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Single-valued pentapartitioned neutrosophic weighted hyperbolic tangent similarity measure to determine the most significant environmental risks during the COVID-19 pandemic

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Abstract:

This paper investigates the concept of Single-Valued Pentapartitioned Neutrosophic Hyperbolic Tangent Similarity Measure (SVPNHTSM) and Single-Valued Pentapartitioned Neutrosophic Weighted Hyperbolic Tangent Similarity Measure (SVPNWHTSM) under the Single-Valued Pentapartitioned Neutrosophic Set (SVPNS) environment. SVPNHTSM and SVPNHTCSM also produce some interesting results relating to similarities between the two SVPNSs. In an SVPNS environment, SVPNHTSM is also used to bring the development of the Multi-Attribute Decision-Making (MADM) strategy. To determine the most affected factor of the environment affected by COVID-19, the novel SVPNHTSM is used. Results obtained from this study show that the incremental rate of water pollution is the major effect of COVID-19 on our environment. Finally, validation of the obtained results is done using comparative studies and sensitivity analysis.

Keywords: Fuzzy set, neutrosophic set, single-valued neutrosophic set, single-valued pentapartitioned neutrosophic set, multi-attribute decision-making, hyperbolic tangent similarity measure, COVID-19

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1. Introduction

COVID-19 is a respiratory illness caused by the novel Coronavirus SARS-CoV-2. It was first identified in December 2019 in Wuhan, China, and has since spread globally, leading to the ongoing COVID-19 pandemic [24]. The disease has affected millions of people and caused significant morbidity and mortality worldwide. Here, we present a literature review on COVID-19, focusing on the epidemiology, clinical features, and management of the disease.COVID-19 has affected people of all ages and backgrounds, but certain populations have been at higher risk of severe disease and death. Older adults, those with underlying health conditions such as diabetes, cardiovascular disease, and respiratory disease, and those with weakened immune systems are more likely to experience severe illness and complications. The virus is primarily transmitted through respiratory droplets when an infected person coughs, sneezes, or talks. It can also be transmitted by touching contaminated surfaces and then touching one's mouth, nose, or eyes. The incubation period for the virus is typically between 2 and 14 days, with an average of 5 days [44, 45].

The clinical features of COVID-19 vary widely, with some people experiencing mild symptoms or no symptoms at all, while others develop severe respiratory illness and other complications. The most common symptoms of COVID-19 include fever, cough, and shortness of breath. Other symptoms can include fatigue, muscle or body aches, headache, loss of taste or smell, sore throat, congestion, and diarrhea. Severe cases can lead to pneumonia, acute respiratory distress syndrome (ARDS), and multiple organ failure [44]. Management of COVID-19 depends on the severity of the illness and the individual patient's risk factors. Mild cases may not require hospitalization and can be managed with supportive care, such as rest, hydration, and fever-relieving medications. More severe cases may require hospitalization, oxygen therapy, and other supportive treatments. In some cases, antiviral medications such as Remdesivir and monoclonal antibodies may be used to reduce the severity of the illness. Vaccination is also a valuable tool in the management of COVID-19, as it can prevent infection and reduce the severity of illness in those who do become infected [16]. COVID-19 continues to be a significant public health threat, with ongoing research aimed at improving our understanding of the disease and developing more effective treatments and preventive measures. Early detection, isolation, and contact tracing remain significant strategies for controlling the spread of the virus, along with vaccination and public health measures such as social distancing, mask-wearing, and hand hygiene [2].

Multi-criteria decision analysis (MCDA) refers to a decision-making technique that involves evaluating and comparing alternatives based on multiple criteria or factors. This approach has been widely used in the context of COVID-19 to help decision-makers make informed choices regarding various aspects of the pandemic. Here are some examples of how MCDA has been applied in relation to COVID-19:One of the most pressing issues related to COVID-19 is the prioritization of vaccines, given the limited supply. MCDA can help decision-makers weigh various factors, such as the risk of severe illness or death, the risk of transmission, and the potential impact on essential workers or vulnerable populations, to determine which groups should receive priority access to the vaccine. For example, the World Health Organization (WHO) used an MCDA approach to develop its framework for vaccine allocation and prioritization, which took into account criteria such as the epidemiology of the disease, the impact on health systems, and ethical and social considerations [45].

Another significant decision related to COVID-19 is selecting which containment measures to implement in order to slow the spread of the virus. MCDA can be used to evaluate the effectiveness of different interventions, such as social distancing, mask mandates, or travel restrictions, based on various criteria, such as their impact on public health, the economy, and social well-being.

MCDA can also be used to assess the risk levels associated with different activities or settings, such as schools, workplaces, or public gatherings. By considering factors such as the number of people involved, the duration of the activity, the degree of ventilation, and the prevalence of the virus in the community, decision-makers can determine which activities pose the greatest risk and which measures should be implemented to mitigate that risk. For example, researchers in the United Kingdom used MCDA to evaluate the risk of COVID-19 transmission in different sports and physical activities [6]. Overall, MCDA is an effective tool for decision-makers who must weigh multiple criteria and factors when making decisions related to COVID-19. By considering a range of factors and evaluating alternative options, decision-makers can make more informed choices and prioritize interventions that are most likely to have a positive impact on public health and well-being.

Alamoodi et al. [1] presented a systematic review of Multi-Criteria Decision Making (MCDM) strategies employed in medical case studies of COVID-19. As research progresses, researchers are very interested in developing new MCDM/MCGDM techniques that use several types of sets and operators [14, 18-23]in various uncertain environments.

Mallick and Pramanik [26] developed the Pentapartitioned Neutrosophic Set (PNS) [26] in 2020 using the Neutrosophic Set (SVNS) [43] and multi-valued neutrosophic logic [41] to cope with uncertainty comprehensively by decomposing the indeterminacy Membership Function (MF) into three independent ingredients, namely, contradiction MF, ignorance MF, as well as unknown MF. Pramanik [36] developed interval PNS. Details studies of SVNSs and their applications and extensions can be found in the studies [3-4, 18-23, 30-35, 37, 42]. In 2021, Das et al. [7] rendered the Q-ideals of Q-algebra in PNS settings. Das and Tripathy [12] discussed topological space in PNS environments. Das et al. [9] presented probability distributions in PNS settings. So, PNSs are getting more attention in conducting research.

Das et al. [11] extended the tangent Similarity Measure (SM)[27, 28, 38] to the SVPNS environment. Das et al. [10] developed the MADM strategy under the SVPNS environment using Grey Relational Analysis (GRA). Cosine SM-based MCDM strategy [25] was presented for identifying the environmental risk factor due to COVID-19 under the SVPNS environment. Saha et al. [39] introduced the Dice SM-based MADM strategy under the SVPNS setting. Das et al. [8] developed the single-valued bipolar PNS and presented its application to the MADM problem.

