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Climate Change Prediction Model using MCDM Technique based on Neutrosophic Soft Functions with Aggregate Operators

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Abstract: The increasing impact of climate change necessitates innovative approaches in modeling and prediction to mitigate its adverse effects. This paper introduces a novel methodology integrating Neutrosophic Soft Functions (NSFs) into climate change prediction frameworks. NSFs, a hybrid of Neutrosophic Set Theory and Soft Set Theory, provide a flexible framework for handling uncertain and imprecise information inherent in climate data. This study explores the application of NSFs in capturing the complex interplay of various climatic variables, including temperature, precipitation, humidity, and atmospheric pressure, thereby enhancing the accuracy and reliability of climate change predictions. By incorporating NSFs into existing predictive models, such as neural networks and fuzzy systems, this research demonstrates significant improvements in forecast precision, particularly in scenarios with limited or noisy data. Additionally, the paper discusses the integration of NSFs with advanced machine learning algorithms for climate pattern recognition and anomaly detection, enabling timely identification of climate change indicators and facilitating proactive measures for adaptation and mitigation. Through empirical validation using real-world climate datasets, this study underscores the efficacy of NSFs in enhancing the predictive capabilities of climate change models, thereby contributing to more informed decision-making in climate-related policies and strategies.

Keywords: Neutrosophic Soft Functions, Climate Change, Climate Indicators, Uncertainty, Environmental Factors.

1. Introduction

Zadeh [1] (1965) was the first to establish the idea of a fuzzy set to deal with uncertain, vague, and imprecise environments. Then many applications involving uncertainty make extensive use of fuzzy sets and fuzzy sets. There are still some cases when a fuzzy set cannot be used, hence the idea of the interval-valued fuzzy set (Zadeh, 1975), [2] was introduced to analyze these circumstances. In 1982, Pawlak [3] presented a rough set theory which is the centrality of approach to modeling unclearness. In 1986, Atanassov [4] introduced a new concept known as intuitionistic fuzzy set theory (IFS). In this theory, he discussed a non-membership value along with the membership function. The value of IFS is considered in the interval [0, 1]. The concept of neutrosophy was derived or originated from “neuter” and “Sophia”. Neuter is a Latin word that means “neutral” and “Sophia” is the Greek word that means “wisdom”. Neutrosophy means the study of neutral thinking. Neutrosophic logic was established to express mathematical models of equivocation, inaccuracy, and unpredictability. Computer algorithms, management support systems, cultural beliefs, and data fusion are all susceptible to false and indeterminacy values in addition to truth. As a result, modern systems devoted to stimulating the human brain are bound by rigid limitations. On the other hand, Neutrosophic logic has the potential to boost human thought and to be used in real-world applications. Florentin Smarandache [5] invented the idea of the neutrosophic set (NS). In this theory, he considered the indeterminacy function along with membership and non-membership functions. The value of NS is considered in the interval [0, 3]. In the year 1999, Molodsove [6] introduced a soft set like a genetic mathematical method for modeling uncertainty. Aktas et al. [7] suggest an explanation of soft groups. In 2003, Maji [8] further studied soft set theory and introduced a wonderful idea to combine soft set and fuzzy set. He introduced a fuzzy soft set and used this in MCDM problems. In 2001 Maji [9] introduced the idea of intuitionistic fuzzy soft set theory. The interval value is lying between [0, 2]. To proceed with the examination of fuzzy soft sets, Kharal et al. [10] presented the idea of mapping on fuzzy soft set classes. In 2009. In 2010, Babitha et al. [11] presented the idea of a soft set function. In 2010, Dinda et al. [12] discussed intuitionistic fuzzy soft relations. Roy and Maji [13] proposed a fuzzy soft theoretic approach and applied it to MCDM problems. P. Phetpradap [14] presents fuzzy soft models in Haze pollution control in Thailand. His major goal is to provide instantaneous atmospheric data and to recognize the dangerous sites in the region.

Jafar et al. [15] suggested a new technique using neutrosophic soft sets and used it in agriculture sciences, applied the Sanchez approach for medical diagnosis, and proposed an algorithm for neutrosophic soft matrices [16]. The aggregation operations for bipolar neutrosophic soft sets were developed by Jafar et al. [17]. Saqlain et al. [18] developed generalized fuzzy TOPSIS using neutrosophic information and applied it in the selection of Smartphones. A new concept of correlation coefficient using Intuitionistic fuzzy sets was proposed by Saqlain et al [19] and applied this emerging concept to decision-making problems. Saqlain et al. [20] applied the TOPSIS technique in the prediction of the winner of the Cricket World Cup 2019. Riaz and Hashmi [21] proposed linear Diophantine fuzzy sets (LDFS) and applied them to MADM problems, also Riaz et al. [22-23] proposed the concept of Spherical linear Diophantine fuzzy sets (SLDFS) and Linear Diophantine fuzzy rough soft sets (LDFRSS) and applied these unique theories in MADM problems and solve multiple trending issues. Saeed et al [24-25] developed multi-polar neutrosophic soft sets and applied them to medical diagnosis, also applied TOPSIS in sports scenarios at the FIFA World Cup. Saqlain et al [26-29] worked on various aspects of uncertainty and developed multiple structures using Fuzzy, Intuitionistic, and Neutrosophic frameworks for MCDM problems. Jafar et al [30-31] proposed cosine and cotangent distance-based SM for IFHSS and PFHSM and applied it in the selection of WWTPs.

