem.

5.1. Similarity Test

To corroborate, the Quadasophic Fuzzy Set method gives accurate results than the existing methods. We conduct the similarity test, and the results of various extensions of the existing fuzzy set model are presented in the following Table 6.

The results obtained in QFS are identical with the existing results and also relatively accurate compared to the values obtained by the other existing methods. In addition, taking the

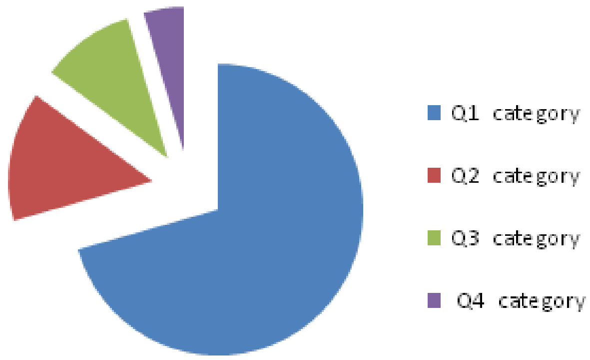

Figure 1: *Division of OCD Category*

reluctant rate into account in QFS yields a negative ranking, which indicates a person's deficiency rate. Based on this observation, the proposed method's verification yields better and more precise results than the existing method.

Table 6: *Comparative Analysis results*

Fuzzy set Environment	Results
Medical Diagnosis under IFS [9]	Malaria : a_1, a_3, a_4 Stomach problem: a_2 $a_1, a_3, a_4 = 0.68$ and $a_2 = 0.57$
Medical Diagnosis under Bipolar valued fuzzy sets [10]	Malaria: a_1, a_3, a_4 Stomach problem: a_2 $a_1 = 1.25, a_3 = 1.15, a_4 = 1.05$, and $a_2 = 1.15$
QFS method [3]	Malaria: a_1, a_3, a_4 Stomach problem: a_2 $a_1 = 0.2667, a_3 = 0.1667, a_4 = 0.0667$, and $a_2 = 0.1667$

6. Assessing stress level and self-esteem connection with real-life data using QF-TOPSIS method

Obsessive Compulsive Disorder (OCD) is a condition characterized by repetitive actions due to unnecessary thoughts and fears. OCD is a disorder characterized by repetitive cleaning, arranging, and washing actions, often unknowingly. It affects 4 out of 100 people in India and can be caused by genetics, brain abnormalities, or the environment. The exact cause is uncertain, but the environment can increase or decrease OCD levels, leading to emotional impairments and increased stress, exacerbating the condition.The environment plays a significant role in this disorder, and stress is a significant factor.

To examine the stress factor triggers OCD disorder, a survey is carried out among Tamil Nadu students and working persons to determine stress levels, self-esteem and the influence of surroundings on mental health. The survey contains questions, related to OCD subcategories like cleaning, arranging, washing, and checking. The data is categorized into four groups based on the different categories, with the percentages of each category at normal and abnormal rates depicted in Figures 1 and 2 respectively. The Quadrasophic Fuzzy Set simplifies the investigation of OCD. The data is categorized as follows:

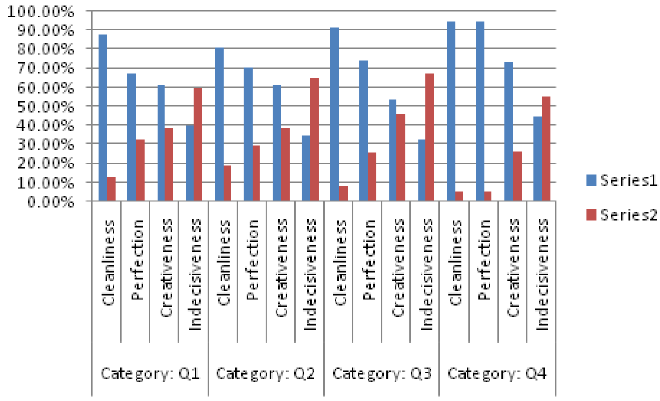

Figure 2: *Representation of category report for the OCD survey*

$\eta-$ represents the level of abnormal behavior
$\lambda_\eta-$stress level from the environment
$\lambda_\mu-$ self esteem level
$\mu-$ represents the level of normal behavior.