Research gap:

- Single Valued Pentapartitioned Neutrosophic Hyperbolic Tangent SM (SVPNHTSM) has not been reported in the literature.
- There is no literature on an MADM strategy based on SVPNHTSM.

Motivation:

To fill the research chasm, we initiate to examine SVPNHTSM and Single Valued Pentapartitioned Neutrosophic Weighted Hyperbolic Tangent Similarity Measure (SVPNWHTSM) and present a few theorems and propositions on SVPNHTSM and SVPNWHTSM in the SVPNS environments. An innovative MADM strategy that is based on SVPNHTM under the SVPNS environment is developed in this paper.

Contributions of the paper are as follows:

1. This paper establishes the properties of the SVPNWHTSM and SVPNWHTSM.
2. This paper develops a novel MADM strategy using the proposed SVPNWHTSM to determine the most significant risk factors in the environment. Based on the proposed strategy, a range of alternatives are created and the ranking order is determined.
3. The novel MADM method's findings are compared to those of other existing strategies. The proposed strategy reveals that under the SVPNS environment, COVID-19 negatively impacts Water Pollution more than other alternatives.

The structure of the remaining paper is shown in Table 1.

Table 1. Structure of the paper

Name of the section	Content
Section 2	recalls some definitions of relevant terms.
Section 3	presents SVPNHTSM and SVPNWHTSM and some of their basic properties.
Section 4	develops SVPNHTSM based MADM strategy under SVPNS environment.
Section 5	presents of application of the developed MADM Strategy for selecting the poignant environmental risk factor at the time of the coronavirus.
Section 6	presents a comparative study.
Section 7	describes the sensitivity analysis.
Section 8	**Presents the advantage and disadvantage of the study**
Section 9	Presents the conclusions of the paper.

2. A list of relevant terms with definition

An overview of some of the results and definitions is presented here.

Let *V* be the sphere of discourse. An SVPNS [26] is presented as follows:

$$G' = \{(\kappa, a_{G'}(\kappa), b_{G'}(\kappa), c_{G'}(\kappa), d_{G'}(\kappa), e_{G'}(\kappa)) : \kappa \in \Omega\}.$$

Here, $a_{G'}(\kappa), b_{G'}(\kappa), c_{G'}(\kappa), d_{G'}(\kappa)$, and $e_{G'}(\kappa)$ are the truth, contradiction, ignorance, unknown and false MFs such that $a_{G'}(\kappa)$, $b_{G'}(\kappa)$, $c_{G'}(\kappa)$, $d_{G'}(\kappa)$, and $e_{G'}(\kappa) \in [0,1]$, for each $\kappa \in \Omega$. So, $0 \le a_{G'}(\kappa) + b_{G'}(\kappa) + c_{G'}(\kappa) + d_{G'}(\kappa) + e_{G'}(\kappa) \le 1$, for each $\kappa \in \Omega$.

Norms for the null SVPNS (0_{PNN}) and the absolute SVPNS (1_{PNN}) [26] for a fixed set Ω are presented as follows:

(a) $1_{PNN} = \{(\kappa, 1, 1, 0, 0, 0) : \kappa \in \Omega\}$,

(b) $0_{PNN} = \{(\kappa, 0, 0, 1, 1, 1) : \kappa \in \Omega\}$.

Let $H' = \{(\kappa, a_{H'}(\kappa), b_{H'}(\kappa), c_{H'}(\kappa), d_{H'}(\kappa), e_{H'}(\kappa)) : \kappa \in \Omega\}$ and

$G' = \{(\kappa, a_{G'}(\kappa), b_{G'}(\kappa), c_{G'}(\kappa), d_{G'}(\kappa), e_{G'}(\kappa)) : \kappa \in \Omega\}$ be any two SVPNSs [26] over V. Then,

(a) $H' \subseteq G'$ if and only if $a_{H'}(\kappa) \le a_{G'}(\kappa)$, $b_{H'}(\kappa) \le b_{G'}(\kappa)$, $c_{H'}(\kappa) \ge c_{G'}(\kappa)$, $d_{H'}(\kappa) \ge d_{G'}(\kappa)$,

$e_{H'}(\kappa) \ge e_{G'}(\kappa)$, for all $\kappa \in \Omega$.

(b) $G'^{c} = \{(\kappa, e_{G'}(\kappa), d_{G'}(\kappa), 1 - c_{G'}(\kappa), b_{G'}(\kappa), a_{G'}(\kappa)) : \kappa \in \Omega\}$;

(c) $H' \cup G'$

$$= \left\{\left(\kappa, \max\{a_{H'}(\kappa), a_{G'}(\kappa)\}, \max\{b_{H'}(\kappa), b_{G'}(\kappa)\}, \min\{c_{H'}(\kappa), c_{G'}(\kappa)\}, \min\{d_{H'}(\kappa), d_{G'}(\kappa)\}, \min\{e_{H'}(\kappa), e_{G'}(\kappa)\}\right) : \kappa \in \Omega\right\}$$

(d)
$H' \cap G'$

$$= \left\{\left(\kappa, \min\{a_{H'}(\kappa), a_{G'}(\kappa)\}, \min\{b_{H'}(\kappa), b_{G'}(\kappa)\}, \max\{c_{H'}(\kappa), c_{G'}(\kappa)\}, \max\{d_{H'}(\kappa), d_{G'}(\kappa)\}, \max\{e_{H'}(\kappa), e_{G'}(\kappa)\}\right) : \kappa \in \Omega\right\}$$

Consider H' = {(r′, 0.21, 0.37, 0.67, 0.14, 0.34), (s′, 0.41, 0.25, 0.48, 0.61, 0.11)} and G' = {(r′, 0.31, 0.48, 0.71, 0.24, 0.44), (s′, 0.49, 0.36, 0.50, 0.72, 0.25)} be two SVPNSs over a set of discourses V = {r′, s′}.

Then,

(i) $H' \subseteq G'$;

(ii) H'^{C} = {(r′, 0.79, 0.63, 0.33, 0.0.86, 0.66), (s′, 0.59, 0.75, 0.52, 0.39, 0.89)} and G'^{C} = {(r′, 0.69, 0.52, 0.29, 0.76, 0.56), (s′, 0.51, 0.64, 0.50, 0.28, .0.75)};

(iii) $H' \cup G'$ = {(r′, 0.31, 0.48, 0.71, 0.24, 0.44), (s′, 0.49, 0.36, 0.50, 0.72, 0.25)};

(iv) $H' \cap G'$ = {(r′, 0.21, 0.37, 0.67, 0.14, 0.34), (s′, 0.41, 0.25, 0.48, 0.61, 0.11)}.