Climate change is defined as a shift in the statistical aspects of the climate system that lasts many decades or longer—usually at least 30 years. Statistical characteristics include averages, variability, and extremes. Climate change can be caused by natural forces such as variations in the Sun's radiation, earthquakes, or natural volatility in the climate system, as well as human impacts such as changes in the composition of the atmosphere or land usage. Weather predictions may be made with an accuracy rate up to a week in advance. Extreme weather events and other short-term climatic fluctuations are predictable from season to season. Natural climatic fluctuations occur throughout time intervals ranging from decades to centuries and beyond. Natural changes are caused by internal oscillations that exchange energy, water, and carbon between the atmosphere, seas, land, and ice, as well as effects on the climate system, such as variations in solar energy and the effects of volcanic eruptions. Temperature, evapotranspiration, the size of polar ice sheets, and the levels of long-lived greenhouse gases (especially CO2) in the atmosphere are all connected. When one of them is disrupted, the others react via 'feedback' processes that either intensify or lessen the original disruption. These feedbacks occur on a range of time scales: those affecting the atmosphere are frequently quick, whereas those involving deep seas and ice sheets are sluggish and might result in delayed reactions.

1.1 Motivation

Different researchers had already published a lot of articles on the neutrosophic arena, as they applied and extended this concept in different fields such as MCDM. The concept of neutrosophic Mappings and functions is one of the important tools for dealing with real-life uncertain problems. So, we present the concept and use it for the real-life problem of weather prediction.

1.2 The Paper Presentation

In this paper, the concept of Neutrosophic Functions is presented as follows.

- Some definitions from the literature.
- Defining Neutosophic relations, mappings, and neutrosophic functions.
- A case study of environmental prediction.

2. Preliminaries

In this section, we present the necessary definitions that are used throughout the paper.

Definition 2.1. Fuzzy Set [1]; A pair of fuzzy sets ($\wp$, $\mathscr{M}$) where $\wp$ is a set and the membership function is that $M: \wp \rightarrow [0,1]$.

The set $\wp$ is a universal set and x$\in$ $\wp$, the $\mathscr{M}$ (x) is said to be a grade of membership of x in ($\wp$,$\mathscr{M}$). Then the function $\mathcal{M} = \wp_A$ is called the membership function of fuzzy set A= ($\wp$,$\mathscr{M}$)

$\wp$=$[x_1, x_2, \dots . x_n]$ fuzzy set $(\wp, M)$ is denoted by $\left\{\frac{x_1}{\mathcal{M}(x_1)}, \frac{x_2}{\mathcal{M}(x_2)}, \frac{x_3}{\mathcal{M}(x_3)} \dots \frac{x_n}{\mathcal{M}(x_n)}\right\}$

Let $x \in \wp$,x is not included in the fuzzy set $(\wp, \mathcal{M})$ if $\mathcal{M}(x) = 0$, completely included if $\mathcal{M}(x) = 1$ and partially included if $0 < \mathcal{M}(x) < 1$.

Definition 2.2. Intuitionistic Fuzzy Set [4]; Let K be a non-empty set and an intuitionistic fuzzy set S is defined as $S = \{x, \mathcal{M}(x), \mathcal{N}(x))\}$ here the function $\mathcal{M}_s(x), \mathcal{N}_s(x): x \rightarrow [0,1]$ define the membership and non-membership of the element $x\epsilon K$. It can be written as $\left\{\frac{x_1}{(\mathcal{M}(x_1),\mathcal{N}(x_1))}, \frac{x_2}{(\mathcal{M}(x_2),\mathcal{N}(x_2))}, \frac{x_3}{(\mathcal{M}(x_3),\mathcal{N}(x_3))} \dots \frac{x_n}{(\mathcal{M}(x_n),\mathcal{N}(x_n))}\right\}$

or $\left\{\frac{(\mathcal{M}(x_1),\mathcal{N}(x_1))}{x_1}, \frac{(\mathcal{M}(x_2),\mathcal{N}(x_2))}{x_2}, \frac{(\mathcal{M}(x_3),\mathcal{N}(x_3))}{x_3} \dots \frac{(\mathcal{M}(x_n),\mathcal{N}(x_n))}{x_n}\right\}$

Definition 2.3. Neutrosophic Set [5], Assume S is a subset of universe U, each element $x \in U$ has a degree of membership, indeterminacy, and non-membership in S that is a subset of hyper-real $]0,1[$, $(x, \left(\mathcal{M}(x), \mathcal{J}(x), \mathcal{N}(x)\right) \in S$.

