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A Novel Intelligent Multi-Attributes Decision-Making Approach Based on Generalized Neutrosophic Vague Hybrid Computing

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Abstract. Neutrosophic vague hypersoft set (nVHs-set) is a novel hybrid model that is projected to address the limitations of existing fuzzy vague set-like structures for degree of indeterminacy and multi argument approximate function. This function maps the cartesian product of disjoint attribute valued sets to power set of initial universe. This study aims to characterize nVHs-set to tackle uncertainties more efficiently. Some essential properties and set-theoretic cum aggregation operations of nVHs-set are characterized by employing axiomatic and analytical approaches respectively and explained with the help of suitable examples. An algorithm is proposed based on aggregations of nVHs-set for dealing real-world decision-making issues and problems. The proposed algorithm is validated by its implementation in real-world decision-making problem for the optimal selection of farmhouse. Moreover advantageous aspects of proposed model are assessed with the help of evaluating features through comparison analysis.

Keywords: Soft set; Vague set; Hypersoft set; Neutrosophic vague soft set; Neutrosophic vague hypersoft set; Decision making.

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1. **Introduction**

The concept of fuzzy set was generated by Zadeh [1] to address uncertainty and vagueness in daily life problems. Real life problems involving indecisive and ambiguous environment under fuzzy sets and fuzzy logic were addressed by different authors [2–5]. Gau et al. [6], Atanassov [7] and Pawlak [8] also worked on research problems under uncertain situations. Neutrosophic set theory [9] generalized the concept of classical set, fuzzy set and intuitionistic fuzzy set. Neutrosophic logic is a logic where every proposition has different values for truth, falsehood, and indeterminacy which means that there exists some neutral part which is neither true, nor false, rather it is vague. Soft set theory was conceptualized by Molodtsov [10] to handle

vagueness and uncertainty in data. The idea of soft set and fuzzy set with their amplified impacts on set theory were undertaken by Maji et al. [11], Feng et al. [12] Zhang et al. [13], Salleh et al. [14] and Alkhazaleh et al. [15]. Xu et al. [16] developed the innovative concept of vague soft set where as Alhazaymeh et al. [17] generalized the concept. Alhazaymeh et al. [18] also discussed vague soft sets relations and functions. Intuitionistic fuzzy soft set and neutrosophic soft set were initiated by Maji et al. [19, 20]. Broumi et al. [21] and Deli [22] depicted the idea of intuitionistic neutrosophic soft set and interval-valued neutrosophic soft sets and applied the concept in decision making. Recent work on interval-valued vague soft sets by Alhazaymeh et al. [23–26] has created many slits for researchers [27–31]. Different vague soft set variants were discussed by Hassan et al. [32, 33]. Vague set and neutrosophic set were hybridized to form neutrosophic vague set [34] which became an efficient tool to discuss and solve problems with uncertain, incomplete and inconsistent data.
Al Quran et al. [35] developed neutrosophic vague soft set nVs-set as hybrid model of soft set and neutrosophic vague set which made it more effective and efficient for solving decision making problems. nVs-set deals with uncertain, incomplete and indeterminate type of data.

1.1. *Research gap and Motivation*

In many real life problems, it is essential to partition attributes into sets of sub attributive values. Soft set theory is incompatible and inadequate to deal with such type of problems. The concept of hypersoft set [36] introduces multi argument approximate function which fulfills the insufficiency of soft set. Fundamentals of hypersoft set have been elaborated in [37]. Many hypersoft set variants under uncertain environment have already been examined by Rahman et al. [38–44] and Saeed et al. [45–50]. Recently the researchers [51–59] made rich contributions towards the characterization of various hybrids of hypersoft set ad their application in decision making and other fields.
The question arises "Can we mingle the concept of neutrosophic vague soft set and hypersoft set"? In other words "How is multi argument approximate function applicable to neutrosophic vague soft sets?" and "How can this new hybrid structure of hypersoft set and neutrosophic vague soft set be more effective and useful than existing models"? The research paper aims to answer these questions.

1.2. *Main Contributions*

The major contributions of the study are given hereafter:

(1) The existing models [34–36] are made adequate with nVHs-set,
(2) the scenario where parameters are divided into sub-parameters, is dealt,

(3) multi-attribute decision making is discussed based on nVHs-set through algorithmic approach,
(4) real life decision making problem is solved using nVHs-set,
(5) proposed model is compared with existing relevant models,
(6) validity and generalization of proposed model is discussed.

1.3. *Paper Layout*

The research paper is divided into different sections as given below:
Some basic definitions are discussed in section 2. The concept of nVHs-set is originated in section 3 whereas a decision making problem is solved in section 4. Comparison analysis of proposed model with existing models is done in section 5. Merits of proposed model are discussed in section 6. Finally section 7 concludes the paper with future directions.

2. **Preliminaries**

In this section, some basic definitions from literature are recalled. In this paper $\mathcal{Z}$ will represent universe of discourse.

Definition 2.1. [6] Let z be a generic element of $\mathcal{Z}$. Let $\mathcal{V}$ in $\mathcal{Z}$ denote vague set which contains a truth membership function $\mathcal{T}_V$ whereas $\mathcal{T}_V(z) \in [0,1]$ is lower bound on grade of membership taken from the evidence for z and false membership function $\mathcal{F}_V$ whereas $\mathcal{F}_V(z) \in [0,1]$ is lower bound on grade of non-membership taken from the evidence against z with condition $\mathcal{T}_V(z) + \mathcal{F}_V(z) \leq 1$.

Definition 2.2. [9] A neutrosophic set $\mathcal{N}$ defined on universal set $\mathcal{Z}$ is given by

$$\mathcal{N} = \{< z; \mathcal{T}_{\mathcal{N}}(z); \mathcal{I}_{\mathcal{N}}(z); \mathcal{F}_{\mathcal{N}}(z) >; z \in \mathcal{Z}\},$$

such that $\mathcal{T}; \mathcal{I}; \mathcal{F} : \mathcal{Z} \to]^{-}0, 1^{+}[$ with $^{-}0 \leq \mathcal{T}_{\mathcal{N}}(z) + \mathcal{I}_{\mathcal{N}}(z) + \mathcal{F}_{\mathcal{N}}(z) \leq 3^{+}$.

Definition 2.3. [34] Let $\mathcal{Z}$ be universe of discourse. A neutrosophic vague set $\mathcal{N}_{\mathcal{V}}$ on $\mathcal{Z}$ denoted by nV-set can be given by

$$\mathcal{N}_{\mathcal{V}} = \{< z; \mathcal{T}_{\mathcal{N}_{\mathcal{V}}}(z); \mathcal{I}_{\mathcal{N}_{\mathcal{V}}}(z); \mathcal{F}_{\mathcal{N}_{\mathcal{V}}}(z) >; z \in \mathcal{Z}\},$$

were $\mathcal{T}_{\mathcal{N}_{\mathcal{V}}}(z) = [\mathcal{T}^{-}, \mathcal{T}^{+}]$, $\mathcal{I}_{\mathcal{N}_{\mathcal{V}}}(z) = [\mathcal{I}^{-}, \mathcal{I}^{+}]$ and $\mathcal{F}_{\mathcal{N}_{\mathcal{V}}}(z) = [\mathcal{F}^{-}, \mathcal{F}^{+}]$ are truth membership, indeterminacy and false membership respectively and satisfy following conditions $\mathcal{T}^{+} = 1 - \mathcal{F}^{-}$, $\mathcal{F}^{+} = 1 - \mathcal{T}^{-}$, $^{-}0 \leq \mathcal{T} + \mathcal{I} + \mathcal{F} \leq 2^{+}$.

Definition 2.4. [34] For two nV-sets $\mathcal{N}_{\mathcal{V}_1}$ and $\mathcal{N}_{\mathcal{V}_2}$, $\mathcal{N}_{\mathcal{V}_1}$ is called nV-subset of $\mathcal{N}_{\mathcal{V}_2}$ if following conditions hold for all $z_i \in \mathcal{Z}$ and $i = 1, 2, 3, ..., n$; $\mathcal{T}_{\mathcal{N}_{\mathcal{V}_1}}(z_i) \leq \mathcal{T}_{\mathcal{N}_{\mathcal{V}_2}}(z_i)$, $\mathcal{I}_{\mathcal{N}_{\mathcal{V}_1}}(z_i) \geq \mathcal{I}_{\mathcal{N}_{\mathcal{V}_2}}(z_i)$ and $\mathcal{F}_{\mathcal{N}_{\mathcal{V}_1}}(z_i) \geq \mathcal{F}_{\mathcal{N}_{\mathcal{V}_2}}(z_i)$.

Definition 2.5. [34] Two nV-sets $\mathcal{N}_{\mathcal{V}_1}$ and $\mathcal{N}_{\mathcal{V}_2}$ are nV-set equal if following conditions hold for all $z_i \in \mathcal{Z}$ and $i = 1, 2, 3, ..., n$; $\mathcal{T}_{\mathcal{N}_{\mathcal{V}_1}}(z_i) = \mathcal{T}_{\mathcal{N}_{\mathcal{V}_2}}(z_i)$, $\mathcal{I}_{\mathcal{N}_{\mathcal{V}_1}}(z_i) = \mathcal{I}_{\mathcal{N}_{\mathcal{V}_2}}(z_i)$ and $\mathcal{F}_{\mathcal{N}_{\mathcal{V}_1}}(z_i) = \mathcal{F}_{\mathcal{N}_{\mathcal{V}_2}}(z_i)$.

Definition 2.6. [34] $\mathcal{N}_{\mathcal{V}}^c$, the complement of nV-set $\mathcal{N}_{\mathcal{V}}$ on $\mathcal{Z}$ is given by

$$\mathcal{N}_{\mathcal{V}}^c = \left\{< z; \mathcal{T}_{\mathcal{N}_{\mathcal{V}}}^c(z); \mathcal{I}_{\mathcal{N}_{\mathcal{V}}}^c(z); \mathcal{F}_{\mathcal{N}_{\mathcal{V}}}^c(z) >; z \in \mathcal{Z}\right\},$$

where $\mathcal{T}_{\mathcal{N}_{\mathcal{V}}}^c(z) = [1-\mathcal{T}^+, 1-\mathcal{T}^-]$, $\mathcal{I}_{\mathcal{N}_{\mathcal{V}}}^c(z) = [1-\mathcal{I}^+, 1-\mathcal{I}^-]$, and $\mathcal{F}_{\mathcal{N}_{\mathcal{V}}}^c(z) = [1-\mathcal{F}^+, 1-\mathcal{F}^-]$.