3. SVPNHTSM and SVPNWHTSM and some of their basic properties

SVPNHTSM and SVPNWHTSM are here presented. Various interesting consequences have been drawn up under the SVPNS environment.

Definition 3.1 Suppose $H' = \{(\kappa, a_{H'}(\kappa), b_{H'}(\kappa), c_{H'}(\kappa), d_{H'}(\kappa), e_{H'}(\kappa)) : \kappa \in \Omega\}$ and

$G' = \{(\kappa, a_{G'}(\kappa), b_{G'}(\kappa), c_{G'}(\kappa), d_{G'}(\kappa), e_{G'}(\kappa)) : \kappa \in \Omega\}$ are two SVPNSs within the set V. Now, the SVPNHTSM between H' and G' is defined as:

$$\mathrm{P}_{\text{SVPNHTSM}}(H',G') =$$

$$\frac{1}{n}\sum_{\kappa\in\Omega}\tanh\left[\left|a_{H'}(\kappa)-a_{G'}(\kappa)\right|+\left|b_{H'}(\kappa)-b_{G'}(\kappa)\right|+\left|c_{H'}(\kappa)-c_{G'}(\kappa)\right|+\left|d_{H'}(\kappa)-d_{G'}(\kappa)\right|+\left|e_{H'}(\kappa)-e_{G'}(\kappa)\right|\right] \quad (1)$$

Theorem 3.2 The following properties hold, if $\mathrm{P}_{\text{SVPNHTSM}}(H',G')$ is the SVPNHTSM between the SVPNSs H' and G':

(a) $0 \le \mathrm{P}_{\text{SVPNHTSM}}(H',G') \le 1$;

(b) $\mathrm{P}_{\text{SVPNHTSM}}(H',G') = \mathrm{P}_{\text{SVPNHTSM}}(G',H')$;

(c) $H' = G' \Leftrightarrow \mathrm{P}_{\text{SVPNHTSM}}(H',G') = 0$.

Proof:(a) Since the hyperbolic tangent function is monotonic increasing function in the number line, therefore, it also belongs to the interval $[-1,1]$. Hence, $0 \le \mathrm{P}_{\text{SVPNHTSM}}(H',G') \le 1$.

(b) $\mathrm{P}_{\text{SVPNHTSM}}(H',G')$

$$=\frac{1}{n}\sum_{\kappa\in\Omega}\tanh\begin{bmatrix}\left|a_{H'}(\kappa)-a_{G'}(\kappa)\right|+\left|b_{H'}(\kappa)-b_{G'}(\kappa)\right|+\left|c_{H'}(\kappa)-c_{G'}(\kappa)\right|+\\ \left|d_{H'}(\kappa)-d_{G'}(\kappa)\right|+\left|e_{H'}(\kappa)-e_{G'}(\kappa)\right|\end{bmatrix}$$

$$=\frac{1}{n}\sum_{\kappa\in\Omega}\tanh\begin{bmatrix}\left|a_{G'}(\kappa)-a_{H'}(\kappa)\right|+\left|b_{G'}(\kappa)-b_{H'}(\kappa)\right|+\left|c_{G'}(\kappa)-c_{H'}(\kappa)\right|+\\ \left|d_{G'}(\kappa)-d_{H'}(\kappa)\right|+\left|e_{G'}(\kappa)-e_{H'}(\kappa)\right|\end{bmatrix} = \mathrm{P}_{\text{SVPNHTSM}}(G',H')$$

Therefore, $\mathrm{P}_{\text{SVPNHTSM}}(H',G') = \mathrm{P}_{\text{SVPNHTSM}}(G',H')$

(c) Assume that H' and G' are any two SVPNSs over Ω such that $H' = G'$.
Since, $H' = G'$

$\Rightarrow a_{H'}(\kappa)=a_{G'}(\kappa), b_{H'}(\kappa)=b_{G'}(\kappa), c_{H'}(\kappa)=c_{G'}(\kappa), d_{H'}(\kappa)=d_{G'}(\kappa), e_{H'}(\kappa)=e_{G'}(\kappa),$ for each $\kappa\in\Omega$.

$\Rightarrow \left|a_{H'}(\kappa)-a_{G'}(\kappa)\right|=0, \left|b_{H'}(\kappa)-b_{G'}(\kappa)\right|=0, \left|c_{H'}(\kappa)-c_{G'}(\kappa)\right|=0, \left|d_{H'}(\kappa)-d_{G'}(\kappa)\right|=0,$

$\left|e_{H'}(\kappa)-e_{G'}(\kappa)\right|=0,$ for each $\kappa\in\Omega$.

Hence $\mathrm{P}_{\text{SVPNHTSM}}(H',G') = \frac{1}{n}\sum_{\kappa\in\Omega}\tanh(0) = 0$.

Conversely, suppose that $\mathrm{P}_{\text{SVPNHTSM}}(H',G') = 0$.

$\Rightarrow \left|a_{H'}(\kappa)-a_{G'}(\kappa)\right|=0, \left|b_{H'}(\kappa)-b_{G'}(\kappa)\right|=0, \left|c_{H'}(\kappa)-c_{G'}(\kappa)\right|=0, \left|d_{H'}(\kappa)-d_{G'}(\kappa)\right|=0,$

$\left|e_{H'}(\kappa)-e_{G'}(\kappa)\right|=0,$ for each $\kappa\in\Omega$..

$$a_{H'}(\kappa)=a_{G'}(\kappa), b_{H'}(\kappa)=b_{G'}(\kappa), c_{H'}(\kappa)=c_{G'}(\kappa), d_{H'}(\kappa)=d_{G'}(\kappa) \text{ and } \chi_{H'}(\kappa)=e_{G'}(\kappa),$$

Hence $H'=G'$.

Theorem 3.3 If H', G' and Z' are any three SVPNSs over a fixed set V such as $H'\subseteq G'\subseteq Z'$, then

$$\mathrm{P}_{\text{SVPNHTSM}}(H',G')\le \mathrm{P}_{\text{SVPNHTSM}}(H',Z') \text{ and } \mathrm{P}_{\text{SVPNHTSM}}(G',Z')\le \mathrm{P}_{\text{SVPNHTSM}}(H',Z').$$

Proof. Let H', G' and Z' be any three SVPNSs over a fixed set V such as v $H'\subseteq G'\subseteq Z'$, .So,

$$a_{H'}(\kappa)\le a_{G'}(\kappa),\ b_{H'}(\kappa)\le b_{G'}(\kappa),\ c_{H'}(\kappa)\ge c_{G'}(\kappa),\ d_{H'}(\kappa)\ge d_{G'}(\kappa),\ e_{H'}(\kappa)\ge e_{G'}(\kappa),$$

$$a_{G'}(\kappa)\le a_{Z'}(\kappa),\quad b_{G'}(\kappa)\le b_{Z'}(\kappa),\quad c_{G'}(\kappa)\ge c_{Z'}(\kappa),\quad d_{G'}(\kappa)\ge d_{Z'}(\kappa),\quad e_{G'}(\kappa)\ge e_{Z'}(\kappa),$$

for each $\kappa\in\Omega$..