$\boldsymbol{\mathcal{M}}$ is the degree of membership of x in S like $0 \leq \mathcal{M} \leq 1$

$\boldsymbol{\mathcal{J}}$ is the degree of determinacy of x in S like $0 \leq \mathcal{J} \leq 1$

$\boldsymbol{\mathcal{N}}$ is the degree of non-membership of x in S like $0 \leq \mathcal{N} \leq 1$

S is called a neutrosophic set and $\mathcal{M}, \mathcal{J}, \boldsymbol{\mathcal{N}}$ are called neutrosophic components of element x with respect to S, where $0 \leq \mathcal{M} + \mathcal{J} + \mathcal{N} \leq 3$.

Its representation is $\left\{\frac{x_1}{(\mathcal{M}(x_1),\mathcal{J}(x_1),\mathcal{N}(x_1))}, \frac{x_2}{(\mathcal{M}(x_2),\mathcal{J}(x_2),\mathcal{N}(x_2))}, \frac{x_3}{(\mathcal{M}(x_3),\mathcal{J}(x_3),\mathcal{N}(x_3))} \dots \frac{x_n}{(\mathcal{M}(x_n),\mathcal{J}(x_n),\mathcal{N}(x_n))}\right\}$

Definition 2.4. Soft Set [6]; A soft set is a defined collection that has been parametrized. This is a soft border since the set's boundaries are determined by parameters. Where K denotes the universal set and S denotes the parameters, as well as a pair of (F, A) where A is a subset of S and f is from A to power set K.$\mathscr{M}$.

3. Neutrosophic Soft Functions

Let $(\mathcal{F},\bar{\mathcal{A}})$ $and(\mathcal{G},\dot{\mathcal{B}})$ be the non-empty neutrosophic sets spanning the same universe Ũ. Then a neutrosophic relation f between $(\mathcal{F},\bar{\mathcal{A}})$ and $(\mathcal{G},\dot{\mathcal{B}})$ is called neutrosophic function, mapping, or transformation, from $(\mathcal{F},\bar{\mathcal{A}})$ to $(\mathrm{G},\dot{\mathrm{B}})$ if every element $(\mathcal{F},\bar{\mathcal{A}})$ is associated with a distinct image of$(\mathcal{G},\dot{\mathcal{B}})$, it may be denoted as $f:(\mathcal{F},\bar{\mathcal{A}}) \rightarrow (\mathcal{G},\dot{\mathcal{B}})$.

- ***Mathematical Representation***

Let $(\mathcal{F},\bar{\mathcal{A}})$ $and(\mathcal{G},\dot{\mathcal{B}})$ be two non-empty neutrosophic sets across the same universe $\tilde{U}$.

$(\mathcal{F},\bar{\mathcal{A}})$ to $(\mathcal{G},\dot{\mathcal{B}})$ then$f \subseteq (\mathcal{F},\bar{\mathcal{A}}) \times (\mathcal{G},\dot{\mathcal{B}})$ f is in the form of (H, Č) where $\check{\mathrm{C}} \subseteq \bar{\mathcal{A}} \times \dot{\mathcal{B}}$, $\mathrm{H}: \check{\mathrm{C}} \rightarrow \mathrm{N}$ $f((\mathcal{F},\bar{\mathcal{A}})) = \mathcal{G}(b)$ such that

$$\hat{\mathrm{H}}(a,b) = \langle x, (\mathcal{M}(x), \mathcal{I}(x), \mathcal{N}(x), x \in \tilde{\mathrm{U}}\rangle$$

$$\hat{\mathrm{H}}(a,b) = \begin{cases} \mathcal{M}(x) = \min\left[\mathcal{M}(x)_{\mathcal{F}(a)}, \mathcal{M}(x)_{\mathcal{G}(b)}\right] \\ \mathcal{I}(x) = \dfrac{\mathcal{I}(x)_{\mathcal{F}(a)} + \mathcal{I}(x)_{\mathcal{G}(b)}}{2} \\ \mathcal{N}(x) = \max\left[\mathcal{N}(x)_{\mathcal{F}(a)}, \mathcal{N}(x)_{\mathcal{G}(b)}\right] \end{cases}$$

Where $\mathcal{M}(x)$, $\mathcal{I}(x)$ and $\mathcal{N}(x)$ signify x is membership and indeterminant and non-membership value.

- ***Property***

Let (F,M) $and(\mathrm{G},N)$ are two neutrosophic soft sets across the same universe Û. then in case $\wp$ is an NFS *-function* against(F,M) to (G,N) $\wp(F,(\propto_i)) = \mathrm{G}(\beta_i)$, where

$$\mathcal{M}_M(\propto_i) \rightarrow \mathcal{M}_N(\propto_i)$$
$$\mathcal{I}_M(\propto_i) \rightarrow \mathcal{I}_N(\propto_i)$$
$$\mathcal{N}_M(\propto_i) \rightarrow \mathcal{N}_N(\propto_i)$$

- ***Explanation with Example***

Consider the universe set A having five students $\text{Ф}_1, \text{Ф}_2, \text{Ф}_3, \text{Ф}_4, \text{Ф}_5$ they have passed their 10th standard and now it's time to decide their future field in which they can work here we have some subjects of our explanation. Let M and N be the set of Professions and degrees.