Definition 2.7. [34] The intersection $\mathcal{N}_{\mathcal{V}}$ of two nV-sets $\mathcal{N}_{\mathcal{V}_1}$ and $\mathcal{N}_{\mathcal{V}_2}$ denoted by $\mathcal{N}_{\mathcal{V}} = \mathcal{N}_{\mathcal{V}_1} \cap \mathcal{N}_{\mathcal{V}_2}$ is nV-set with following conditions $\forall z_i \in \mathcal{Z}$ and $i = 1, 2, 3, ..., n$; $\mathcal{T}_{\mathcal{N}_{\mathcal{V}}}(z_i) = \left[\min(\mathcal{T}_{\mathcal{N}_{\mathcal{V}_1}}^-, \mathcal{T}_{\mathcal{N}_{\mathcal{V}_2}}^-), \min(\mathcal{T}_{\mathcal{N}_{\mathcal{V}_1}}^+, \mathcal{T}_{\mathcal{N}_{\mathcal{V}_2}}^+)\right]$, $\mathcal{I}_{\mathcal{N}_{\mathcal{V}}}(z_i) = \left[\max(\mathcal{I}_{\mathcal{N}_{\mathcal{V}_1}}^-, \mathcal{I}_{\mathcal{N}_{\mathcal{V}_2}}^-), \max(\mathcal{I}_{\mathcal{N}_{\mathcal{V}_1}}^+, \mathcal{I}_{\mathcal{N}_{\mathcal{V}_2}}^+)\right]$ and $\mathcal{F}_{\mathcal{N}_{\mathcal{V}}}(z_i) = \left[\max(\mathcal{F}_{\mathcal{N}_{\mathcal{V}_1}}^-, \mathcal{F}_{\mathcal{N}_{\mathcal{V}_2}}^-), \max(\mathcal{F}_{\mathcal{N}_{\mathcal{V}_1}}^+, \mathcal{F}_{\mathcal{N}_{\mathcal{V}_2}}^+)\right]$.

Definition 2.8. [34] The union $\mathcal{N}_{\mathcal{V}}$ of two nV-sets $\mathcal{N}_{\mathcal{V}_1}$ and $\mathcal{N}_{\mathcal{V}_2}$ denoted by $\mathcal{N}_{\mathcal{V}} = \mathcal{N}_{\mathcal{V}_1} \cup \mathcal{N}_{\mathcal{V}_2}$ is nV-set with following conditions $\forall z_i \in \mathcal{Z}$ and $i = 1, 2, 3, ..., n$; $\mathcal{T}_{\mathcal{N}_{\mathcal{V}}}(z_i) = \left[\max(\mathcal{T}_{\mathcal{N}_{\mathcal{V}_1}}^-, \mathcal{T}_{\mathcal{N}_{\mathcal{V}_2}}^-), \max(\mathcal{T}_{\mathcal{N}_{\mathcal{V}_1}}^+, \mathcal{T}_{\mathcal{N}_{\mathcal{V}_2}}^+)\right]$, $\mathcal{I}_{\mathcal{N}_{\mathcal{V}}}(z_i) = \left[\min(\mathcal{I}_{\mathcal{N}_{\mathcal{V}_1}}^-, \mathcal{I}_{\mathcal{N}_{\mathcal{V}_2}}^-), \min(\mathcal{I}_{\mathcal{N}_{\mathcal{V}_1}}^+, \mathcal{I}_{\mathcal{N}_{\mathcal{V}_2}}^+)\right]$ and $\mathcal{F}_{\mathcal{N}_{\mathcal{V}}}(z_i) = \left[\min(\mathcal{F}_{\mathcal{N}_{\mathcal{V}_1}}^-, \mathcal{F}_{\mathcal{N}_{\mathcal{V}_2}}^-), \min(\mathcal{F}_{\mathcal{N}_{\mathcal{V}_1}}^+, \mathcal{F}_{\mathcal{N}_{\mathcal{V}_2}}^+)\right]$.

Definition 2.9. [35] Let $\mathcal{E}$ be set of parameters for $\mathcal{Z}$ and $\Lambda \subset \mathcal{E}$. A neutrosophic vague soft set $(\mathcal{N}_{\mathcal{VS}}, \Lambda)$ on $\mathcal{Z}$ denoted by nVs-set can be given by $\mathcal{N}_{\mathcal{VS}} : \Lambda \to \mathcal{N}_{\mathcal{V}}(\mathcal{Z})$ where $\mathcal{N}_{\mathcal{V}}(\mathcal{Z})$ represents set of all nV-subsets of $\mathcal{Z}$.

Definition 2.10. [35] For two nVs-sets $(\mathcal{N}_{\mathcal{VS}_1}, \Lambda)$ and $(\mathcal{N}_{\mathcal{VS}_2}\Delta)$, $(\mathcal{N}_{\mathcal{VS}_1}, \Lambda)$ is called nVs-subset of $(\mathcal{N}_{\mathcal{VS}_2}, \Delta)$ i.e. $(\mathcal{N}_{\mathcal{VS}_1}, \Lambda) \subseteq (\mathcal{N}_{\mathcal{VS}_2}\Delta)$ if following conditions hold: $\Lambda \subseteq \Delta$, $\mathcal{N}_{\mathcal{VS}_1}(\theta)$ is nV-subset of $\mathcal{N}_{\mathcal{VS}_2}(\theta)$ for all $\theta \in \Lambda$.

Definition 2.11. [35] Two nVs-sets $(\mathcal{N}_{\mathcal{VS}_1}, \Lambda)$ and $(\mathcal{N}_{\mathcal{VS}_2}\Delta)$, are nVs-set equal if $(\mathcal{N}_{\mathcal{VS}_1}, \Lambda) \subseteq (\mathcal{N}_{\mathcal{VS}_2}, \Delta)$ and $(\mathcal{N}_{\mathcal{VS}_2}, \Delta) \subseteq (\mathcal{N}_{\mathcal{VS}_1}\Lambda)$.

Definition 2.12. [35] A nVs-set $(\mathcal{N}_{\mathcal{VS}}, \Lambda)$ is null nVs-set written as $\Phi_{\mathcal{N}_{\mathcal{VS}}}$ if following conditions holds for all values $\pi \in \mathcal{Z}$ and $\theta \in \Lambda$; $\mathcal{T}_{\mathcal{N}_{\mathcal{VS}(\theta)}}(\pi) = [0, 0]$, $\mathcal{I}_{\mathcal{N}_{\mathcal{VS}(\theta)}}(\pi) = [1, 1]$, and $\mathcal{F}_{\mathcal{N}_{\mathcal{VS}(\theta)}}(\pi) = [1, 1]$.

Definition 2.13. [35] A nVs-set $(\mathcal{N}_{\mathcal{VS}}, \Lambda)$ is absolute nVs-set written as $\Psi_{\mathcal{N}_{\mathcal{VS}}}$ if following conditions holds for all values $\pi \in \mathcal{Z}$ and $\theta \in \Lambda$; $\mathcal{T}_{\mathcal{N}_{\mathcal{VS}(\theta)}}(\pi) = [1, 1]$, $\mathcal{I}_{\mathcal{N}_{\mathcal{VS}(\theta)}}(\pi) = [0, 0]$, and $\mathcal{F}_{\mathcal{N}_{\mathcal{VS}(\theta)}}(\pi) = [0, 0]$.

Definition 2.14. [35] The compliment $(\mathcal{N}_{\mathcal{VS}}, \Lambda)^\varsigma$ of nVs-set $(\mathcal{N}_{\mathcal{VS}}, \Lambda)$ is given by $(\mathcal{N}_{\mathcal{VS}}, \Lambda)^\varsigma = (\mathcal{N}_{\mathcal{VS}}^\varsigma, \Lambda)$ where $\mathcal{N}_{\mathcal{VS}}^\varsigma : \Lambda \to \mathcal{N}_{\mathcal{V}}(\mathcal{Z})$ is defined as $\mathcal{N}_{\mathcal{VS}}^\varsigma(\pi) = \varsigma(\mathcal{N}_{\mathcal{VS}}(\pi)), \forall \pi \in \Lambda$ such that $\mathcal{N}_{\mathcal{V}}(\mathcal{Z})$ represents set of all nV-subsets of $\mathcal{Z}$ and ς is neutrosophic vague compliment.

Definition 2.15. [35] The intersection $(\mathcal{N}_{\mathcal{VS}}, \Upsilon)$ of two nVs-sets $(\mathcal{N}_{\mathcal{VS}_1}, \Lambda)$ and $(\mathcal{N}_{\mathcal{VS}_2}, \Delta)$ denoted by $\mathcal{N}_{\mathcal{VS}} = \mathcal{N}_{\mathcal{VS}_1} \hat{\cap} \mathcal{N}_{\mathcal{VS}_2}$ where $\Upsilon = \Lambda \cup \Delta$ and $\forall \theta \in \Upsilon$, is given by

$$(\mathcal{N}_{\mathcal{VS}}, \Upsilon) = \left\{ \begin{array}{cc} \mathcal{N}_{\mathcal{VS}_1}(\theta) & ;\theta \in \Lambda - \Delta \\ \mathcal{N}_{\mathcal{VS}_2}(\theta) & ;\theta \in \Delta - \Lambda \\ \mathcal{N}_{\mathcal{VS}_1}(\theta) \hat{\cap} \mathcal{N}_{\mathcal{VS}_2}(\theta) & ;\theta \in \Lambda \cap \Delta \end{array} \right\},$$

where $\hat{\cap}$ is nV-set intersection.

Definition 2.16. [35] The union $(\mathcal{N}_{\mathcal{VS}}, \Upsilon)$ of two nVs-sets $(\mathcal{N}_{\mathcal{VS}_1}, \Lambda)$ and $(\mathcal{N}_{\mathcal{VS}_2}, \Delta)$ denoted by $\mathcal{N}_{\mathcal{VS}} = \mathcal{N}_{\mathcal{VS}_1} \check{\cup} \mathcal{N}_{\mathcal{VS}_2}$ where $\Upsilon = \Lambda \cup \Delta$ and $\forall \theta \in \Upsilon$, is given by

$$(\mathcal{N}_{\mathcal{VS}}, \Upsilon) = \left\{ \begin{array}{cc} \mathcal{N}_{\mathcal{VS}_1}(\theta) & ;\theta \in \Lambda - \Delta \\ \mathcal{N}_{\mathcal{VS}_2}(\theta) & ;\theta \in \Delta - \Lambda \\ \mathcal{N}_{\mathcal{VS}_1}(\theta) \check{\cap} \mathcal{N}_{\mathcal{VS}_2}(\theta) & ;\theta \in \Lambda \cap \Delta \end{array} \right\},$$

where $\check{\cup}$ is nV-set union.

3. NEUTROSOPHIC VAGUE HYPERSOFT SET (nVHs-set)

Neutrosophic vague hypersoft set (nVHs-set) is introduced in this section. Some basic operations of (nVHs-set) are also discussed.

Definition 3.1. For a universal set $\mathcal{Z}$, let $\mathcal{E}$ be set of parameters and $\Lambda \subseteq \mathcal{E}$. The pair $(\mathcal{N}_{\mathcal{VHS}}, \Lambda)$ is called neutrosophic vague hypersoft set (nVHs-set) over $\mathcal{Z}$ where $\mathcal{N}_{\mathcal{VHS}}$ is defined by $\mathcal{N}_{\mathcal{VHS}} : \Lambda \to NV(\mathcal{Z})$ such that $\Lambda = \Lambda_1 \times \Lambda_2 \times ... \times \Lambda_n$ with $\Lambda_i, i = 1, 2, 3, .., n$ are disjoint attribute-valued sets corresponding to distinct attributes $\varepsilon_i, i = 1, 2, 3, ..., n$ respectively and θ is a n-tuple element of Λ and $\mathcal{N}_{\mathcal{VHS}}(\theta)$ is an approximate element of nVHs-set over $\mathcal{Z}$.