Therefore $|a_{H'}(\kappa)-a_{G'}(\kappa)|\le|a_{H'}(\kappa)-a_{Z'}(\kappa)|, |b_{H'}(\kappa)-b_{G'}(\kappa)|\le|b_{H'}(\kappa)-b_{Z'}(\kappa)|,$

$$|c_{H'}(\kappa)-c_{G'}(\kappa)|\le|c_{H'}(\kappa)-c_{Z'}(\kappa)|, |d_{H'}(\kappa)-d_{G'}(\kappa)|\le|d_{H'}(\kappa)-d_{Z'}(\kappa)|,$$
$$|e_{H'}(\kappa)-e_{G'}(\kappa)|\le|e_{H'}(\kappa)-e_{Z'}(\kappa)| \text{ for each } \kappa\in\Omega.$$

Therefore

$$\begin{aligned}&\mathrm{P}_{\text{SVPNHTSM}}(H',G')\\&=\frac{1}{n}\sum_{\kappa\in\Omega}\tanh\left[|a_{H'}(\kappa)-a_{G'}(\kappa)|+|b_{H'}(\kappa)-b_{G'}(\kappa)|+|c_{H'}(\kappa)-c_{G'}(\kappa)|+|d_{H'}(\kappa)-d_{G'}(\kappa)|+|e_{H'}(\kappa)-e_{G'}(\kappa)|\right]\\&\le\frac{1}{n}b\sum_{\kappa\in\Omega}\tanh\left[|a_{H'}(\kappa)-a_{Z'}(\kappa)|+|b_{H'}(\kappa)-b_{Z'}(\kappa)|+|c_{H'}(\kappa)-c_{Z'}(\kappa)|+d\,|\Phi_{H'}(\kappa)-d_{Z'}(\kappa)|+|e_{H'}(\kappa)-e_{G'}(\kappa)|\right]\\&=\mathrm{P}_{\text{SVPNHTSM}}(H',Z')\end{aligned}$$

Thus $\mathrm{P}_{\text{SVPNHTSM}}(H',G')\le \mathrm{P}_{\text{SVPNHTSM}}(H',Z')$.

Moreover,

$$|a_{G'}(\kappa)-a_{Z'}(\kappa)|\le|a_{H'}(\kappa)-a_{Z'}(\kappa)|, |b_{G'}(\kappa)-b_{Z'}(\kappa)|\le|b_{H'}(\kappa)-b_{Z'}(\kappa)|,$$

$$|c_{G'}(\kappa)-c_{Z'}(\kappa)|\le|c_{H'}(\kappa)-c_{Z'}(\kappa)|, |d_{G'}(\kappa)-d_{Z'}(\kappa)|\le|d_{H'}(\kappa)-d_{Z'}(\kappa)|,$$

$$|e_{G'}(\kappa)-e_{Z'}(\kappa)|\le|e_{H'}(\kappa)-e_{Z'}(\kappa)| \text{ for all } \kappa\in\Omega..$$

Therefore,

$\mathrm{P}_{\mathrm{SVPNHTSM}}(G',Z')$

$$=\frac{1}{n}\sum_{\kappa\in\Omega}\tanh\begin{bmatrix}|a_{G'}(\kappa)-a_{Z'}(\kappa)|+|b_{G'}(\kappa)-b_{Z'}(\kappa)|+|c_{G'}(\kappa)-c_{Z'}(\kappa)|+|d_{G'}(\kappa)-d_{Z'}(\kappa)|\\+|e_{G'}(\kappa)-e_{Z'}(\kappa)|\end{bmatrix}$$

$$\leq\frac{1}{n}\sum_{b\in U}\tanh\begin{bmatrix}|a_{H'}(\kappa)-a_{Z'}(\kappa)|+|b_{H'}(\kappa)-b_{Z'}(\kappa)|+|c_{H'}(\kappa)-c_{Z'}(\kappa)|+|d_{H'}(\kappa)-d_{Z'}(\kappa)|\\+|e_{H'}(\kappa)-e_{Z'}(\kappa)|\end{bmatrix}$$

$=\mathrm{P}_{\mathrm{SVPNHTSM}}(H',Z')$

Hence $\mathrm{P}_{\mathrm{SVPNHTSM}}(G',Z')\leq\mathrm{P}_{\mathrm{SVPNHTSM}}(H',Z')$.

Definition 3.4

Consider two SVPNSs $H'=\{(\kappa,\xi_{H'}(\kappa),\zeta_{H'}(\kappa),\vartheta_{H'}(\kappa),\Phi_{H'}(\kappa),\chi_{H'}(\kappa)):\kappa\in\Omega\}$ and

$\omega''=\{(\kappa,\xi_{\omega''}(\kappa),\zeta_{\omega''}(\kappa),\vartheta_{\omega''}(\kappa),\Phi_{\omega''}(\kappa),\chi_{\omega''}(\kappa)):\kappa\in\Omega\}$ within a universe of discourse V, the SVPNWHTSM between H' and ω'' is defined by:

$\mathrm{P}_{\mathrm{SVPNWHTSM}}(H',\omega'')=$

$$\frac{1}{n}\sum_{\kappa\in\Omega}\omega''_f\tanh\begin{bmatrix}|\xi_{H'}(\kappa)-\xi_{\omega''}(\kappa)|+|\zeta_{H'}(\kappa)-\zeta_{\omega''}(\kappa)|+|\vartheta_{H'}(\kappa)-\vartheta_{\omega''}(\kappa)|+|\Phi_{H'}(\kappa)-\Phi_{\omega''}(\kappa)|\\+|\chi_{H'}(\kappa)-\chi_{\omega''}(\kappa)|\end{bmatrix} \quad (2)$$

where $\sum_{\kappa\in\Omega}\omega''_e=1$.