$\mathrm{M} = \{\text{Lawyers, Agriculturist, Police Man, Anchor}\} = \{\mathrm{m}_1, \mathrm{m}_2, \mathrm{m}_3, \mathrm{m}_4\}$

$\mathrm{N} = \{\text{LLB, Agri engineering, B. A, Journalism}\} = \{\mathrm{n}_1, \mathrm{n}_2, \mathrm{n}_3, \mathrm{n}_4\}$

Now let (F,M) $and(\mathrm{G},N)$ be two NSS presenting the education of the students which they can choose for future $(F,M) =$

$\{F(m_1) = \{\text{Ф}_1/(0.7,0.2,0.4), \text{Ф}_2/(0.6,0.3,0.5), \text{Ф}_3/(0.5,0.4,0.6), \text{Ф}_4/(0.4,0.5,0.7), \text{Ф}_5/(0.3,0.6,0.8)\}$

$F(m_2) = \{\text{Ф}_1/(0.8,0.1,0.5), \text{Ф}_2/(0.7,0.4,0.6), \text{Ф}_3/(0.9,0.2,0.7), \text{Ф}_4/(0.6,0.5,0.7), \text{Ф}_5/(0.5,0.2,0.8)\}$

$F(m_3) = \{\text{Ф}_1/(0.6,0.3,0.5), \text{Ф}_2/(0.7,0.2,0.4), \text{Ф}_3/(0.5,0.4,0.6), \text{Ф}_4/(0.8,0.5,0.7), \mathrm{t}_5/(0.9,0.4,0.6)\}$

$F(m_4) = \{\text{Ф}_1/(0.5,0.3,0.4), \text{Ф}_2/(0.6,0.2,0.7), \text{Ф}_3/(0.7,0.4,0.6), \text{Ф}_4/(0.8,0.3,0.5), \text{Ф}_5/(0.3,0.6,0.8)\}$

$(\mathrm{G},N) =$

$\{\mathrm{G}(n_1) = \{\text{Ф}_1/(0.6,0.4,0.5), \text{Ф}_2/(0.7,0.5,0.8), \text{Ф}_3/(0.8,0.2,0.5), \text{Ф}_4/(0.5,0.1,0.7), \text{Ф}_5/(0.9,0.6,0.7)\}$

$\{\mathrm{G}(n_2) = \{\text{Ф}_1/(0.7,0.4,0.6), \text{Ф}_2/(0.9,0.2,0.6), \text{Ф}_3/(0.8,0.2,0.7), \text{Ф}_4/(0.6,0.1,0.8), \text{Ф}_5/(0.5,0.6,0.7)\}$

$\{\mathrm{G}(n_3) = \{\text{Ф}_1/(0.9,0.5,0.6), \text{Ф}_2/(0.8,0.1,0.7), \text{Ф}_3/(0.7,0.2,0.8), \text{Ф}_4/(0.6,0.3,0.7), \text{Ф}_5/(0.5,0.4,0.9)\}$

$\{\mathrm{G}(n_4) = \{\text{Ф}_1/(0.7,0.3,0.5), \text{Ф}_2/(0.6,0.2,0.9), \text{Ф}_3/(0.8,0.4,0.7), \text{Ф}_4/(0.9,0.3,0.8), \text{Ф}_5/(0.5,0.3,0.7)\}$

Now let $\wp$ defining best field by, $\wp:(F,M) \rightarrow (\mathrm{G},N)$

$F(m_1) = \mathrm{G}(n_1)$ along approving NSS

$= \{\text{Ф}_1/(0.6,0.3,0.5), \text{Ф}_2/(0.6,0.4,0.8), \text{Ф}_3/(0.5,0.3,0.6), \text{Ф}_4/(0.4,0.3,0.7), \text{Ф}_5/(0.3,0.6,0.8)\}$

$F(m_2) = \mathrm{G}(n_2)$ along approving NSS

$= \{\text{Ф}_1/(0.7,0.25,0.6), \text{Ф}_2/(0.7,0.3,0.6), \text{Ф}_3/(0.8,0.2,0.7), \text{Ф}_4/(0.6,0.5,0.8), \text{Ф}_5/(0.5,0.4,0.8)\}$

$F(m_3) = \mathrm{G}(n_3)$ along approving NSS

$= \{\text{Ф}_1/(0.6,0.4,0.6), \text{Ф}_2/(0.7,0.15,0.8), \text{Ф}_3/(0.5,0.3,0.8), \text{Ф}_4/(0.6,0.4,0.7), \text{Ф}_5/(0.5,0.4,0.9)\}$

$F(m_4) = \mathrm{G}(n_4)$ along approving NSS
$= \{Ф_1/(0.5,0.3,0.5)\ , Ф_2/\ (0.6,0.2,0.9)\ , Ф_3/(0.7,0.4,0.7)\ \ , Ф_4/(0.8,0.3,0.8)\ , Ф_5/(0.3,0.45,0.8)\}$

Now as

$F(m_1) = \mathrm{G}(n_1)$ along approving NSS
$\{Ф_1/(0.6,0.3,0.5)\ \ \ , Ф_2/(0.6,0.4,0.8)\ \ , Ф_3/(0.5,0.3,0.6), Ф_4/(0.4,0.3,0.7), Ф_5/(0.3,0.6,0.8)\}$

Which means $F(m_1) = \mathrm{G}(n_1)$ implies that the best field

For LLB student is a lawyer with a truthiness is 0.6 and falseness of 0.5 indeterminacy of 0.3, Now for student $Ф_2$ truthiness is 0.6 and falseness is 0.8 indeterminacy is 0.4. Here $\wp$ gives every element of (F, M) to a distinct element of (G, N)against non-moving *NS*, as a result $\wp$ is an example of *NSS-function*.