The TOPSIS [1] [2] approach is integrated with Quadrasophic Fuzzy data to identify the most OCD-affected category of people based on specific criteria in multi-criteria decision-making. The set of alternatives $Q_i = \{Q_1, Q_2, Q_3, Q_4\}$ represents individuals with different self-esteem levels, with Q_1 representing high-self-esteem individuals surrounded by high-self-esteem people, Q_2 representing high-self-esteem people surrounded by low-self-esteem people , Q_3 representing low-self-esteem individuals surrounded by high-self-esteem people, and Q_4 representing low-self-esteem individuals surrounded by low-self-esteem people.

The collection of criteria $C_i = \{C_1, C_2, C_3, C_4\}$ where C_1 represents the level of cleanliness, C_2 represents the level of perfection, C_3 indicates the level of creativeness, and C_4 indicates the level of indecisiveness. The weight vector of Q_j is $P_K \in [0,1]$ and $\sum_{j=1}^{n} P_j = 1$. In this instance, the weight vector is $(0.3, 0.3, 0.2, 0.2)$.

Algorithm QF-TOPSIS Method:

Step 1: Evaluate the Quadrasophic Decision Matrix Q_{ij} for the specified condition relating to the given alternatives.
Step 2: Normalize Q_{ij}, and use score value definition to calculate score function.
Step 3: Using the values from Step 2, calculate the $QFPIS$ $(X_i^{\rightarrow +})$ and $QFNIS$ $(X_i^{\rightarrow +})$ using [2] .
$QFPIS : X^{\rightarrow +} = \{Q_j, max(sv(Q_j(x_{iw})))/j = 1, 2, \ldots, n\}$

$$\begin{aligned} where,\ X^{\rightarrow +} = \{&Q_1(\eta_1^{\rightarrow +}(x), \lambda_{\eta 1}^{\rightarrow +}(x), \lambda_{\mu 1}^{\rightarrow +}(x), \mu_1^{\rightarrow +}(x)), \ldots, \\ &Q_n(\eta_1^{\rightarrow +}(x), \lambda_{\eta n}^{\rightarrow +}(x), \lambda_{\mu n}^{\rightarrow +}(x), \mu_n^{\rightarrow +}(x))\} \end{aligned}$$

$QFNIS : X^{\rightarrow -} = \{Q_j, min(sv(Q_j(x_{iw})))/j = 1, 2, ?, 4\}$

$$\begin{aligned} where, X^{\rightarrow -} = \{&Q_1(\eta_1^{\rightarrow -}(x), \lambda_{\eta 1}^{\rightarrow -}(x), \lambda_{\mu 1}^{\rightarrow -}(x), \mu_1^{\rightarrow -}(x)), \ldots, \\ &Q_n(\eta_1^{\rightarrow -}(x), \lambda_{\eta n}^{\rightarrow -}(x), \lambda_{\mu n}^{\rightarrow -}(x), \mu_n^{\rightarrow -}(x))\} \end{aligned}$$

Step 4: Determine the distance between categories (Q_i) and QFPIS $(X_i^{\rightarrow +})$, QFNIS $(X_i^{\rightarrow -})$ using definition 4 .

$$d(Q_i, X_i^{\to+}) = \sqrt{\frac{1}{2n}\sum_{i=1}^{n}[(\eta_{Q_i}(x_i))^2 - (\eta_{X_i}(x_i^{\to+}))^2]^2 + [(\lambda_{\eta_{Q_i}}(x_i))^2 - (\lambda_{\eta_{X_i}}(x_i^{\to+}))^2]^2 + [(\lambda_{\mu_{Q_i}}(x_i))^2 - (\lambda_{\mu_{X_i}}(x_i^{\to+}))^2]^2 + [(\mu_{Q_i}(x_i)^2 - (\mu_{X_i}(x_i^{\to+}))^2]^2}$$

$$d(Q_i, X_i^{\to-}) = \sqrt{\frac{1}{2n}\sum_{i=1}^{n}[(\eta_{Q_i}(x_i))^2 - (\eta_{X_i}(x_i^{\to-}))^2]^2 + [(\lambda_{\eta_{Q_i}}(x_i))^2 - (\lambda_{\eta_{X_i}}(x_i^{\to-}))^2]^2 + [(\lambda_{\mu_{Q_i}}(x_i))^2 - (\lambda_{\mu_{X_i}}(x_i^{\to-}))^2]^2 + [(\mu_{Q_i}(x_i)^2 - (\mu_{X_i}(x_i^{\to-}))^2]^2}$$

Step 5: Apply the following formula, to obtain the coefficient of closeness cc(Q) [2].

$$cc(Q) = d(Q_i, X_i^{\to-}) / [[d(Q_i, X_i^{\to-}) + d(Q_i, X_i^{\to+})]$$

Step 6: Using the values from Step 5, rank the category, with the smallest rank indicating the beneficial category. This allows us to identify the people who are most affected by OCD causes.