The following sub sequent effects are derived in view of the above theorem:

Proposition 3.5 Assume that $\mathrm{P}_{\mathrm{SVPNWHTSM}}(H',\omega'')$ is the SVPNWHTSM of similarities between the SVPNSs H' and ω'' .Then,

(a) $0\leq\mathrm{P}_{\mathrm{SVPNWHTSM}}(H',\omega'')\leq 1$;

(b) $\mathrm{P}_{\mathrm{SVPNWHTSM}}(H',\omega'')=\mathrm{P}_{\mathrm{SVPNWHTSM}}(\omega'',H')$;

(c) $H'=\omega''\Leftrightarrow\mathrm{P}_{\mathrm{SVPNWHTSM}}(H',\omega'')=0$.

Proposition 3.6 If H',G' and Z' over the hippodrome of discourse V so $H'\subseteq G'\subseteq\omega''$,

$\mathrm{P}_{\mathrm{SVPNWHTSM}}(H',G')\leq\mathrm{P}_{\mathrm{SVPNWHTSM}}(R',\omega'')$ and $\mathrm{P}_{\mathrm{SVPNWHTSM}}(G',\omega'')\leq\mathrm{P}_{\mathrm{SVPNWHTSM}}(H',\omega'')$.

4. MADM Strategy Based on SVPNHTSM in an SVPNS Environment

This section focuses on creating the MADM approach through the employment of the SVPNHTSMs in SVPNS situations. Consider an MADM problem in which $V=\{V'_1,V'_2,.....,V'_p\}$ and

$B' = \{B'_1, B'_2, ..., B'_p\}$ represent the collection of feasible alternatives and attributes. In terms of Pentapartitioned neutrosophic numbers, the Decision-Maker (DM) provides all estimation details for all alternatives. Then, construct a decision matrix by applying the decision maker's entire evaluation details. In the next section, a new MADM strategy (see figure 1) is developed.

Phase 1: The decision matrix's construction

The estimation details are combined to create the decision matrix. $P_{V_i} = \{(B'_j, \xi_{ij}(V'_i, B'_j), \zeta_{ij}(V'_i, B'_j), \vartheta_{ij}(V'_i, B'_j), \Phi_{ij}(V'_i, B'_j), \chi_{ij}(V'_i, B'_j) : B'_j \in B'\}$ of the DM for each alternative $V'_i (i = 1(1)p)$ based on the attribute $B'_j (j = 1(1)q)$, where $\left(\xi_{ij}(V'_i, B'_j), \zeta_{ij}(V'_i, B'_j), \vartheta_{ij}(V'_i, B'_j), \Phi_{ij}(V'_i, B'_j), \chi_{ij}(V'_i, B'_j)\right) = \left(V'_i, B'_j\right)$ (say) $(i = 1(1)p \text{ and } j = 1(1)q)$ indicates the metrics used to evaluate alternative $V'_i (i = 1(1)p)$ with respect to attribute $B'_j (j = 1(1)q)$.

Decision matrix is delineated below:

DMA	B'_1	B'_2	$\cdots$	B'_q
V'_1	(V'_1, B'_1)	(V'_1, B'_2)	$\cdots$	(V'_1, B'_q)
V'_2	(V'_2, B'_1)	(V'_2, B'_2)	$\cdots$	(V'_2, B'_q)
$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$
V'_p	(V'_p, B'_1)	(V'_p, B'_2)	$\cdots$	(V'_p, B'_q)

Phase -2: Determining attribute weights

Verifying the weights for each of the attributes is an important part of the MADM strategy. It is possible for DM to use compromise functions to compute the weights for each characteristic when the details of the weights are unknown.

The compromise function of Γ''_j for each V'_i is interpreted as follows:

$$\Gamma''_j = \sum_{i=1}^{p} \left(3 + \xi_{ij}(V'_i, B'_j) + \zeta_{ij}(V'_i, B'_j) - \vartheta_{ij}(V'_i, B'_j) - \Phi_{ij}(V'_i, B'_j) - \chi_{ij}(V'_i, B'_j)\right) / 5 \quad (3)$$

Then the weight of the j-the characteristic is obtained by $\omega_j'' = \frac{\Gamma_j''}{\sum_{j=1}^{q} \Gamma_j''}$ (4)

Here, $\sum_{j=1}^{q} \omega_j'' = 1.$

Phase -3: Evaluation of a Positive Ideal Alternative (PIA)

This step involves constructing the PIA for all attributes by using the maximum operator. In the following, PIA is represented by the letter *I* and is defined as:

$$I = \left(\xi_1'', \xi_2'', \ldots, \xi_q'' \right), \quad (5)$$

where $\xi_j'' = \left(\max\{\xi_{ij}(V'_i, B'_j) : i = 1(1)p\}, \max\{\zeta_{ij}(V'_i, B'_j) : i = 1(1)p\}, \min\{\vartheta_{ij}(V'_i, B'_j) : i = 1(1)p\}, \right.$ (6)

Phase -4: Compute the Accumulated Measure Value (AMV)

Let SVPNHTSM for each of the alternatives be aggregated using the AMV. Here, $P_{AMV}(V_i')$ denotes AMV and $P_{AMV}(V_i')$ is defined by

$$P_{AMF}(V_i') = \sum_{j=1}^{q} \omega_j'' . P_{SVPNHTSM}\left((V_i', B_j'), \xi_j'' \right), \quad (7)$$

where $\left(V_i', B_j' \right) = \left(\xi_{ij}(V_i', B_j'), \zeta_{ij}(V_i', B_j'), \vartheta_{ij}(V_i', B_j'), \Phi_{ij}(V_i', B_j'), \chi_{ij}(V_i', B_j') \right).$

Phase -5: Analyze the alternatives and rank them

Using a descending order of AMVs, the ranking order is determined. The highest value of AMV corresponds the best option.