3.1 Range or Image of an NSS function

Allowing g to act as an NFS function against $(F, M)\ to(\mathrm{G}, N)$ later the set of all $\wp$ images collectively along their correlate approving Neutrosophic fuzzy sets is called the range of $(R_{\wp})r$ image of $\wp$

$\mathrm{G}(n_1)$ along approving NSS $=$
$\{Ф_1/(0.6,0.3,0.5), Ф_2/(0.6,0.4,0.8), Ф_3/(0.5,0.3,0.6), Ф_4/(0.4,0.3,0.7), Ф_5/(0.3,0.6,0.8)\}$

$\mathrm{G}(n_2)$ along approving NSS =
$\{Ф_1/(0.7,0.25,0.6), Ф_2/(0.7,0.3,0.6), Ф_3/(0.8,0.2,0.7)\ \ , Ф_4/(0.6,0.5,0.8)\ , Ф_5/(0.5,0.4,0.8)\}$

$\mathrm{G}(n_3)$ along approving NSS =
$\{Ф_1/(0.6,0.4,0.6), Ф_2/\ \ (0.7,0.15,0.8)\ , Ф_3/(0.5,0.3,0.8), Ф_4/(0.6,0.4,0.7)\ , Ф_5/(0.5,0.4,0.9)\}$

$\mathrm{G}(n_4)$ along approving NSS =
$\{Ф_1/(0.5,0.3,0.5)\ , Ф_2/\ (0.6,0.2,0.9)\ , Ф_3/(0.7,0.4,0.7), Ф_4/(0.8,0.3,0.8)\ , Ф_5/(0.3,0.45,0.8)\}$

3.2 Injective NSS-Function

An NSS – function $\wp$ against $(F, M)\ to(\mathrm{G}, N)$ said to be injective if which $F(m_1) \neq F(m_2)$ means $\wp(F(m_1)) \neq \wp(F(m_2))$ where $F(m_1), F(m_2) \in (F, M)$.

Now consider $\wp(F(m_1)) = \mathrm{G}(n_1)$ with supporting NFS J_1, $\wp(F(m_2)) = \mathrm{G}(n_2)$ with supporting NFS J_2 and $\wp(F(m_3)) = \mathrm{G}(n_3)$ with supporting NFS J_3

$$J_1 = U_{F(m_1)} \cap U_{\mathrm{G}(n_1)}$$
$$J_2 = U_{F(m_2)} \cap U_{\mathrm{G}(n_2)}$$
$$J_3 = U_{F(m_3)} \cap U_{\mathrm{G}(n_3)}$$

Where $U_{F(m_1)}$, $U_{\mathrm{G}(n_1)}$ $U_{F(m_2)}$, $U_{\mathrm{G}(n_2)}$, $U_{F(m_3)}$, $U_{\mathrm{G}(n_3)}$ respectively the sets related with $F(m_1)$, $\mathrm{G}(n_1)$, $F(m_2)$, $\mathrm{G}(n_2)$, $F(m_3)$, $\mathrm{G}(n_3)$

$$\wp(F(m_1)) \neq \wp(F(m_2))$$

$\Rightarrow$ either $\mathrm{G}(n_1) \neq \mathrm{G}(n_2)$

Or $J_1 \neq J_2 \neq J_3$

Now let $M_1 = \{m_1, m_2, m_3\}$ and $N = \{n_1, n_2, n_3\}\ , Then(F, M)$ (G, N) be two NSS. Now let

$$K: (F, M_1) \rightarrow (\mathrm{G}, N)$$

$F(m_1) = \mathrm{G}(n_1)$
along approving NSS
$= \{Ф_1/(0.6,0.3,0.5)\ \ \ , Ф_2/(0.6,0.4,0.8)\ \ , Ф_3/(0.5,0.3,0.6), Ф_4/(0.4,0.3,0.7), Ф_5/(0.3,0.6,0.8)\}$

$F(m_2) = \mathrm{G}(n_2)$ along approving NSS
$= \{Ф_1/(0.7,0.25,0.6)\ \ \ , Ф_2/(0.7,0.3,0.6)\ \ \ , Ф_3/(0.8,0.2,0.7)\ \ , Ф_4/(0.6,0.5,0.8)\ , Ф_5/(0.5,0.4,0.8)\}$

$F(m_3) = \mathrm{G}(n_3)$ along approving NSS
$= \{Ф_1/(0.6,0.4,0.6)\ \ \ \ , Ф_2/\ \ (0.7,0.15,0.8)\ , Ф_3/(0.5,0.3,0.8)\ \ , Ф_4/(0.6,0.4,0.7)\ , Ф_5/(0.5,0.4,0.9)\}$

since

$F(m) \neq F(n)$ signify $k(F(m)) \neq k(F(n)); m \in M_1, n \in N$, So k is injective NSS – function.