6.1. Illustration of the QF-TOPSIS method

Step 1: The Q_{ij} matrix is shown in Table 7.

Table 7: *Quadrasophic Decision Matrix*

DM	$Cleanliness$	$Perfection$	$Creativeness$	$Indecisiveness$
Q_1	(-0.201,-0.319, 0.405,0.638)	(-0.327,-0.319, 0.405, 0.538)	(-0.389,-0.319, 0.405, 0.244)	(-0.598,-0.319, 0.405,0.161)
Q_2	(-0.188,-0.3, 0.393,0.65)	(-0.297,-0.3, 0.393,0.562)	(-0.385, -0.3, 0.393, 0.246)	(-0.671, ,-0.3, 0.393, 0.13)
Q_3	(-0.087,-0.284, 0.332,0.73)	(-0.26,-0.284, 0.332,0.591)	(-0.46, ,-0.284, 0.332, 0.214)	(-0.673, ,-0.284, 0.332, 0.13)
Q_4	(-0.05,-0.285, 0.24,0.76)	(-0.05, -0.285, 0.24, 0.76)	(-0.67,-0.285, 0.24,0.133)	(-0.55,-0.285, 0.24,0.18)

Step 2: Table 8 gives the scoring function for the normalized Q_{ij}.
Step 3: Table 8 highlights the highest and lowest values used to determine the $QFPIS$ $(X_i^{\to+})$,

Table 8: *Score function of QFS*

$sv(Q)$	$Cleanliness$	$Perfection$	$Creativeness$	$Indecisiveness$
Q_1	**0.1743**	**0.02966**	**-0.0477**	-0.00567
Q_2	0.0103	0.0173	-0.0587	**0.0033**
Q_3	-0.0223	-0.011	**-0.07**	-0.027
Q_4	**-0.055**	**-0.055**	-0.0573	**-0.0817**

and $QFNIS$ $(X_i^{\to+})$.
Step 4: The Table 9 displays the distance measure values of $d(Q_i, X_i^{\to+})$ and $d(Q_i, X_i^{\to-})$.
Step 5: Table 10 indicates the $cc(Q)$ value.
Step 6: Use the cc(Q) values to rank the category. Thus, $Q_4 < Q_3 < Q_2 < Q_1$.

In addition to heredity and brain abnormalities, the environment and psychological stress play a crucial role in the development of OCD problems. Such brain and genetic defects cannot be fixed. However, maintaining a healthy environment can help live in harmony. Quadrasophic Fuzzy Sets are implemented in MCDM-TOPSIS techniques to find the most appropriate solution.

Correlations

			Self-esteem	environmental_self esteem:	Impact_environment	collecting_uselessthings	repeated_checking	repetition_routineaction	irritated_objects	checking_light_switches
Spearman's rho	Self-esteem	Correlation Coefficient	1.000	.356**	.176**	0.126	0.032	0.114	.170*	.181**
		Sig. (2-tailed)		0.000	0.009	0.062	0.638	0.092	0.011	0.007
		N	221	221	221	221	221	221	221	221
	Environmental_self esteem:	Correlation Coefficient		1.000	.201**	0.092	-0.014	0.045	0.078	0.127
		Sig. (2-tailed)			0.003	0.174	0.834	0.502	0.250	0.059
		N		221	221	221	221	221	221	221
	Impact_environment	Correlation Coefficient			1.000	0.081	0.033	0.008	-0.044	0.021
		Sig. (2-tailed)				0.231	0.623	0.903	0.514	0.761
		N			221	221	221	221	221	221
	collecting_uselessthings	Correlation Coefficient				1.000	.344**	0.131	.136*	0.106
		Sig. (2-tailed)					0.000	0.051	0.044	0.115
		N				221	221	221	221	221
	repeated_checking	Correlation Coefficient					1.000	0.095	.240**	.242**
		Sig. (2-tailed)						0.161	0.000	0.000
		N					221	221	221	221
	repetition_routineaction	Correlation Coefficient						1.000	.175**	.141*
		Sig. (2-tailed)							0.009	0.036
		N						221	221	221
	irritated_objects	Correlation Coefficient							1.000	.505**
		Sig. (2-tailed)								0.000
		N							221	221
	checking_light_switches	Correlation Coefficient								1.000
		Sig. (2-tailed)								
		N								221