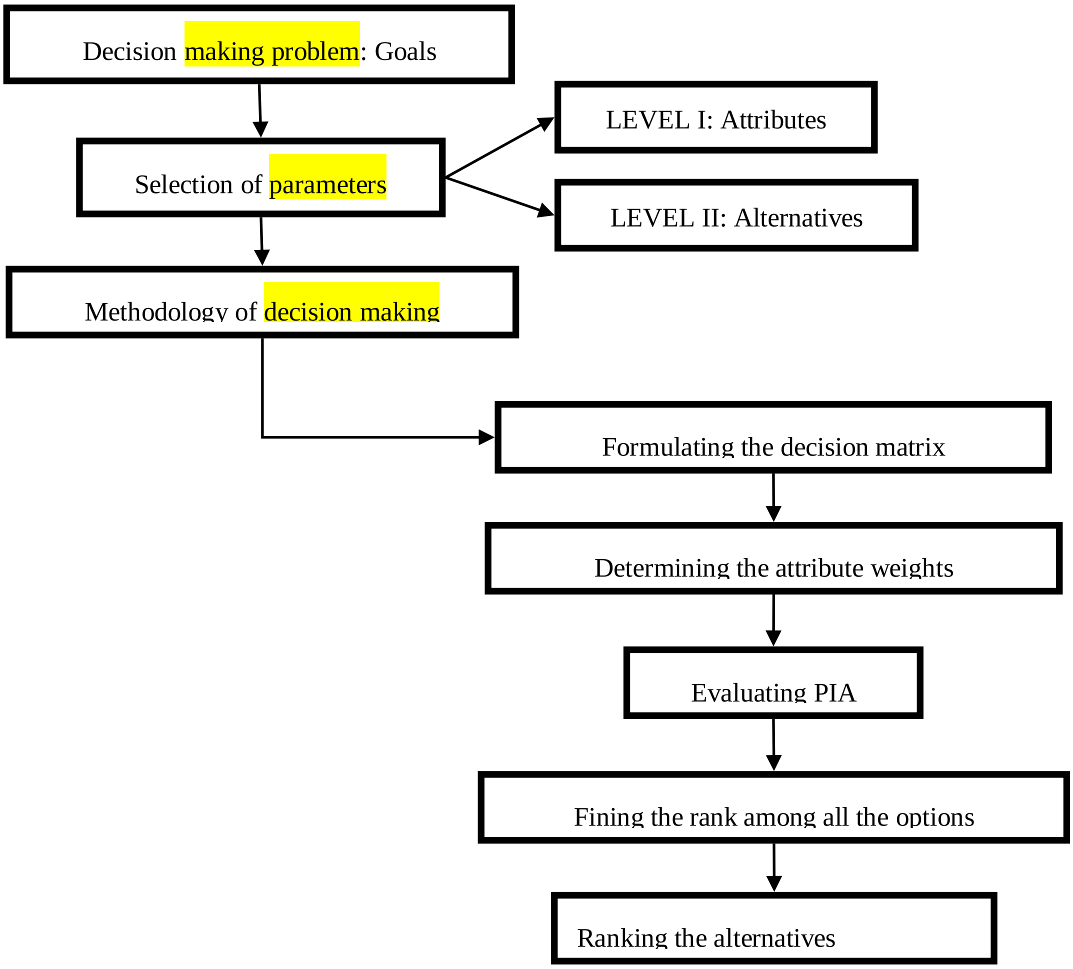

Figure 1. Flowchart of the proposed MADM strategy

5. MADM Strategy Implementation for Identifying the Most Serious Environmental Risk Factors During the COVID-19 Pandemic

The whole human race is in danger of extinction in the present scenario of the COVID-19 pandemic. As more than 6,34,000 people have died till now because of the virus thus it is very much clear that the virus will have a great effect on our lifestyle as well as the biological condition of mother earth [5].All the technological and scientific developments are proved meaningless in front of the SARS-COV2. The virus has affected every country (i.e., 213) present on earth in a drastic manner.

Most of the countries have taken massive screening measures and establishing public policies to fight the pandemic e.g., China has strictly taken the policy of self-quarantine, Britain has taken the method of herd immunity, India has taken the method of massive lockdown, etc. But still, the policies are not enough to meet the challenges presented by the virus. In the present scenario, the whole world is stuck in such a situation where economic and technical growth is too much affected.

No doubt the virus has affected our environment in a very good manner as the CO_2 and NO_2 emission has been drastically decreased due to the less usage of vehicles and as a result the temperature of earth has also decreased. Due to the halt of industries the air pollution as well as the noise pollution also came under control[5].

But still, there are also some bad impacts of the virus are there on the environment especially on the soil, water, and air sectors. e.g., the number of medical wastes coming from the hospitals has increased by at least 5 times which is quite difficult to recycle. However, a crucial topic of concern remains to be the proper waste management & recycling as recycling is considered to be an

efficacious way to obviate pollution & minimize energy wastage, using natural resources sustainably. Considering the present situation USA have put a halt in some recycling centers for minimizing the risk of escalation of the corona virus there.
Moreover, the production of organic and inorganic wastes effects the environment in a very wide manner e.g., deforestation, soil erosion, air as well as water pollution are frequently spotted. Additional to that due to the quarantine process the usage of inorganic plastic material has increased [40] .
Thus, the major goal of the task is to determine the most important option that has the least impact on the environmental criteria using the MADM technique. The alternatives are wisely selected based on various disaster management department's reports & are again established by the experts. So, generation of inorganic waste (β_1),organic waste (β_2) and medical waste (β_3) are considered as attributes in the present study. Since all the attributes have impact on deforestation (ν_1),water pollution (ν_2), air pollution (ν_3), and soil erosion (ν_4), so in the present study these factors are considered as the feasible alternatives. The Figure 2 shows the decision hierarchy for the present problem.

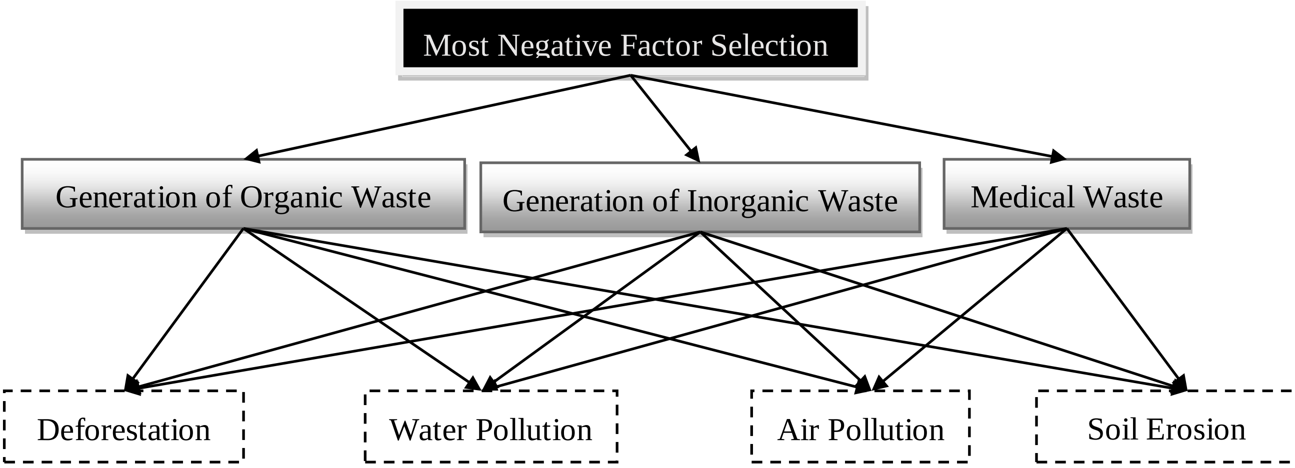

Figure 2. Hierarchical structure of the considered problem

Prepare the decision matrix in Table-2 using data pertaining to all possibilities offered by the DM. The PIA (***I***) for the decision matrix in Table-3 can be calculated using equation (3).