Example 3.2. A company wants to supply antibacterial soap for cure of Covid-19 patient in a hospital. Let $\mathcal{Z} = \{z_1, z_2, ..., z_5\}$ be the universal set consisting of five kinds of antibacterial soap for cure of Covid-19 patient available in market. Let $\mathcal{E}$ be the set of parameters. Let Λ_i be the nonempty subset of $\mathcal{E}$ for each $i = 1, 2, 3$ represent multi attribute set corresponding to each element of $\mathcal{E}$ and $\Lambda = \Lambda_1 \times \Lambda_2 \times \Lambda_3$, where $\Lambda_1 = \{a_{11}\}, \Lambda_2 = \{b_{11}, b_{12}\}, \Lambda_3 = \{c_{11}\}$. Let $\Lambda = \{\theta_1, \theta_2, \theta_3\}$ i.e. we have three criteria for evaluation of material where θ_1 stands for ingredient of soap which triclosan, triclocarban and benzalkonium chloride, θ_2 stands for color of soap which is blue, green and white, and θ_3 stands for price which is low, medium and high. A mapping is defined as follows $\mathcal{N}_{\mathcal{VHS}} : \Lambda \to NV(\mathcal{Z})$. Consider

$$\mathcal{N}_{\mathcal{VHS}}(\theta_1) = \left\{ \begin{array}{l} z_1/ < [0.1, 0.3]; [0.2, 0.4]; [0.7, 0.9] >, z_2/ < [0.2, 0.5]; [0.3, 0.4]; [0.5, 0.8] >, \\ z_3/ < [0.2, 0.6]; [0.2, 0.4]; [0.4, 0.8] >, z_4/ < [0.1, 0.7]; [0.4, 0.5]; [0.3, 0.9] >, \\ z_5/ < [0.2, 0.4]; [0.4, 0.5]; [0.6, 0.8] > \end{array} \right\}$$

Table 1. nVHs-set $(\mathcal{N}_{\mathcal{VHS}}, \Lambda)$

$\mathcal{Z}$	θ_1	θ_2	θ_3
z_1	$<[0.1,0.3];[0.2,0.4];[0.7,0.9]>$	$<[0.2,0.5];[0.3,0.5];[0.5,0.8]>$	$<[0.3,0.5];[0.1,0.3];[0.5,0.7]>$
z_2	$<[0.2,0.5];[0.3,0.4];[0.5,0.8]>$	$<[0.2,0.3];[0.2,0.4];[0.7,0.8]>$	$<[0.2,0.7];[0.3,0.4];[0.3,0.8]>$
z_3	$<[0.2,0.6];[0.2,0.4];[0.4,0.8]>$	$<[0.4,0.5];[0.2,0.6];[0.5,0.6]>$	$<[0.1,0.3];[0.5,0.8];[0.7,0.9]>$
z_4	$<[0.1,0.7];[0.4,0.5];[0.3,0.9]>$	$<[0.1,0.3];[0.1,0.5];[0.7,0.9]>$	$<[0.2,0.5];[0.3,0.7];[0.5,0.8]>$
z_5	$<[0.2,0.4];[0.4,0.5];[0.6,0.8]>$	$<[0.3,0.6];[0.4,0.7];[0.4,0.7]>$	$<[0.3,0.6];[0.2,0.3];[0.4,0.7]>$

$$\mathcal{N}_{\mathcal{VHS}}(\theta_2) = \left\{ \begin{array}{l} z_1/<[0.2,0.5];[0.3,0.5];[0.5,0.8]>, z_2/<[0.2,0.3];[0.2,0.4];[0.7,0.8]>, \\ z_3/<[0.4,0.5];[0.2,0.6];[0.5,0.6]>, z_4/<[0.1,0.3];[0.1,0.5];[0.7,0.9]>, \\ z_5/<[0.3,0.6];[0.4,0.7];[0.4,0.7]> \end{array} \right\}$$

$$\mathcal{N}_{\mathcal{VHS}}(\theta_3) = \left\{ \begin{array}{l} z_1/<[0.3,0.5];[0.1,0.3];[0.5,0.7]>, z_2/<[0.2,0.7];[0.3,0.4];[0.3,0.8]>, \\ z_3/<[0.1,0.3];[0.5,0.8];[0.7,0.9]>, z_4/<[0.2,0.5];[0.3,0.7];[0.5,0.8]>, \\ z_5/<[0.3,0.6];[0.2,0.3];[0.4,0.7]> \end{array} \right\}$$

It can also be written as

$$(\mathcal{N}_{\mathcal{VHS}}, \Lambda) = \left\{ \begin{array}{l} \left(\theta_1, \left\{ \begin{array}{l} z_1/<[0.1,0.3];[0.2,0.4];[0.7,0.9]>, z_2/<[0.2,0.5];[0.3,0.4];[0.5,0.8]>, \\ z_3/<[0.2,0.6];[0.2,0.4];[0.4,0.8]>, z_4/<[0.1,0.7];[0.4,0.5];[0.3,0.9]>, \\ z_5/<[0.2,0.4];[0.4,0.5];[0.6,0.8]> \end{array} \right\}\right), \\ \left(\theta_2, \left\{ \begin{array}{l} z_1/<[0.2,0.5];[0.3,0.5];[0.5,0.8]>, z_2/<[0.2,0.3];[0.2,0.4];[0.7,0.8]>, \\ z_3/<[0.4,0.5];[0.2,0.6];[0.5,0.6]>, z_4/<[0.1,0.3];[0.1,0.5];[0.7,0.9]>, \\ z_5/<[0.3,0.6];[0.4,0.7];[0.4,0.7]> \end{array} \right\}\right), \\ \left(\theta_3, \left\{ \begin{array}{l} z_1/<[0.3,0.5];[0.1,0.3];[0.5,0.7]>, z_2/<[0.2,0.7];[0.3,0.4];[0.3,0.8]>, \\ z_3/<[0.1,0.3];[0.5,0.8];[0.7,0.9]>, z_4/<[0.2,0.5];[0.3,0.7];[0.5,0.8]>, \\ z_5/<[0.3,0.6];[0.2,0.3];[0.4,0.7]> \end{array} \right\}\right) \end{array} \right\}$$

nVHs-set $(\mathcal{N}_{\mathcal{VHS}}, \Lambda)$ can also be represented in the form of table 1

Definition 3.3. For two nVHs-sets $(\mathcal{N}_{\mathcal{VHS}_1}, \Lambda)$ and $(\mathcal{N}_{\mathcal{VHS}_2}\Delta)$, $(\mathcal{N}_{\mathcal{VHS}_1}, \Lambda)$ is called nVHs-subset of $(\mathcal{N}_{\mathcal{VHS}_2}, \Delta)$ i.e. $(\mathcal{N}_{\mathcal{VHS}_1}, \Lambda) \subseteq (\mathcal{N}_{\mathcal{VHS}_2}\Delta)$ if following conditions hold; $\Lambda \subseteq \Delta$ and $\mathcal{N}_{\mathcal{VHS}_1}(\theta)$ is nVs-subset of $\mathcal{N}_{\mathcal{VHS}_2}(\theta)$ for all $\theta \in \Lambda$.

Example 3.4. Consider Example 3.2 where $\Lambda = \{\theta_2, \theta_3\}$ for $\theta_i \in \Lambda_1 \times \Lambda_2 \times \Lambda_3, i = 2, 3$ and $\Delta = \{\theta_1, \theta_2, \theta_3\}$ for $\theta_i \in \Delta_1 \times \Delta_2 \times \Delta_3, i = 1, 2, 3$. Suppose $(\mathcal{N}_{\mathcal{VHS}_1}, \Lambda)$ and $(\mathcal{N}_{\mathcal{VHS}_2}, \Delta)$ are two nVHs-sets of defined as follow and demonstrated in table 2 and table 3:

$$(\mathcal{N}_{\mathcal{VHS}_1}, \Lambda) =$$

TABLE 2. nVHs-set $(\mathcal{N}_{\mathcal{VHS}_1}, \Lambda)$

$\mathcal{Z}$	θ_2	θ_3
z_1	$<[0.2,0.4];[0.3,0.6];[0.6,0.8]>$	$<[0.2,0.4];[0.2,0.5];[0.6,0.8]>$
z_2	$<[0.1,0.3];[0.2,0.5];[0.7,0.9]>$	$<[0.2,0.6];[0.3,0.5];[0.4,0.8]>$
z_3	$<[0.3,0.5];[0.2,0.7];[0.5,0.7]>$	$<[0.1,0.2];[0.6,0.9];[0.8,0.9]>$
z_4	$<[0.1,0.3];[0.1,0.7];[0.7,0.9]>$	$<[0.2,0.4];[0.4,0.8];[0.6,0.8]>$
z_5	$<[0.2,0.5];[0.4,0.8];[0.5,0.8]>$	$<[0.2,0.5];[0.4,0.7];[0.5,0.8]>$

TABLE 3. nVHs-set $(\mathcal{N}_{\mathcal{VHS}_2}, \Delta)$

$\mathcal{Z}$	θ_1	θ_2	θ_3
z_1	$<[0.1,0.3];[0.2,0.4];[0.7,0.9]>$	$<[0.2,0.5];[0.3,0.5];[0.5,0.8]>$	$<[0.3,0.5];[0.1,0.3];[0.5,0.7]>$
z_2	$<[0.2,0.5];[0.3,0.4];[0.5,0.8]>$	$<[0.2,0.3];[0.2,0.4];[0.7,0.8]>$	$<[0.2,0.7];[0.3,0.4];[0.3,0.8]>$
z_3	$<[0.2,0.6];[0.2,0.4];[0.4,0.8]>$	$<[0.4,0.5];[0.2,0.6];[0.5,0.6]>$	$<[0.1,0.3];[0.5,0.8];[0.7,0.9]>$
z_4	$<[0.1,0.7];[0.4,0.5];[0.3,0.9]>$	$<[0.1,0.3];[0.1,0.5];[0.7,0.9]>$	$<[0.2,0.5];[0.3,0.7];[0.5,0.8]>$
z_5	$<[0.2,0.4];[0.4,0.5];[0.6,0.8]>$	$<[0.3,0.6];[0.4,0.7];[0.4,0.7]>$	$<[0.3,0.6];[0.2,0.3];[0.4,0.7]>$

$$\left\{\begin{array}{l} \left(\theta_2, \left\{\begin{array}{l} z_1/<[0.2,0.4];[0.3,0.6];[0.6,0.8]>, z_2/<[0.1,0.3];[0.2,0.5];[0.7,0.9]>, \\ z_3/<[0.3,0.5];[0.2,0.7];[0.5,0.7]>, z_4/<[0.1,0.3];[0.1,0.7];[0.7,0.9]>, \\ z_5/<[0.2,0.5];[0.4,0.8];[0.5,0.8]> \end{array}\right\}\right), \\ \left(\theta_3, \left\{\begin{array}{l} z_1/<[0.2,0.4];[0.2,0.5];[0.6,0.8]>, z_2/<[0.2,0.6];[0.3,0.5];[0.4,0.8]>, \\ z_3/<[0.1,0.2];[0.6,0.9];[0.8,0.9]>, z_4/<[0.2,0.4];[0.4,0.8];[0.6,0.8]>, \\ z_5/<[0.2,0.5];[0.4,0.7];[0.5,0.8]> \end{array}\right\}\right) \end{array}\right\}$$

$$(\mathcal{N}_{\mathcal{VHS}_2}, \Delta) =$$

$$\left\{\begin{array}{l} \left(\theta_1, \left\{\begin{array}{l} z_1/<[0.1,0.3];[0.2,0.4];[0.7,0.9]>, z_2/<[0.2,0.5];[0.3,0.4];[0.5,0.8]>, \\ z_3/<[0.2,0.6];[0.2,0.4];[0.4,0.8]>, z_4/<[0.1,0.7];[0.4,0.5];[0.3,0.9]>, \\ z_5/<[0.2,0.4];[0.4,0.5];[0.6,0.8]> \end{array}\right\}\right), \\ \left(\theta_2, \left\{\begin{array}{l} z_1/<[0.2,0.5];[0.3,0.5];[0.5,0.8]>, z_2/<[0.2,0.3];[0.2,0.4];[0.7,0.8]>, \\ z_3/<[0.4,0.5];[0.2,0.6];[0.5,0.6]>, z_4/<[0.1,0.3];[0.1,0.5];[0.7,0.9]>, \\ z_5/<[0.3,0.6];[0.4,0.7];[0.4,0.7]> \end{array}\right\}\right), \\ \left(\theta_3, \left\{\begin{array}{l} z_1/<[0.3,0.5];[0.1,0.3];[0.5,0.7]>, z_2/<[0.2,0.7];[0.3,0.4];[0.3,0.8]>, \\ z_3/<[0.1,0.3];[0.5,0.8];[0.7,0.9]>, z_4/<[0.2,0.5];[0.3,0.7];[0.5,0.8]>, \\ z_5/<[0.3,0.6];[0.2,0.3];[0.4,0.7]> \end{array}\right\}\right) \end{array}\right\}$$

It can easily be seen that nVHs-set $(\mathcal{N}_{\mathcal{VHS}_1}, \Lambda) \subseteq$ nVHs-set $(\mathcal{N}_{\mathcal{VHS}_2}, \Delta)$ where as $\Lambda \subseteq \Delta$.