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Figure 3: *Correlations*

Table 9: *Distance measures between QFPIS, QFNIS and, Qj*

Distance between Q_j and $QFPIS$	Distance between Q_j and $QFNIS$
0.0067	0.0398
0.0075	0.0392
0.0188	0.0291
0.104	0.0173

Table 10: *Value of cc(Q)*

The values of $cc(Q)$	
Q_1	0.855913
Q_2	0.8394
Q_3	0.6075
Q_4	0.1426

The data indicates that the Q_4 group experiences increased stress, which in turn triggers OCD. The Q_4 category is greatly impacted by the environment. Additionally, the survey recommends that living in a conducive environment is crucial for OCD-free lives.

7. Analysis of Quadrasophic Fuzzy Data using SPSS software

A SPSS software is used for processing the collected data for statistical evaluation. Figure 3 displays Spearman's rho correlation coefficients among several variables, such as individual's self-esteem, environmental self-esteem, other behavioral and emotional metrics. A significant positive correlation $(r = 0.350, p < 0.01 \& r = 0.350, p < 0.01 \& r = 0.350, p < 0.01)$ was found between environmental factors and high self-esteem. Q_1 category and environmental factors are positively correlated, but environmental factor is negatively associated with certain behaviors.

Figure 4 indicates that the Environment is a significant predictor, accounting for 31.2% of Q_4, with an R-value of 0.558 (indicating a moderate correlation). However, 68.8% of the variance remains unexplained, suggesting that other factors may also influence Q_4 individuals.

The ANOVA results shown in Figure 5 indicate that the environmental factor significantly influences the variation in the dependent variable, Q_4 category, with a significant F-value of 44.389 and a p-value of 0.000.

In Figure 6, beta (standardized coefficient) of -0.558 indicates a moderately strong negative impact of the environment on the Q4 category. The t-value is -6.662, and the p-value is 0.000, suggesting a strong correlation between changes in the environment and changes in Q_4.

Outcome of the study: The study reveals that environmental factors significantly impact

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.558[a]	.312	.305	4.01317

a. Predictors: (Constant), Environ

Figure 4: *Model Summary*

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	714.901	1	714.901	44.389	.000[b]
	Residual	1578.339	98	16.105		
	Total	2293.240	99			

a. Dependent Variable: LL
b. Predictors: (Constant), Environ

Figure 5: *ANOVA result*

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.366	.434		7.751	.000
	Environ	-.485	.073	-.558	-6.662	.000

a. Dependent Variable: LL

Figure 6: *Coefficients Value*

the Q_4 category, with a negative impact on it and a significant positive association with the Q_1 category. The environment factor accounts for 31.2% of the Q_4 category, indicating the existence of other variables and similar results between SPSS and QFS. Social Environment self-esteem and the environmental effect have been associated with self-esteem. The research highlights the link between environmental stressors and emotional deficiencies, leading to OCD. It emphasizes the importance of QFS in incorporating environmental factors to achieve the most appropriate outcome.

8. Conclusion

This artifact defines the operations and properties of the Quadrasophic Fuzzy Set (QFS), including the distance measure, QFR (Quadrasophic Fuzzy Relation), score function, and composition functions. The Quadrasophic Fuzzy Relation is applied in a comparative analysis to validate this novel fuzzy set extension. The QFS max-min composition is effectively utilized in solving decision-making (DM) problems. Additionally, the integration of QFS data with the TOPSIS approach is demonstrated for solving multi-criteria decision-making (MCDM) problems. The QF-TOPSIS method is employed to address an OCD analysis problem, with its novel membership functions highlighting the influence of environmental factors on stress and OCD. SPSS analysis confirms that QFS is highly effective in investigating additional factors, including environmental impact, to achieve accurate outcomes.

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