Table 2. Decision Matrix

	A^{β_1}	A^{β_2}	A^{β_3}
ν_1	(.0.75, .0.5, .0.3, 0.2, 0.6)	(0.9, 0.7, 0.3, 0.1, 0.4)	(0.75, 0.54, 0.23, 0.4, 0.13)
ν_2	(0.9, 0.8, 0.3, 0.2, 0.3)	(0.9, 0.4, 0.45, 0.2, 0.3)	(0.65, 0.45, 0.28, 0.3, 0.23)
ν_3	(0.8, 0.7, 0.3, 0.3, 0.4)	(0.8, 0.5, 0.3, 0.1, 0.2)	(0.86, 0.54, 0.4, 0.23, 0.12)

v_4	(0.8, 0.7, 0.5, 0.1, 0.2)	(0.9, 0.6, 0.3, 0.1, 0.3)	(0.76, 0.67, 0.34, 0.32, 0.5)

Table 3. Positive Ideal Solution

	A^{β_1}	A^{β_2}	A^{β_3}
I	(.0.9, .0.8, .0.3, .0.1, .0.2)	(0.9, 0.7, 0.3, 0.1, 0.2)	(0.86, 0.67, 0.23, 0.23, 0.12)

Using equations (4) and (5), the weights of the attributes are determined as:

$\omega_1'' = 0.335$, $\omega_2'' = 0.341$, $\omega_3'' = 0.323$.

Using equation (2), the SVPNHTSM of similarity between the PIS and the decision components belonging to the decision matrix are obtained as:

$P_{SVPNHTSM}(v_1, I) = 0.147938$, $P_{SVPNHTSM}(v_2, I) = 0.156656$, $P_{SVPNHTSM}(v_3, I) = 0.124575$

$P_{SVPNHTSM}(v_4, I) = 0.134095$.

SVPNWDSM ascends between the PIS and the decision elements from the DM in the following order:

$$P_{SVPNHTSM}(v_3, I) < P_{SVPNHTSM}(v_4, I) < P_{SVPNHTSM}(v_1, I) < P_{SVPNHTSM}(v_2, I)$$

Water pollution is more impacted by COVID-19 under the SVPNS environment. Figure 3 illustrates numerical results with graphical representations.

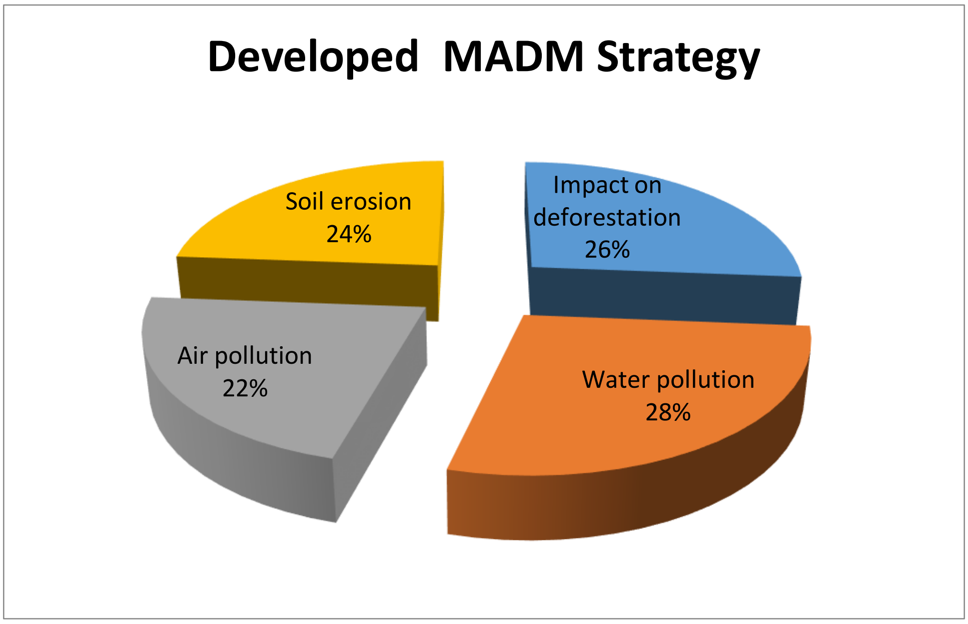

Figure 3. Result of MADM Strategy

6. Comparative study

Comparing the existing strategies with the proposed strategy (see Table 4), it can be seen that they obtain water pollution as the best alternative. Table-4 shows that the weighted values for all attributes are significantly closer to the two existing techniques. The weighted values of the similarity measures in the proposed strategy are not closed like the existing strategies, which enables a better decision for considering attributes. Compared to MADM strategies, this form of weighting supports a better decision. An illustration of a comparative study is shown in Figure 4.

Table 4-. Comparison among the existing strategies and the developed strategy

Methods	v_1	v_2	v_3	v_4	Order of Preference
MADM strategy based on cosine similarity measure [25]	0.672339	0.67277	0.66963	0.670349	$v_3 < v_4 < v_1 < v_2$
MADM strategy Weighted Dice SM [39]	0.206911	0.208836	0.208706	0.199668	$v_4 < v_3 < v_1 < v_2$
Developed MADM Strategy	0.147938	0.156656	0.124575	0.134095	$v_3 < v_4 < v_1 < v_2$