Definition 3.5. Two nVHs-sets $(\mathcal{N}_{\mathcal{VHS}_1}, \Lambda)$ and $(\mathcal{N}_{\mathcal{VHS}_2}\Delta)$, are nVHs-set equal if $(\mathcal{N}_{\mathcal{VHS}_1}, \Lambda) \subseteq (\mathcal{N}_{\mathcal{VHS}_2}, \Delta)$ and $(\mathcal{N}_{\mathcal{VHS}_2}, \Delta) \subseteq (\mathcal{N}_{\mathcal{VHS}_1}\Lambda)$

TABLE 4. $(\mathcal{N}_{\mathcal{VHS}}, \Lambda)^{\varsigma}$

$\mathcal{Z}$	θ_1	θ_2	θ_3
z_1	$<[0.7,0.9];[0.6,0.8];[0.1,0.3]>$	$<[0.5,0.8];[0.5,0.8];[0.2,0.5]>$	$<[0.5,0.7];[0.7,0.9];[0.3,0.5]>$
z_2	$<[0.5,0.8];[0.6,0.7];[0.2,0.5]>$	$<[0.7,0.8];[0.6,0.8];[0.2,0.3]>$	$<[0.3,0.8];[0.6,0.7];[0.2,0.7]>$
z_3	$<[0.4,0.8];[0.6,0.8];[0.2,0.6]>$	$<[0.5,0.6];[0.4,0.8];[0.4,0.5]>$	$<[0.7,0.9];[0.2,0.5];[0.1,0.3]>$
z_4	$<[0.3,0.9];[0.5,0.6];[0.1,0.7]>$	$<[0.7,0.9];[0.5,0.9];[0.1,0.3]>$	$<[0.5,0.8];[0.3,0.7];[0.2,0.5]>$
z_5	$<[0.6,0.8];[0.5,0.6];[0.2,0.4]>$	$<[0.4,0.7];[0.3,0.6];[0.3,0.6]>$	$<[0.4,0.7];[0.7,0.8];[0.3,0.6]>$

Definition 3.6. A nVHs-set $(\mathcal{N}_{\mathcal{VS}}, \Lambda)$ is null nVHs-set written as $\Phi_{\mathcal{N}_{\mathcal{VHS}}}$ if following conditions holds for all values $\pi \in \mathcal{Z}$ and $\theta \in \Lambda$; $\mathcal{T}_{\mathcal{N}_{\mathcal{VHS}(\theta)}}(\pi) = [0,0]$, $\mathcal{I}_{\mathcal{N}_{\mathcal{VHS}(\theta)}}(\pi) = [1,1]$, and $\mathcal{F}_{\mathcal{N}_{\mathcal{VHS}(\theta)}}(\pi) = [1,1]$.

Definition 3.7. A nVHs-set $(\mathcal{N}_{\mathcal{VHS}}, \Lambda)$ is absolute nVHs-set written as $\Psi_{\mathcal{N}_{\mathcal{VHS}}}$ if following conditions holds for all values $\pi \in \mathcal{Z}$ and $\theta \in \Lambda$; $\mathcal{T}_{\mathcal{N}_{\mathcal{VHS}(\theta)}}(\pi) = [1,1]$, $\mathcal{I}_{\mathcal{N}_{\mathcal{VHS}(\theta)}}(\pi) = [0,0]$, and $\mathcal{F}_{\mathcal{N}_{\mathcal{VHS}(\theta)}}(\pi) = [0,0]$.

Definition 3.8. The compliment $(\mathcal{N}_{\mathcal{VHS}}, \Lambda)^{\varsigma}$ of nVs-set $(\mathcal{N}_{\mathcal{VHS}}, \Lambda)$ is given by $(\mathcal{N}_{\mathcal{VHS}}, \Lambda)^{\varsigma} = (\mathcal{N}^{\varsigma}_{\mathcal{VHS}}, \Lambda)$ where $\mathcal{N}^{\varsigma}_{\mathcal{VHS}} : \Lambda \to \mathcal{N}_{\mathcal{V}}(\mathcal{Z})$ is defined as $\mathcal{N}^{\varsigma}_{\mathcal{VHS}}(\pi) = \varsigma(\mathcal{N}_{\mathcal{VHS}}(\pi)), \forall \pi \in \Lambda$ such that $\mathcal{N}_{\mathcal{V}}(\mathcal{Z})$ represents set of all nVHs-subsets of $\mathcal{Z}$ and ς is neutrosophic vague compliment.

Example 3.9. Consider $(\mathcal{N}_{\mathcal{VHS}}, \Lambda)$ is nVHs-set defined as in Example 3.2 where $\Lambda = \{\theta_1, \theta_2, \theta_3\}$ for $\theta_i \in \Lambda_1 \times \Lambda_2 \times \Lambda_3, i = 1,2,3$. The compliment $(\mathcal{N}_{\mathcal{VHS}}, \Lambda)^{\varsigma}$ of nVHs-set $(\mathcal{N}_{\mathcal{VHS}}, \Lambda)$ is demonstrated in table 4 and given by:

$$(\mathcal{N}_{\mathcal{VHS}}, \Lambda)^{\varsigma} = \left\{ \begin{array}{l} \left(\theta_1, \left\{ \begin{array}{l} z_1/<[0.7,0.9];[0.6,0.8];[0.1,0.3]>, z_2/<[0.5,0.8];[0.6,0.7];[0.2,0.5]>, \\ z_3/<[0.4,0.8];[0.6,0.8];[0.2,0.6]>, z_4/<[0.3,0.9];[0.5,0.6];[0.1,0.7]>, \\ z_5/<[0.6,0.8];[0.5,0.6];[0.2,0.4]> \end{array} \right\} \right), \\ \left(\theta_2, \left\{ \begin{array}{l} z_1/<[0.5,0.8];[0.5,0.8];[0.2,0.5]>, z_2/<[0.7,0.8];[0.6,0.8];[0.2,0.3]>, \\ z_3/<[0.5,0.6];[0.4,0.8];[0.4,0.5]>, z_4/<[0.7,0.9];[0.5,0.9];[0.1,0.3]>, \\ z_5/<[0.4,0.7];[0.3,0.6];[0.3,0.6]> \end{array} \right\} \right), \\ \left(\theta_3, \left\{ \begin{array}{l} z_1/<[0.5,0.7];[0.7,0.9];[0.3,0.5]>, z_2/<[0.3,0.8];[0.6,0.7];[0.2,0.7]>, \\ z_3/<[0.7,0.9];[0.2,0.5];[0.1,0.3]>, z_4/<[0.5,0.8];[0.3,0.7];[0.2,0.5]>, \\ z_5/<[0.4,0.7];[0.7,0.8];[0.3,0.6]> \end{array} \right\} \right) \end{array} \right\}.$$

Definition 3.10. The intersection $(\mathcal{N}_{\mathcal{VHS}}, \Upsilon)$ of two nVHs-sets $(\mathcal{N}_{\mathcal{VHS}_1}, \Lambda)$ and $(\mathcal{N}_{\mathcal{VHS}_2}, \Delta)$ denoted by $\mathcal{N}_{\mathcal{VHS}} = \mathcal{N}_{\mathcal{VHS}_1} \hat{\cap} \mathcal{N}_{\mathcal{VHS}_2}$ where $\Upsilon = \Lambda \cup \Delta$ and $\forall \theta \in \Upsilon$, is given by

$$(\mathcal{N}_{\mathcal{VHS}}, \Upsilon) = \left\{ \begin{array}{cc} \mathcal{N}_{\mathcal{VHS}_1}(\theta) & , if \theta \in \Lambda - \Delta \\ \mathcal{N}_{\mathcal{VHS}_2}(\theta) & , if \theta \in \Delta - \Lambda \\ \mathcal{N}_{\mathcal{VHS}_1}(\theta) \hat{\cap} \mathcal{N}_{\mathcal{VHS}_2}(\theta) & , if \theta \in \Lambda \cap \Delta, \end{array} \right\},$$

where $\hat{\cap}$ is nV-set intersection.

TABLE 5. nVHs-set $(\mathcal{N}_{\mathcal{VHS}_1}, \Lambda)$

$\mathcal{Z}$	θ_1	θ_2
z_1	$< [0.1, 0.3]; [0.2, 0.4]; [0.7, 0.9] >$	$< [0.3, 0.6]; [0.2, 0.5]; [0.4, 0.7] >$
z_2	$< [0.2, 0.5]; [0.3, 0.4]; [0.5, 0.8] >$	$< [0.1, 0.3]; [0.2, 0.5]; [0.7, 0.9] >$
z_3	$< [0.2, 0.6]; [0.2, 0.4]; [0.4, 0.8] >$	$< [0.3, 0.6]; [0.2, 0.4]; [0.4, 0.7] >$
z_4	$< [0.1, 0.7]; [0.4, 0.5]; [0.3, 0.9] >$	$< [0.2, 0.3]; [0.3, 0.5]; [0.7, 0.8] >$
z_5	$< [0.2, 0.4]; [0.4, 0.5]; [0.6, 0.8] >$	$< [0.3, 0.4]; [0.5, 0.7]; [0.6, 0.7] >$

TABLE 6. nVHs-set $(\mathcal{N}_{\mathcal{VHS}_2}, \Delta)$

$\mathcal{Z}$	θ_2	θ_3
z_1	$< [0.2, 0.5]; [0.3, 0.5]; [0.5, 0.8] >$	$< [0.3, 0.5]; [0.1, 0.3]; [0.5, 0.7] >$
z_2	$< [0.2, 0.3]; [0.2, 0.4]; [0.7, 0.8] >$	$< [0.2, 0.7]; [0.3, 0.4]; [0.3, 0.8] >$
z_3	$< [0.4, 0.5]; [0.2, 0.6]; [0.5, 0.6] >$	$< [0.1, 0.3]; [0.5, 0.8]; [0.7, 0.9] >$
z_4	$< [0.1, 0.3]; [0.1, 0.5]; [0.7, 0.9] >$	$< [0.2, 0.5]; [0.3, 0.7]; [0.5, 0.8] >$
z_5	$< [0.3, 0.6]; [0.4, 0.7]; [0.4, 0.7] >$	$< [0.3, 0.6]; [0.2, 0.3]; [0.4, 0.7] >$