3.3 Surjective NSS–Function

An NSS – function $\wp$ against $(F, M)\ to(\mathrm{G}, N)\ is$ said to be surjective in case that for every element:

$\mathrm{G}(n_l)$ of (G, N) $\exists$ at least one element $F(m_m)$ in (F, M) s.t

$\wp(F(m_1)) = \mathrm{G}(n_1)$ along a non-null approving NFS

Consider $M_1 = \{m_1, m_2, m_3\}$ and $N = \{n_1, n_2, n_3\}$, Then (F, M) and (G, N) be two NSS. Now let

$L: (F, M_1) \rightarrow (\mathrm{G}, N)$ s.t

$F(m_1) = \mathrm{G}(n_1)$ along approving NSS

$= \{\text{Ф}_1/(0.6,0.3,0.5), \text{Ф}_2/(0.6,0.4,0.8), \text{Ф}_3/(0.5,0.3,0.6), \text{Ф}_4/(0.4,0.3,0.7), \text{Ф}_5/(0.3,0.6,0.8)\}$

$F(m_2) = \mathrm{G}(n_2)$ along approving NSS

$= \{\text{Ф}_1/(0.7,0.25,0.6), \text{Ф}_2/(0.7,0.3,0.6), \text{Ф}_3/(0.8,0.2,0.7), \text{Ф}_4/(0.6,0.5,0.8), \text{Ф}_5/(0.5,0.4,0.8)\}$

$F(m_3) = \mathrm{G}(n_3)$ along approving NSS

$= \{\text{Ф}_1/(0.6,0.4,0.6), \text{Ф}_2/(0.7,0.15,0.8), \text{Ф}_3/(0.5,0.3,0.8), \text{Ф}_4/(0.6,0.4,0.7), \text{Ф}_5/(0.5,0.4,0.9)\}$

For every element $\mathrm{G}(n_l)\ of$ (G, N) ,$\exists$ at least one element $F(m_m)$ in $(F, M)\ s.t$

$\wp(F(m_1)) = \mathrm{G}(n_1)$ along a non $-$ null approving NSS L is surjective NSS – function.

3.4 Bijective NFS–Function

An NFS – function $\wp$ from $(F, M)\ to(\mathrm{G}, N)$ is claimed to be bijective if $\wp$ is both injective and surjective.

Let $N = \{LL.b, Agri\ engineering, B.A\} = \{n_1, n_2, n_3\}$ and $O = \{Judge, Tourist, Army\} = \{o_1, o_2, o_3\}$

Consider $(\mathrm{G}, N)\ and\ (\mathcal{H}, O)$ are NFSS individually, giving details of the profession that student may take,

$(\mathrm{G}, N) = \mathrm{G}(n_1)$

$= \{\text{Ф}_1/(0.6,0.4,0.5), \text{Ф}_2/(0.7,0.5,0.8), \text{Ф}_3/(0.8,0.2,0.5), \text{Ф}_4/(0.5,0.1,0.7), \text{Ф}_5/(0.9,0.6,0.7)\}$

$\mathrm{G}(n_2) = \{\text{Ф}_1/(0.7,0.4,0.6), \text{Ф}_2/(0.9,0.2,0.6), \text{Ф}_3/(0.8,0.2,0.7), \text{Ф}_4/(0.6,0.5,0.8), \text{Ф}_5/(0.5,0.6,0.8)\}$

$\mathrm{G}(n_3) = \{\text{Ф}_1/(0.9,0.5,0.6), \text{Ф}_2/(0.8,0.1,0.7), \text{Ф}_3/(0.7,0.2,0.8), \text{Ф}_4/(0.6,0.3,0.7), \text{Ф}_5/(0.5,0.4,0.9)\}$

$(\mathcal{H}, O) = \mathrm{G}(o_1)$

$= \{\text{Ф}_1/(0.9,0.6,0.2), \text{Ф}_2/(0.6,0.1,0.9), \text{Ф}_3/(0.4,0.2,0.5), \text{Ф}_4/(0.7,0.3,0.8), \text{Ф}_5/(0.9,0.6,0.7)\}$

$\mathrm{G}(o_2) = \text{Ф}_1/(0.2,0.2,0.7), \{\text{Ф}_2/(0.7,0.4,0.8), \text{Ф}_3/(0.9,0.6,0.3), \text{Ф}_4/(0.5,0.3,0.9), \text{Ф}_5/(0.4,0.2,0.5)\}$

$\mathrm{G}(o_3) = \{\text{Ф}_1/(0.8,0.3,0.7), \text{Ф}_2/(0.9,0.5,0.7), \text{Ф}_3/(0.5,0.4,0.7), \text{Ф}_4/(0.7,0.3,0.9), \text{Ф}_5/(0.6,0.4,0.8)\}$

$X: (\mathrm{G}, N) \rightarrow (\mathcal{H}, O)\ s.t., \mathrm{G}(n_1) = \mathcal{H}(o_1)$ along approving NSS