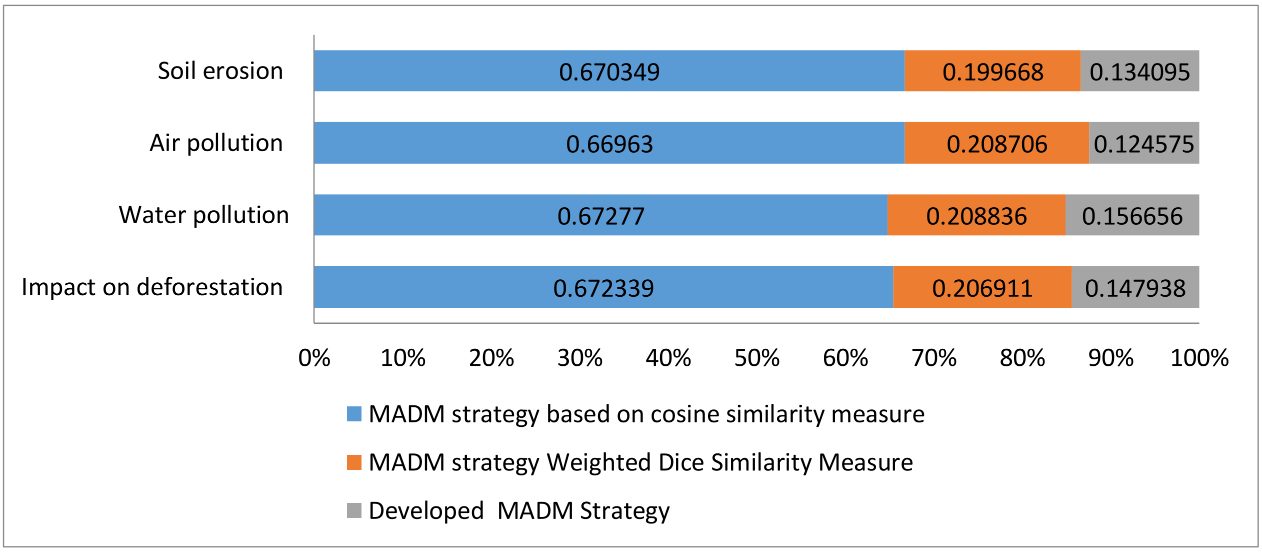

Figure-4: Result of Comparative study

7. Analyzing Sensitivity

To validate the predictions, this step aims to confirm the significance of the alternative as estimated using the developed MADM strategy. A change in the secondary criteria's magnitude can determine the sensitivity of the MADM strategy. Some vital alternatives remain unchanged. Therefore, if the rank changes, the strategy is understood to be under radar of sensitivity, and conversely. Hamby [17] proposed this type of sensitivity analysis and it is known as rank relative sensitivity analysis.

In studies, estimation is done by sensitivity analysis where a numerical model is required to validate the estimated output. Table 5 denotes the output obtained by sensitivity analysis. As per the results obtained, 'water pollution' is found to have a Swing^2 value of 30.80% whereas 'deforestation' was found to have a Swing^2 value of 27.20 %. Thus, the 'water pollution' is considered as the most sensitive parameter. The less sensitive parameter is obtained as 'Soil erosion' which has Swing^2 value heaving 19.50 %. It suggests water pollution's being the most sensitive factor which gets followed by the bad effect of the corona virus in accordance with the weights gained by SVPNHTSM. Figure 5 illustrates the result of the sensitivity analysis.

Table 5- Result of sensitivity analysis

	Corresponding Input Value			Output Value				Percent
Input Variable	Low Output	Base Case	High Output	Low	Base	High	Swing	Swing^2
water pollution	0	0.5	1	0.20303	0.281358	0.359686	0.156656	30.8%
Deforestation	0	0.5	1	0.207663	0.281358	0.355053	0.14739	27.2%
Air pollution	0	0.5	1	0.2143105	0.281358	0.3484055	0.134095	22.5%
Soil erosion	0	0.5	1	0.2190705	0.281358	0.3436455	0.124575	19.5%

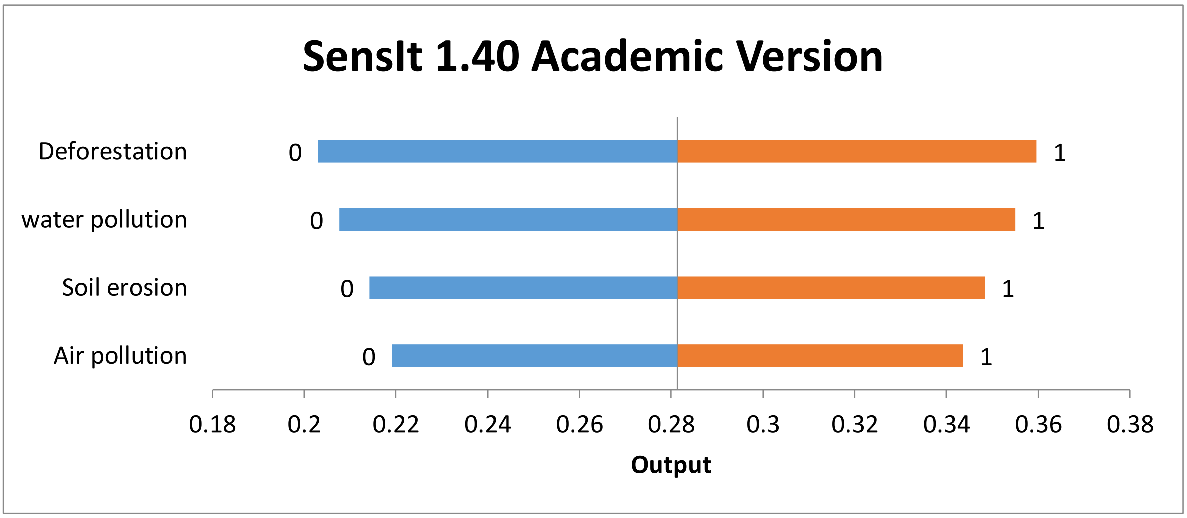

Figure-5: Result of sensitivity analysis

8. Advantage and Disadvantage of the study

Advantages: An MADM strategy based on SVPNHTSM has a four-time greater gradient of tanh than a sigmoid-based strategy. By using the tanh activation function, the gradient during training will be higher and the weights will be updated more frequently. Uncertainty has been comprehensively dealt with using SVPNSs as SVPNSs deal with degrees of contradiction, ignorance and unknown which are more realistic in decision making situation.

Disadvantages: SVPNSs have more components than fuzzy sets and IFSs. Therefore, more times are required to solve the mathematical model involving SVPNSs.

9. Conclusions

This paper develops a new MADM strategy to determine the most significant risk factor in the environment. Based on the proposed strategy, we create a range of alternatives, and obtain ranking order. The novel MADM method's findings are compared to those of other existing approaches. Under the SVPNS environment, it is evident that COVID-19 negatively impacts Water Pollution more than other alternatives. A major weakness of the study is that it doesn't ensure that, as the number of parameters increase, the most significant parameters remain ranked in the same order. In this study, there is no scenario analysis, which is another drawback. It is possible to extend the newly defined SVPNHTSM and SVPNWHTSM operators to other uncertain environments to address uncertainties in decision-making. In addition to clay-brick selection [29], air surveillance, and multiple target tracking [13],watershed hydrological system [15], the approach suggested here could be used to address other MCDM problems as well.

Conflict of Interest: There is no conflict of interest on the part of the authors.

Authors Contribution: The authors contributed equally to develop the paper.

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