Example 3.11. Let $(\mathcal{N}_{\mathcal{VHS}_1}, \Lambda)$ and $(\mathcal{N}_{\mathcal{VHS}_2}, \Delta)$ are two nVHs-sets where $\Lambda = \{\theta_1, \theta_2\}$ for $\theta_i \in \Lambda_1 \times \Lambda_2 \times \Lambda_3, i = 1, 2$ and $\Delta = \{\theta_2, \theta_3\}$ for $\theta_i \in \Delta_1 \times \Delta_2 \times \Delta_3, i = 2, 3$, as discussed in Example 3.2 and demonstrated in table 5 and table 6 and given as following:

$$(\mathcal{N}_{\mathcal{VHS}_1}, \Lambda) = \left\{ \begin{array}{l} \left(\theta_1, \left\{ \begin{array}{l} z_1/ < [0.1, 0.3]; [0.2, 0.4]; [0.7, 0.9] >, z_2/ < [0.2, 0.5]; [0.3, 0.4]; [0.5, 0.8] >, \\ z_3/ < [0.2, 0.6]; [0.2, 0.4]; [0.4, 0.8] >, z_4/ < [0.1, 0.7]; [0.4, 0.5]; [0.3, 0.9] >, \\ z_5/ < [0.2, 0.4]; [0.4, 0.5]; [0.6, 0.8] > \end{array} \right\} \right), \\ \left(\theta_2, \left\{ \begin{array}{l} z_1/ < [0.3, 0.6]; [0.2, 0.5]; [0.4, 0.7] >, z_2/ < [0.1, 0.3]; [0.2, 0.5]; [0.7, 0.9] >, \\ z_3/ < [0.3, 0.6]; [0.2, 0.4]; [0.4, 0.7] >, z_4/ < [0.2, 0.3]; [0.3, 0.5]; [0.7, 0.8] >, \\ z_5/ < [0.3, 0.4]; [0.5, 0.7]; [0.6, 0.7] > \end{array} \right\} \right), \end{array} \right\}.$$

$$(\mathcal{N}_{\mathcal{VHS}_2}, \Delta) = \left\{ \begin{array}{l} \left(\theta_2, \left\{ \begin{array}{l} z_1/ < [0.2, 0.5]; [0.3, 0.5]; [0.5, 0.8] >, z_2/ < [0.2, 0.3]; [0.2, 0.4]; [0.7, 0.8] >, \\ z_3/ < [0.4, 0.5]; [0.2, 0.6]; [0.5, 0.6] >, z_4/ < [0.1, 0.3]; [0.1, 0.5]; [0.7, 0.9] >, \\ z_5/ < [0.3, 0.6]; [0.4, 0.7]; [0.4, 0.7] > \end{array} \right\} \right), \\ \left(\theta_3, \left\{ \begin{array}{l} z_1/ < [0.3, 0.5]; [0.1, 0.3]; [0.5, 0.7] >, z_2/ < [0.2, 0.7]; [0.3, 0.4]; [0.3, 0.8] >, \\ z_3/ < [0.1, 0.3]; [0.5, 0.8]; [0.7, 0.9] >, z_4/ < [0.2, 0.5]; [0.3, 0.7]; [0.5, 0.8] >, \\ z_5/ < [0.3, 0.6]; [0.2, 0.3]; [0.4, 0.7] > \end{array} \right\} \right) \end{array} \right\}.$$

The intersection $(\mathcal{N}_{\mathcal{VHS}}, \Upsilon)$ of two nVHs-sets $(\mathcal{N}_{\mathcal{VHS}_1}, \Lambda)$ and $(\mathcal{N}_{\mathcal{VHS}_2}, \Delta)$ represented by $\mathcal{N}_{\mathcal{VHS}} = \mathcal{N}_{\mathcal{VHS}_1} \hat{\cap} \mathcal{N}_{\mathcal{VHS}_2}$ where $\Upsilon = \Lambda \cup \Delta$ and $\forall \theta \in \Upsilon$, is demonstrated in table 7 and given by $(\mathcal{N}_{\mathcal{VHS}}, \Upsilon) = (\mathcal{N}_{\mathcal{VHS}_1}, \Lambda) \hat{\cap} (\mathcal{N}_{\mathcal{VHS}_2}, \Delta)$

$$(\mathcal{N}_{\mathcal{VHS}}, \Upsilon) = \left\{ \begin{array}{l} \left(\theta_1, \left\{ \begin{array}{l} z_1/ < [0.1, 0.3]; [0.2, 0.4]; [0.7, 0.9] >, z_2/ < [0.2, 0.5]; [0.3, 0.4]; [0.5, 0.8] >, \\ z_3/ < [0.2, 0.6]; [0.2, 0.4]; [0.4, 0.8] >, z_4/ < [0.1, 0.7]; [0.4, 0.5]; [0.3, 0.9] >, \\ z_5/ < [0.2, 0.4]; [0.4, 0.5]; [0.6, 0.8] > \end{array} \right\} \right), \\ \left(\theta_2, \left\{ \begin{array}{l} z_1/ < [0.2, 0.5]; [0.3, 0.5]; [0.5, 0.8] >, z_2/ < [0.1, 0.3]; [0.2, 0.5]; [0.7, 0.9] >, \\ z_3/ < [0.3, 0.5]; [0.2, 0.6]; [0.5, 0.7] >, z_4/ < [0.1, 0.3]; [0.3, 0.5]; [0.7, 0.9] >, \\ z_5/ < [0.3, 0.4]; [0.5, 0.7]; [0.6, 0.7] > \end{array} \right\} \right), \\ \left(\theta_3, \left\{ \begin{array}{l} z_1/ < [0.3, 0.5]; [0.1, 0.3]; [0.5, 0.7] >, z_2/ < [0.2, 0.7]; [0.3, 0.4]; [0.3, 0.8] >, \\ z_3/ < [0.1, 0.3]; [0.5, 0.8]; [0.7, 0.9] >, z_4/ < [0.2, 0.5]; [0.3, 0.7]; [0.5, 0.8] >, \\ z_5/ < [0.3, 0.6]; [0.2, 0.3]; [0.4, 0.7] > \end{array} \right\} \right) \end{array} \right\}$$

TABLE 7. $(\mathcal{N}_{\mathcal{VHS}}, \Upsilon) = (\mathcal{N}_{\mathcal{VHS}_1}, \Lambda)\hat{\cap}(\mathcal{N}_{\mathcal{VHS}_2}, \Delta)$

$\mathcal{Z}$	θ_1	θ_2	θ_3
z_1	$< [0.1, 0.3]; [0.2, 0.4]; [0.7, 0.9] >$	$< [0.2, 0.5]; [0.3, 0.5]; [0.5, 0.8] >$	$< [0.3, 0.5]; [0.1, 0.3]; [0.5, 0.7] >$
z_2	$< [0.2, 0.5]; [0.3, 0.4]; [0.5, 0.8] >$	$< [0.1, 0.3]; [0.2, 0.5]; [0.7, 0.9] >$	$< [0.2, 0.7]; [0.3, 0.4]; [0.3, 0.8] >$
z_3	$< [0.2, 0.6]; [0.2, 0.4]; [0.4, 0.8] >$	$< [0.3, 0.5]; [0.2, 0.6]; [0.5, 0.7] >$	$< [0.1, 0.3]; [0.5, 0.8]; [0.7, 0.9] >$
z_4	$< [0.1, 0.7]; [0.4, 0.5]; [0.3, 0.9] >$	$< [0.1, 0.3]; [0.3, 0.5]; [0.7, 0.9] >$	$< [0.2, 0.5]; [0.3, 0.7]; [0.5, 0.8] >$
z_5	$< [0.2, 0.4]; [0.4, 0.5]; [0.6, 0.8] >$	$< [0.3, 0.4]; [0.5, 0.7]; [0.6, 0.7] >$	$< [0.3, 0.6]; [0.2, 0.3]; [0.4, 0.7] >$

TABLE 8. nVHs-set $(\mathcal{N}_{\mathcal{VHS}}, \Upsilon)$

$\mathcal{Z}$	θ_1	θ_2	θ_3
z_1	$< [0.1, 0.3]; [0.2, 0.4]; [0.7, 0.9] >$	$< [0.2, 0.5]; [0.3, 0.5]; [0.5, 0.8] >$	$< [0.3, 0.5]; [0.1, 0.3]; [0.5, 0.7] >$
z_2	$< [0.2, 0.5]; [0.3, 0.4]; [0.5, 0.8] >$	$< [0.1, 0.3]; [0.2, 0.5]; [0.7, 0.9] >$	$< [0.2, 0.7]; [0.3, 0.4]; [0.3, 0.8] >$
z_3	$< [0.2, 0.6]; [0.2, 0.4]; [0.4, 0.8] >$	$< [0.3, 0.5]; [0.2, 0.6]; [0.5, 0.7] >$	$< [0.1, 0.3]; [0.5, 0.8]; [0.7, 0.9] >$
z_4	$< [0.1, 0.7]; [0.4, 0.5]; [0.3, 0.9] >$	$< [0.1, 0.3]; [0.3, 0.5]; [0.7, 0.9] >$	$< [0.2, 0.5]; [0.3, 0.7]; [0.5, 0.8] >$
z_5	$< [0.2, 0.4]; [0.4, 0.5]; [0.6, 0.8] >$	$< [0.3, 0.4]; [0.5, 0.7]; [0.6, 0.7] >$	$< [0.3, 0.6]; [0.2, 0.3]; [0.4, 0.7] >$

Definition 3.12. The union $(\mathcal{N}_{\mathcal{VHS}}, \Upsilon)$ of two nVHs-sets $(\mathcal{N}_{\mathcal{VHS}_1}, \Lambda)$ and $(\mathcal{N}_{\mathcal{VHS}_2}, \Delta)$ denoted by $\mathcal{N}_{\mathcal{VHS}} = \mathcal{N}_{\mathcal{VHS}_1} \check{\cup} \mathcal{N}_{\mathcal{VHS}_2}$ where $\Upsilon = \Lambda \cup \Delta$ and $\forall \theta \in \Upsilon$, is given by

$$(\mathcal{N}_{\mathcal{VHS}}, \Upsilon) = \left\{ \begin{array}{cc} \mathcal{N}_{\mathcal{VHS}_1}(\theta) & , if \theta \in \Lambda - \Delta \\ \mathcal{N}_{\mathcal{VHS}_2}(\theta) & , if \theta \in \Delta - \Lambda \\ \mathcal{N}_{\mathcal{VHS}_1}(\theta) \check{\cap} \mathcal{N}_{\mathcal{VHS}_2}(\theta) & , if \theta \in \Lambda \cap \Delta, \end{array} \right\},$$

where $\check{\cup}$ is nV-set union.