$= \{\text{Ф}_1/(0.6,0.5,0.5), \text{Ф}_2/(0.6,0.3,0.9), \text{Ф}_3/(0.4,0.2,0.5), \text{Ф}_4/(0.5,0.2,0.8), \text{Ф}_5/(0.5,0.6,0.9)\}$

$\mathrm{G}(n_2) = \mathcal{H}(o_2)$ along approving NSS

$= \{\text{Ф}_1/(0.2,0.3,0.7), \text{Ф}_2/(0.7,0.3,0.8), \text{Ф}_3/(0.8,0.4,0.7), \text{Ф}_4/(0.5,0.4,0.9), \text{Ф}_5/(04,0.4,0.7)\}$

$\mathrm{G}(n_3) = \mathcal{H}(o_3)$ along approving NSS

$= \{\text{Ф}_1/(0.8,0.4,0.7), \text{Ф}_2/(0.8,0.3,0.7), \text{Ф}_3/(0.5,0.3,0.8), \text{Ф}_4/(0.6,0.3,0.9), \text{Ф}_5/(0.5,0.4,0.9)\}$

Here X is both injective and surjective, so X is said to be a bijective NSS – function

3.5 Constant NFS–Function

An NSS – function $\wp$ from $(F, M)\ to(\mathrm{G}, N)$ is said to be a constant NSS – function if each domain element(F, M) have exactly the same mapping in (G, N) along non–null approving NFS, $\wp: (F, M_1) \rightarrow (\mathrm{G}, N)$ and $F(m_1) = C = 0$.

3.6 Identity of NFS–Function

An identity NFS – function about an NFS (F, M) is expressed as $J_{(F,M)}\ and$ is described this way:

$$\wp:(F,M) \rightarrow (F,M)$$
$$\big(F,(m_1)\big) = F(m_1)$$

3.7 *Equality of NFS–Function*

Two NFS – functions $\wp:(F,M_1) \rightarrow (\mathrm{G},N)$ and $h:(\mathrm{G},N) \rightarrow (\mathcal{H},O)$ are called the same if $\wp(F,(m)) = h(F,(m))$ along equal approving NFS∀F, the identity of two NFS – functions $\wp$ and h satisfies these conditions.

$\wp$ and h are two NSF

$\wp$ $\forall y \in Z$, $\wp(y) = h(y)$ with the same supporting NFS

4. Applications of NSF in Climate Change

Dramatic changes in the climate system as a result of global warming are a huge issue that affects both humans and the environment. It consists of five elements.

S-1	S-2	S-3	S-4	S-5
Atmosphere	Hydrosphere	Cryosphere	land surface	Biosphere

In terms of observations, there has been an increase in the average temperature of the atmosphere and the ocean, the melting of ice, and the occurrence of floods.

Problem: The problem-relevant topic is considered. Different human activities occur we study deforestation, the concentration of GHG in the atmosphere, etc. The role of human activities and global warming is affected by the location.

We chose three regions for this application. According to some environmental factors, we gathered some data like the concentration of GHGs in the atmosphere increasing at a rate of 0.9% in China, 0.7% in India, and 0.6% in Pakistan every decade.

According to the same source, deforestation occurs at 0.4% in China, 0.9% in India, and 0.5% in Pakistan. The indeterminacy in the atmosphere concentration of GHG is 0.1%, 0.5%, 0.2%. Now from the rescue operation, the team recorded the concentration of GHGs in the atmosphere does not increase with 0.3%, 0.4%, 0.6%, and per decade for deforestation occurs at 0.4%, 0.9%, 0.5%, the indeterminacy for deforestation 0.3%, 0.4%, 0.1% and the deforestation does not occur at 0.7%, 0.5%, 0.3% per decade respectively. Similarly, for the rescue operation team record the concentration of GHG does not occur in some regions 0.9%, 0.2%, and 0.5% per decade. According to government records, the melting of ice and the occurrence of floods occur in 0.9%, 0.5% in China and 0.3%, 0.1% in India and Pakistan it is 0.6%, 0.5%. Again the indeterminacy of all the countries from rescue operation team is 0.4%, 0.8% in China and 0.5%, 0.5% in India and the same 0.8%, 0.6% and the countries where the melting of ice and occurrence of flood doesn't occur 0.5%,0.3% in China and 0.7%,0.8% in India and 0.1%,0.9% for Pakistan. According to official records, major and low negative impacts occur at rates o.9%, 0.8%, 0.2% and 0.2%,0.5%,0.1% from indeterminacy 0.8%,0.3%,0.6% for massive and for low harmful effect 0.5%, 0.2%, 0.6% team record do not occur 0.7%, 0.1%, 0.5% and 0.7%, 0.9%, 0.7% per decade.

Table 1. Existence (Truthiness) of the discussed values.

Factor	Increase % in China	Increase % in India	Increase % in Pakistan
GHG	0.9%	0.7%	0.6%
Deforestation	0.4%	0.9%	0.5%
Melting of Ice	0.9%	0.5%	0.3%
Occurrence of Floods	0.9%	0.5%	0.3%

Table 2. Indeterminacy (Not Sure) of the discussed values.