Example 3.13. Let $(\mathcal{N}_{\mathcal{VHS}_1}, \Lambda)$ and $(\mathcal{N}_{\mathcal{VHS}_2}, \Delta)$ are two nVHs-sets as discussed in example 3.2 and defined in example 3.11
The union $(\mathcal{N}_{\mathcal{VHS}}, \Upsilon)$ of $(\mathcal{N}_{\mathcal{VHS}_1}, \Lambda)$ and $(\mathcal{N}_{\mathcal{VHS}_2}, \Delta)$ represented by $\mathcal{N}_{\mathcal{VHS}} = \mathcal{N}_{\mathcal{VHS}_1} \check{\cup} \mathcal{N}_{\mathcal{VHS}_2}$ where $\Upsilon = \Lambda \cup \Delta$ and $\forall \theta \in \Upsilon$, is demonstrated in table 8 and given by $(\mathcal{N}_{\mathcal{VHS}}, \Upsilon) = (\mathcal{N}_{\mathcal{VHS}_1}, \Lambda) \check{\cup} (\mathcal{N}_{\mathcal{VHS}_2}, \Delta) =$

$$(\mathcal{N}_{\mathcal{VHS}}, \Upsilon) = \left\{ \begin{array}{c} \left(\theta_1, \left\{ \begin{array}{c} z_1/ < [0.1, 0.3]; [0.2, 0.4]; [0.7, 0.9] >, z_2/ < [0.2, 0.5]; [0.3, 0.4]; [0.5, 0.8] >, \\ z_3/ < [0.2, 0.6]; [0.2, 0.4]; [0.4, 0.8] >, z_4/ < [0.1, 0.7]; [0.4, 0.5]; [0.3, 0.9] >, \\ z_5/ < [0.2, 0.4]; [0.4, 0.5]; [0.6, 0.8] > \end{array} \right\} \right), \\ \left(\theta_2, \left\{ \begin{array}{c} z_1/ < [0.3, 0.6]; [0.2, 0.5]; [0.4, 0.7] >, z_2/ < [0.2, 0.3]; [0.2, 0.4]; [0.7, 0.8] >, \\ z_3/ < [0.4, 0.6]; [0.2, 0.4]; [0.4, 0.6] >, z_4/ < [0.2, 0.3]; [0.1, 0.5]; [0.7, 0.8] >, \\ z_5/ < [0.3, 0.6]; [0.4, 0.7]; [0.4, 0.7] > \end{array} \right\} \right), \\ \left(\theta_3, \left\{ \begin{array}{c} z_1/ < [0.3, 0.5]; [0.1, 0.3]; [0.5, 0.7] >, z_2/ < [0.2, 0.7]; [0.3, 0.4]; [0.3, 0.8] >, \\ z_3/ < [0.1, 0.3]; [0.5, 0.8]; [0.7, 0.9] >, z_4/ < [0.2, 0.5]; [0.3, 0.7]; [0.5, 0.8] >, \\ z_5/ < [0.3, 0.6]; [0.2, 0.3]; [0.4, 0.7] > \end{array} \right\} \right) \end{array} \right\}.$$

Proposition 3.14. *Let $(\mathcal{N}_{\mathcal{VHS}_1}, \Lambda)$ and $(\mathcal{N}_{\mathcal{VHS}_2}, \Delta)$ are two nVHs-sets over $\mathcal{Z}$, the following laws hold.*

(1) $(\mathcal{N}_{\mathcal{VHS}_1}, \Lambda)\hat{\cap}(\mathcal{N}_{\mathcal{VHS}_1}, \Lambda) = (\mathcal{N}_{\mathcal{VHS}_1}, \Lambda)$

(2) $(\mathcal{N}_{\mathcal{VHS}_1},\Lambda)\breve{\cup}(\mathcal{N}_{\mathcal{VHS}_1},\Lambda) = (\mathcal{N}_{\mathcal{VHS}_1},\Lambda)$
(3) $(\mathcal{N}_{\mathcal{VHS}_1},\Lambda)\hat{\cap}(\mathcal{N}_{\mathcal{VHS}_2},\Delta) = (\mathcal{N}_{\mathcal{VHS}_2},\Delta)\hat{\cap}(\mathcal{N}_{\mathcal{VHS}_1},\Lambda)$
(4) $(\mathcal{N}_{\mathcal{VHS}_1},\Lambda)\breve{\cup}(\mathcal{N}_{\mathcal{VHS}_2},\Delta) = (\mathcal{N}_{\mathcal{VHS}_2},\Delta)\breve{\cup}(\mathcal{N}_{\mathcal{VHS}_1},\Lambda)$

Proposition 3.15. *Let $(\mathcal{N}_{\mathcal{VHS}_1},\Lambda)$, $(\mathcal{N}_{\mathcal{VHS}_2},\Delta)$ and $(\mathcal{N}_{\mathcal{VHS}_3},\Upsilon)$ are three nVHs-sets over $\mathcal{Z}$, the following laws hold.*

(1) $(\mathcal{N}_{\mathcal{VHS}_1},\Lambda)\hat{\cap}((\mathcal{N}_{\mathcal{VHS}_2},\Delta)\hat{\cap}(\mathcal{N}_{\mathcal{VHS}_1},\Upsilon)) = ((\mathcal{N}_{\mathcal{VHS}_1},\Lambda)\hat{\cap}(\mathcal{N}_{\mathcal{VHS}_2},\Delta))\hat{\cap}(\mathcal{N}_{\mathcal{VHS}_1},\Upsilon)$,
(2) $(\mathcal{N}_{\mathcal{VHS}_1},\Lambda)\breve{\cup}((\mathcal{N}_{\mathcal{VHS}_2},\Delta)\breve{\cup}(\mathcal{N}_{\mathcal{VHS}_1},\Upsilon)) = ((\mathcal{N}_{\mathcal{VHS}_1},\Lambda)\breve{\cup}(\mathcal{N}_{\mathcal{VHS}_2},\Delta))\breve{\cup}(\mathcal{N}_{\mathcal{VHS}_1},\Upsilon)$,
(3) $(\mathcal{N}_{\mathcal{VHS}_1},\Lambda)\hat{\cap}((\mathcal{N}_{\mathcal{VHS}_2},\Delta)\breve{\cup}(\mathcal{N}_{\mathcal{VHS}_3},\Upsilon)) =$
$((\mathcal{N}_{\mathcal{VHS}_1},\Lambda)\hat{\cap}(\mathcal{N}_{\mathcal{VHS}_2},\Delta))\breve{\cup}((\mathcal{N}_{\mathcal{VHS}_1},\Lambda)\hat{\cap}(\mathcal{N}_{\mathcal{VHS}_3},\Upsilon))$,
(4) $(\mathcal{N}_{\mathcal{VHS}_1},\Lambda)\breve{\cup}((\mathcal{N}_{\mathcal{VHS}_2},\Delta)\hat{\cap}(\mathcal{N}_{\mathcal{VHS}_3},\Upsilon)) =$
$((\mathcal{N}_{\mathcal{VHS}_1},\Lambda)\breve{\cup}(\mathcal{N}_{\mathcal{VHS}_2},\Delta))\hat{\cap}((\mathcal{N}_{\mathcal{VHS}_1},\Lambda)\breve{\cup}(\mathcal{N}_{\mathcal{VHS}_3},\Upsilon))$.

Proposition 3.16. *Let $(\mathcal{N}_{\mathcal{VHS}},\Lambda)$ be nVHs-set over $\mathcal{Z}$, the following laws hold.* 1) $(\mathcal{N}_{\mathcal{VHS}},\Lambda)\hat{\cap}(\mathcal{N}_{\mathcal{VHS}},\Lambda)^{\varsigma} = (\Phi_{\mathcal{N}_{\mathcal{VHS}}},\Lambda)$ *where* $(\Phi_{\mathcal{N}_{\mathcal{VHS}}},\Lambda)$ *is null nVHs-set* 2) $(\mathcal{N}_{\mathcal{VHS}},\Lambda)\breve{\cup}(\mathcal{N}_{\mathcal{VHS}},\Lambda)^{\varsigma} = (\Psi_{\mathcal{N}_{\mathcal{VHS}}},\Lambda)$ *where* $(\Psi_{\mathcal{N}_{\mathcal{VHS}}},\Lambda)$ *is called absolute nVHs-set*

Proposition 3.17. *Let $(\mathcal{N}_{\mathcal{VHS}_1},\Lambda)$ and $(\mathcal{N}_{\mathcal{VHS}_2},\Delta)$ are two nVHs-sets over $\mathcal{Z}$, the following laws hold.*

$$1)\ ((\mathcal{N}_{\mathcal{VHS}_1},\Lambda)\hat{\cap}(\mathcal{N}_{\mathcal{VHS}_2},\Delta))^{\varsigma} = (\mathcal{N}_{\mathcal{VHS}_1},\Lambda)^{\varsigma}\breve{\cup}(\mathcal{N}_{\mathcal{VHS}_2},\Delta)^{\varsigma}$$

$$2)\ ((\mathcal{N}_{\mathcal{VHS}_1},\Lambda)\breve{\cup}(\mathcal{N}_{\mathcal{VHS}_2},\Delta))^{\varsigma} = (\mathcal{N}_{\mathcal{VHS}_1},\Lambda)^{\varsigma}\hat{\cap}(\mathcal{N}_{\mathcal{VHS}_2},\Delta)^{\varsigma}$$

4. Decision Making Technique based on nVHs-set

A decision making nVHs-set based problem is discussed and an approach is made to address and solve this problem but first of all concept of level soft set is discussed.

Definition 4.1. Let $\bar{L} = \{(\bar{\alpha},\bar{\beta},\bar{\gamma})\}$ where $\bar{\alpha},\bar{\beta},\bar{\gamma} \in \bar{I}$ and $\bar{I}$ is set of all close subintervals of $[0,1]$, $\bar{\alpha} = [\bar{\alpha_1},\bar{\alpha_2}]$, $\bar{\beta} = [\bar{\beta}_1,\bar{\beta}_2]$ and $\bar{\gamma} = [\bar{\gamma_1},\bar{\gamma_2}]$, $0 \leq \bar{\alpha_2}+\bar{\beta}_2+\bar{\gamma_2} \leq 2$. The relation $\gtrapprox_{\bar{L}}$ on set $\bar{L}$ is called partial ordering on $\bar{L}$ if it satisfies following conditions:
$\forall(\bar{\alpha},\bar{\beta},\bar{\gamma}),(\bar{\mu},\bar{\nu},\bar{\omega}) \in \bar{L}$, $(\bar{\alpha},\bar{\beta},\bar{\gamma}) \gtrapprox_{\bar{L}} (\bar{\mu},\bar{\nu},\bar{\omega}) \in \bar{L} \Leftrightarrow \bar{\alpha} \geq \bar{\mu}, \bar{\beta} \leq \bar{\nu}, \bar{\gamma} \leq \bar{\omega}$, which means $[\bar{\alpha_1},\bar{\alpha_2}] \geq [\bar{\mu_1},\bar{\mu_2}]$ i.e. $\bar{\alpha_1} \geq \bar{\mu_1}$ and $\bar{\alpha_2} \geq \bar{\mu_2}$. Similarly $\bar{\beta}_1 \leq \bar{\nu_1}, \bar{\beta}_2 \leq \bar{\nu_2}$ and $\bar{\gamma_1} \leq \bar{\omega_1}, \bar{\gamma_2} \leq \bar{\omega_2}$

Definition 4.2. For a universal set $\mathcal{Z}$, let $\mathcal{E}$ be set of parameters and $\Lambda \subseteq \mathcal{E}$. $\digamma = (\mathcal{N}_{\mathcal{VHS}},\Lambda)$ be nVHs-set over $\mathcal{Z}$. $(\bar{\alpha},\bar{\beta},\bar{\gamma})-$level hypersoft set of $\digamma$ is crisp hypersoft set $\bar{L}(\digamma;\bar{\alpha},\bar{\beta},\bar{\gamma}) = (\mathcal{N}_{\mathcal{VHS}(\bar{\alpha},\bar{\beta},\bar{\gamma})},\Lambda)$, for $\bar{\alpha},\bar{\beta},\bar{\gamma} \in \bar{L}$ and is given by

$$\mathcal{N}_{\mathcal{VHS}(\bar{\alpha},\bar{\beta},\bar{\gamma})}(\theta) = \{\mathcal{N}_{\mathcal{VHS}(\theta)}(z) \gtrapprox_{\bar{L}} (\bar{\alpha},\bar{\beta},\bar{\gamma}) \forall z \in \mathcal{Z}\}$$

$$= \left\{\mathcal{T}_{\mathcal{N}_{\mathcal{VHS}(\theta)}}(z) \geq \bar{\alpha}, \mathcal{I}_{\mathcal{N}_{\mathcal{VHS}(\theta)}}(z) \leq \bar{\beta}, \mathcal{F}_{\mathcal{N}_{\mathcal{VHS}_{(\theta)}}}(z) \leq \bar{\gamma}, \forall z \in \mathcal{Z}, \theta \in \Lambda\right\}$$

The above definition was restated by replacing threshold parameter constant value triplets by function as thresholds on truth membership, indeterminacy and false membership values.

Definition 4.3. For a universal set $\mathcal{Z}$, let $\mathcal{E}$ be set of parameters and $\Lambda \subseteq \mathcal{E}$. $\mathcal{F} = (\mathcal{N}_{\mathcal{VHS}}, \Lambda)$ be nVHs-set over $\mathcal{Z}$. Let $\chi : \Lambda \to I \times I \times I$ be nVHs-set where $I = [0, 1]$. On the basis of χ, the level hypersoft set of $\mathcal{F}$ is a crisp hypersoft set $\bar{L}(\mathcal{F}, \chi) = (\mathcal{N}_{\mathcal{VHS}}, \Lambda)$ given by

$$\mathcal{N}_{\mathcal{VHS}_\chi}(\theta) = \bar{L}(\mathcal{N}_{\mathcal{VHS}}(\theta); \chi(\theta))$$
$$= \left\{\mathcal{N}_{\mathcal{VHS}(\theta)}(z) \gtrapprox_{\bar{L}} \chi(\theta) \forall z \in \mathcal{Z}\right\}$$
$$= \left\{\mathcal{T}_{\mathcal{N}_{\mathcal{VHS}(\theta)}}(z) \geq \mathcal{T}_\chi(\theta), \mathcal{I}_{\mathcal{N}_{\mathcal{VHS}(\theta)}}(z) \leq \mathcal{I}_\chi(\theta), \mathcal{F}_{\mathcal{N}_{\mathcal{VHS}(\theta)}}(z) \leq \mathcal{F}_\chi(\theta), \forall z \in \mathcal{Z}, \theta \in \Lambda\right\}$$

Consider the following example

Example 4.4. For a universal set $\mathcal{Z}$, let $\mathcal{E}$ be set of parameters and $\Lambda \subseteq \mathcal{E}$. $\mathcal{F} = (\mathcal{N}_{\mathcal{VHS}}, \Lambda)$ be nVHs-set over $\mathcal{Z}$. Let $avg_{\mathcal{F}} : \Lambda \to I \times I \times I$ be nV-set where $I = [0, 1]$ and is given by

$$\mathcal{T}^L_{avg_{\mathcal{F}}}(\theta) = \frac{1}{|\mathcal{Z}|} \sum_{z \in \mathcal{Z}} \mathcal{T}^L_{\mathcal{N}_{\mathcal{VHS}(\theta)}}(z), \mathcal{T}^R_{avg_{\mathcal{F}}}(\theta) = \frac{1}{|\mathcal{Z}|} \sum_{z \in \mathcal{Z}} \mathcal{T}^R_{\mathcal{N}_{\mathcal{VHS}(\theta)}}(z)$$
$$\mathcal{I}^L_{avg_{\mathcal{F}}}(\theta) = \frac{1}{|\mathcal{Z}|} \sum_{z \in \mathcal{Z}} \mathcal{I}^L_{\mathcal{N}_{\mathcal{VHS}(\theta)}}(z), \mathcal{I}^R_{avg_{\mathcal{F}}}(\theta) = \frac{1}{|\mathcal{Z}|} \sum_{z \in \mathcal{Z}} \mathcal{I}^R_{\mathcal{N}_{\mathcal{VHS}(\theta)}}(z)$$
$$\mathcal{F}^L_{avg_{\mathcal{F}}}(\theta) = \frac{1}{|\mathcal{Z}|} \sum_{z \in \mathcal{Z}} \mathcal{F}^L_{\mathcal{N}_{\mathcal{VHS}(\theta)}}(z), \mathcal{F}^R_{avg_{\mathcal{F}}}(\theta) = \frac{1}{|\mathcal{Z}|} \sum_{z \in \mathcal{Z}} \mathcal{F}^R_{\mathcal{N}_{\mathcal{VHS}(\theta)}}(z)$$

Here nV-set $avg_{\mathcal{F}}$ is known as $avg-$threshold of nVHs-set $\mathcal{F}$. $\bar{L}(\mathcal{F}; avg\mathcal{F}) = (\mathcal{N}_{\mathcal{VHS}_{avg\mathcal{F}}}, \Lambda)$ is called $avg-$level hypersoft set of $\mathcal{F}$ and can be given as

$$\mathcal{N}_{\mathcal{VHS}_{avg\mathcal{F}}}(\theta) = \bar{L}(\mathcal{N}_{\mathcal{VHS}}(\theta); avg_{\mathcal{F}}(\theta)) = \{\mathcal{N}_{\mathcal{VHS}\theta}(z) \gtrapprox_{\bar{L}} avg_{\mathcal{F}}(\theta)\}$$
$$= \left\{\mathcal{T}_{\mathcal{N}_{\mathcal{VHS}(\theta)}}(z) \geq \mathcal{T}_{avg_{\mathcal{F}}}(\theta), \mathcal{I}_{\mathcal{N}_{\mathcal{VHS}(\theta)}}(z) \leq \mathcal{I}_{avg_{\mathcal{F}}}(\theta), \mathcal{F}_{\mathcal{N}_{\mathcal{VHS}(\theta)}}(z) \leq \mathcal{F}_{avg_{\mathcal{F}}}(\theta), z \in \mathcal{Z}, \theta \in \Lambda\right\}$$

Example 4.5. An individual wants to buy a farmhouse from a real estate agent. He can construct a nVHs-set $\mathcal{F} = (\mathfrak{F}, \Lambda)$ according to his preference which describes characteristics of farmhouse. Let $\mathcal{Z} = \{z_1, z_2, ..., z_5\}$ be the universal set consisting of five farmhouses under consider-
ation. Let $\mathcal{E} = \{covered\,area = \theta_1, beautiful = \theta_2, cheap = \theta_3, location = \theta_4, altitude = \theta_5\}$ be the set of parameters. Let Λ_i be the nonempty subset of $\mathcal{E}$ for each $i = 1, 2, 3$ represent multi attribute set corresponding to each element of $\mathcal{E}$ and $\Lambda = \Lambda_1 \times \Lambda_2 \times \Lambda_3$, where $\Lambda_1 = \{a_{11}, a_{12}\}, \Lambda_2 = \{b_{11}\}, \Lambda_3 = \{c_{11}\}$. Let $\Lambda = \{\theta_1, \theta_2, \theta_3\}$ i.e. we have three criteria for evaluation where θ_1 stands for price which is low, high, very high, θ_2 stands for covered area which is less than 1 sq. mile, between 1 sq. mile to 5 sq. mile, more than 5 sq. miles and θ_3 stands for location which is sea shore, hilly area, desert.

TABLE 9. $(\mathfrak{F}, \Lambda)$

$\mathcal{Z}$	θ_1	θ_2	θ_3
z_1	$< [0.2, 0.3]; [0.2, 0.4]; [0.8, 0.9] >$	$< [0.2, 0.5]; [0.2, 0.5]; [0.5, 0.8] >$	$< [0.2, 0.5]; [0.1, 0.3]; [0.5, 0.8] >$
z_2	$< [0.3, 0.5]; [0.3, 0.4]; [0.5, 0.7] >$	$< [0.1, 0.3]; [0.2, 0.4]; [0.7, 0.9] >$	$< [0.2, 0.4]; [0.3, 0.4]; [0.6, 0.8] >$
z_3	$< [0.2, 0.6]; [0.2, 0.4]; [0.4, 0.8] >$	$< [0.4, 0.5]; [0.2, 0.6]; [0.5, 0.6] >$	$< [0.1, 0.3]; [0.4, 0.8]; [0.7, 0.9] >$
z_4	$< [0.1, 0.7]; [0.4, 0.6]; [0.3, 0.9] >$	$< [0.2, 0.4]; [0.1, 0.5]; [0.6, 0.8] >$	$< [0.2, 0.5]; [0.3, 0.7]; [0.5, 0.8] >$
z_5	$< [0.1, 0.4]; [0.4, 0.5]; [0.6, 0.9] >$	$< [0.3, 0.6]; [0.3, 0.7]; [0.4, 0.7] >$	$< [0.2, 0.6]; [0.2, 0.3]; [0.4, 0.8] >$

Consider

$$\mathfrak{F}(\theta_1) = \left\{ \begin{array}{l} z_1/ < [0.2, 0.3]; [0.2, 0.4]; [0.8, 0.9] >, z_2/ < [0.3, 0.5]; [0.3, 0.4]; [0.5, 0.7] >, \\ z_3/ < [0.2, 0.6]; [0.2, 0.4]; [0.4, 0.8] >, z_4/ < [0.1, 0.7]; [0.4, 0.6]; [0.3, 0.9] >, \\ z_5/ < [0.1, 0.4]; [0.4, 0.5]; [0.6, 0.9] > \end{array} \right\}$$

$$\mathfrak{F}(\theta_2) = \left\{ \begin{array}{l} z_1/ < [0.2, 0.5]; [0.2, 0.5]; [0.5, 0.8] >, z_2/ < [0.1, 0.3]; [0.2, 0.4]; [0.7, 0.9] >, \\ z_3/ < [0.4, 0.5]; [0.2, 0.6]; [0.5, 0.6] >, z_4/ < [0.2, 0.4]; [0.1, 0.5]; [0.6, 0.8] >, \\ z_5/ < [0.3, 0.6]; [0.3, 0.7]; [0.4, 0.7] > \end{array} \right\}$$

$$\mathfrak{F}(\theta_3) = \left\{ \begin{array}{l} z_1/ < [0.2, 0.5]; [0.1, 0.3]; [0.5, 0.8] >, z_2/ < [0.2, 0.4]; [0.3, 0.4]; [0.6, 0.8] >, \\ z_3/ < [0.1, 0.3]; [0.4, 0.8]; [0.7, 0.9] >, z_4/ < [0.2, 0.5]; [0.3, 0.7]; [0.5, 0.8] >, \\ z_5/ < [0.2, 0.6]; [0.2, 0.3]; [0.4, 0.8] > \end{array} \right\}$$

It can also be written as

$$(\mathfrak{F}, \Lambda) = \left\{ \begin{array}{l} \left(\theta_1, \left\{ \begin{array}{l} z_1/ < [0.2, 0.3]; [0.2, 0.4]; [0.8, 0.9] >, z_2/ < [0.3, 0.5]; [0.3, 0.4]; [0.5, 0.7] >, \\ z_3/ < [0.2, 0.6]; [0.2, 0.4]; [0.4, 0.8] >, z_4/ < [0.1, 0.7]; [0.4, 0.6]; [0.3, 0.9] >, \\ z_5/ < [0.1, 0.4]; [0.4, 0.5]; [0.6, 0.9] > \end{array} \right\} \right), \\ \left(\theta_2, \left\{ \begin{array}{l} z_1/ < [0.2, 0.5]; [0.2, 0.5]; [0.5, 0.8] >, z_2/ < [0.1, 0.3]; [0.2, 0.4]; [0.7, 0.9] >, \\ z_3/ < [0.4, 0.5]; [0.2, 0.6]; [0.5, 0.6] >, z_4/ < [0.2, 0.4]; [0.1, 0.5]; [0.6, 0.8] >, \\ z_5/ < [0.3, 0.6]; [0.3, 0.7]; [0.4, 0.7] > \end{array} \right\} \right), \\ \left(\theta_3, \left\{ \begin{array}{l} z_1/ < [0.2, 0.5]; [0.1, 0.3]; [0.5, 0.8] >, z_2/ < [0.2, 0.4]; [0.3, 0.4]; [0.6, 0.8] >, \\ z_3/ < [0.1, 0.3]; [0.4, 0.8]; [0.7, 0.9] >, z_4/ < [0.2, 0.5]; [0.3, 0.7]; [0.5, 0.8] >, \\ z_5/ < [0.2, 0.6]; [0.2, 0.3]; [0.4, 0.8] > \end{array} \right\} \right) \end{array} \right\}.$$

The nVHs-set $(\mathfrak{F}, \Lambda)$ can also be represented in the form of table 9 $avg-$threshold of $\digamma = (\mathfrak{F}, \Lambda)$ can easily be calculated as:

$$avg_(\mathfrak{F}, \Lambda) = \left\{ \begin{array}{l} < [0.18, 0.50]; [0.30, 0.46]; [0.50, 0.72] \setminus \theta_1 >, \\ < [0.24, 0.46]; [0.20, 0.67]; [0.54, 0.76] \setminus \theta_2 >, \\ < [0.18, 0.46]; [0.26, 0.50]; [0.54, 0.72] \setminus \theta_3 > \end{array} \right\}$$

$\bar{L}(\digamma, avg)$, the $avg-$level hypersoft set of $\digamma = (\mathfrak{F}, \Lambda)$ can be evaluated as:

$$\mathfrak{F}_{avg_\digamma}(\theta_1) = \bar{L}(\mathfrak{F}(\theta_1); avg_\digamma(\theta_1)) = \{z_2, z_3\}$$

$$\mathfrak{F}_{avg_\digamma}(\theta_2) = \bar{L}(\mathfrak{F}(\theta_2); avg_\digamma(\theta_2)) = \{z_3\}$$

$$\mathfrak{F}_{avg_\digamma}(\theta_3) = \bar{L}(\mathfrak{F}(\theta_3); avg_\digamma(\theta_3)) = \{z_1, z_5\}$$

4.1. *Level hypersoft set based approach*

An algorithm based on nVHs-set is developed for decision making

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Algorithm I

▷ **Start**

▷ **Input Stage**:

———1. Consider $\mathcal{Z}$ as universe of discourse

———2. Consider Λ as subset of set of parameters

———3. Classify parameters into disjoint parametric valued sets $\Lambda_1, \Lambda_2, \Lambda_3, ..., \Lambda_n$

———4. $\Lambda = \Lambda_1 \times \Lambda_2 \times \Lambda_3 \times ... \times \Lambda_n$

▷ **Construction Stage**:

———5. Construct nVHs-set $\digamma = (\mathfrak{F}, \Lambda)$

———6. Choose threshold value triple $(\bar{\alpha}, \bar{\beta}, \bar{\gamma}) \in \bar{L}$

OR

———6. Construct threshold nV-set $\chi : \Lambda \to I \times I \times I$ where $I = [0, 1]$

OR

———6. Choose $avg-$level decision rule.

▷ **Computation Stage**:

———7. Compute $(\bar{\alpha}, \bar{\beta}, \bar{\gamma})-$level hypersoft set $\bar{L}(\digamma, \bar{\alpha}, \bar{\beta}, \bar{\gamma})$

OR

———7. Compute level hypersoft set $\bar{L}(\digamma, \chi)$

OR

———7. Compute $avg-$level hypersoft set $\bar{L}(\digamma, avg)$

▷ **Output Stage**:

———8. Present $\bar{L}(\digamma, \bar{\alpha}, \bar{\beta}, \bar{\gamma})$ or $\bar{L}(\digamma, \chi)$ or $\bar{L}(\digamma, avg)$ in tabular form.

———9. Compute choice value c_p of z_p for any $z_p \in \mathcal{Z}$

———10. Select z_m if $c_m = \max_{z_p \in \mathcal{Z}}(c_p)$.

———11. Choose any value z_m if m has more than one values

▷ **End**

Example 4.6. Let $\digamma = (\mathfrak{F}, \Lambda)$ is nVHs-set as discussed in example 4.5 and demonstrated in table 9. By $avg-$level rule, $\bar{L}((\mathfrak{F}, \Lambda); avg)$ is obtained which is demonstrated in table 10. The elements of table 10 are represented by $z_{pq} = 1$ if $z_p \in \mathfrak{F}_{avg_{\digamma}}(\theta_q)$, otherwise $z_{pq} = 0$.

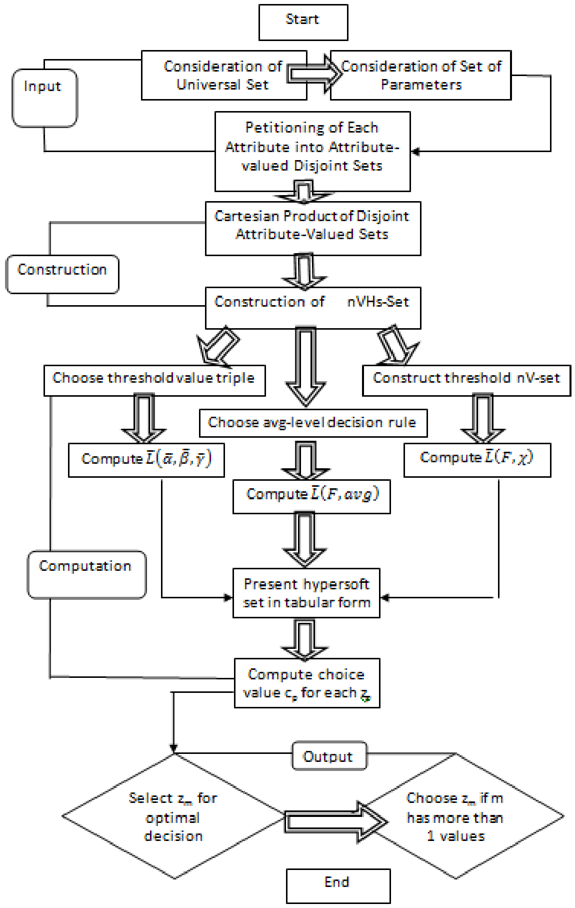

FIGURE 1. Algorithm I : Optimal Selection of material for manufacturing of Surgical Masks

TABLE 10. $\bar{L}((\mathfrak{F},\Lambda);avg)$ with choice vales

$\mathcal{Z}$	θ_1	θ_2	θ_3	choice value
z_1	0	0	1	1
z_2	1	0	0	1
z_3	1	1	0	2
z_4	0	0	0	0
z_5	0	0	1	1

Choice value can be obtained by $c_p = \sum_{q=1}^{5} z_{pq}$ i.e. $c_1 = 1$, $c_2 = 1$, $c_3 = 2$, $c_4 = 0$ and $c_5 = 1$
Farmhouse z_3 is selected as $c_3 = \max_{z_p \in \mathcal{Z}}(c_p)$

5. Comparison Analysis

Different decision making approaches have already been discussed in literature [12, 13, 17, 22, 23] that were based on hybridized structures of fuzzy set, intuitionistic fuzzy soft set and

Table 11. The advantage of the proposed study

Sr. No.	Author	Structure	Multi-argument approximate function
1	Smarandache [9]	Neutrosophic set	Insufficient
2	Molodtsov [10]	Soft set	Insufficient
3	Xu et al. [16]	Vague soft set	Insufficient
4	Alhazaymeh et al. [17]	Generalized vague soft set	Insufficient
5	Maji et al. [20]	Neutrosophic soft set	Insufficient
6	Alhazaymeh et al. [23]	Interval valued vague soft set	Insufficient
7	Alkhazaleh [34]	Neutrosophic vague set	Insufficient
8	Al Quran et al. [35]	Neutrosophic vague soft set	Insufficient
9	Smarandache [36]	Hypersoft set	Insufficient
10	Proposed Structure	Neutrosophic vague hypersoft set	Sufficient

neutrosophic set. Decision making is greatly affected due to many factors where attributes are not further classified into their disjoint attributive valued sets. The above mentioned existing decision making models are insufficient either for vague soft sets or for multi-argument approximate function but in proposed model, the inadequacies of these models have been addressed. The consideration of neutrosophic vague hypersoft set will make the decision making process more reliable and trust-worthy.

6. Discussion and Merits

In this section some merits of proposed structure are discussed:
The introduced approach took the significance of the idea of nVHs-set to deal with current decision making issues. The presented idea enables the researchers to deal with real-world scenario where problems involving indeterminacy and vagueness needs more attention. The core idea in this association has tremendous potential in the genuine depiction inside the space of computational incursions. As the proposed structure emphasizes on in-depth study of attributes (i.e. further partitioning of attributes) rather than focussing on attributes merely therefore it makes the decision-making process better, flexible and more reliable. It covers the characteristics and properties of the existing relevant structures i.e. fuzzy set, soft set, fuzzy soft set, intuitionistic fuzzy set, neutrosophic set, vague set, vague soft set, hypersoft set, neutrosophic vague soft set etc., so one can call it the generalized form of all these structures. The advantage of the proposed study can easily be judged from the table 11.

7. Conclusion

The summary of the proposed study is highlighted as:

(1) The relevant literature on fuzzy set, neutrosophic set, soft set, vague set and hypersoft set has been reviewed to support the main results.

(2) Some axiomatic and algebraic properties, set-theoretic operations and laws of nVHs-set have been investigated and explained with the help of illustrative examples.

(3) An algorithm based on set-theoretic operational concept of nVHs-set has been proposed to asses the role of proposed model in real-world decision-making scenario.

(4) A real-world decision-making application has been discussed by implementing the steps of proposed algorithm which opted the best farmhouse from real estate dealer.

(5) The advantageous aspects of the proposed model have been judged by comparing it with most relevant existing models.

(6) Many other real-world decision-making problems can be resolved with the help of the proposed algorithm.

Conflict of interest

The authors declare that they have no conflict of interest.

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