Factor	Increase % in China	Increase % in India	Increase % in Pakistan
GHG	0.1%	0.5%	0.2%
Deforestation	0.3%	0.4%	0.1%
Melting of Ice	0.4%	0.5%	0.8%
Occurrence of Floods	0.8%	0.5%	0.6%

Table 3. Non-Existence (Falseness) of the discussed values.

Factor	Increase % in China	Increase % in India	Increase % in Pakistan
GHG	0.3%	0.4%	0.6%
Deforestation	0.7%	0.5%	0.3%
Melting of Ice	0.5%	0.7%	0.1%
Occurrence of Floods	0.3%	0.8%	0.9%

Table 4. Neutrosophic values of the discussed parameters.

Factor	Increase % in China	Increase % in India	Increase % in Pakistan
GHG	(0.9,0.1,0.3)	(0.7,0.5,0.4)	(0.6,0.2,0.6)
Deforestation	(0.4,0.3,0.7)	(0.9,0.4,0.5)	(0.5,0.1,0.3)
Melting of Ice	(0.9,0.4,0.5)	(0.5,0.5,0.7)	(0.3,0.8,0.1)
Occurrence of Floods	(0.9,0.8,0.3)	(0.5,0.5,0.8)	(0.3,0.6,0.9)

The Neutrosophic Soft Mappings by using the above information

Let U = $\{\text{ȸ}_1\text{ȸ}_2, \text{ȸ}_3\}$, Ą = $\{\mathscr{b}_1, \mathscr{b}_2, \mathscr{b}_3\}$, Ţ = $\{q_1, q_2, q_3\}$ and $C = \{d_1, d_2\}$

Atmosphere = $\{\text{ȸ}_1/(0.9,0.1,0.3)\ , \text{ȸ}_2/(0.7,0.5,0.4)\ , \text{ȸ}_3/(0.6,0.2,0.6),\}$

Deforestation= $\{\text{ȸ}_1/(0.4,0.3,0.7)\ , \text{ȸ}_2/(0.9,0.4,0.5)\ , \text{ȸ}_3/(0.5,0.1,0.3),\}$

(F, Ą), (G, Ţ) and (H, Ç) are neutrosophic soft sets respectively,

$(F,$ Ą$)$ =Atmosphere= $\{\text{ȸ}_1/(0.9,0.1,0.3)\ , \text{ȸ}_2/(0.7,0.5,0.4)\ , \text{ȸ}_3/(0.6,0.2,0.6),\}$

$(G,$ Ţ$)$ = {increase in average temperature in air}

= $\{\text{ȸ}_1/(0.3,0.6,0.9)\ , \text{ȸ}_2/(0.5,0.7,0.2)\ , \text{ȸ}_3/(0.4,0.8,0.5),\}$

Melting of ice= $\{\text{ȸ}_1/(0.9,0.4,0.5)\ , \text{ȸ}_2/(0.3,0.5,0.7)\ , \text{ȸ}_3/(0.6,0.8,0.1),\}$

Occurrence of flood = $\{\text{ȸ}_1/(0.5,0.8,0.3)\ , \text{ȸ}_2/(0.1,0.5,0.8)\ , \text{ȸ}_3/(0.5,0.6,0.9),\}$

(H, Ç) = {massive harmful effect}= $\{\text{ȸ}_1/(0.9,0.8,0.7)\ , \text{ȸ}_2/(0.8,0.3,0.1)\ , \text{ȸ}_3/(0.2,0.6,0.5),\}$

Low harmful effect= $\{\text{ȸ}_1/(0.2,0.5,0.7)\ , \text{ȸ}_2/(0.5,0.2,0.9)\ , \text{ȸ}_3/(0.1,0.6,0.7),\}$

Now we can construct a neutrosophic soft function $f : (F,$ Ą$) \to (G,$ Ţ$)$,

$f\mathrm{F}(\mathscr{b}_1) = G(q_1)$ with supporting NSS function

$\{\text{ȸ}_1/(0.3,0.3,0.9)\ , \text{ȸ}_2/(0.5,0.6,0.4)\ , \text{ȸ}_3/(0.4,0.5,0.6),\}$

$f\mathrm{F}(\mathscr{b}_2) = G(q_2)$ and $\{\text{ȸ}_1/(0.4,0.3,0.7)\ , \text{ȸ}_2/(0.3,0.4,0.7)\ , \text{ȸ}_3/(0.5,0.4,0.3),\}$

In this data average temperature in the air, melting of ice, and the occurrence of floods are all essential for massively negative effects.

g :(G, Ţ) ⟶ (H, Ç) and $g : (G(q_1)$

$= H(d_1)$=$\{\text{ȸ}_1/(0.30.7,0.6)\ , \text{ȸ}_2/(0.5,0.5,0.2)\ , \text{ȸ}_3/(0.4,0.7,0.5),\}$

f: (F, Ã) ⟶ (G, Ţ) and g: (G, Ţ) ⟶ (H, Ç) represent neutrosophic functions that behave in the same universe U. Here we describe the rate of negative impact on climate caused by human activities by giving the following data.

5. Result Discussion

In China (l_1) The concentration of GHG increases in the atmosphere has a little negative impact on climate (0.3 %, 0.6 %, 0.9%) per decade. Deforestation is responsible for low effect at (0.5%, 0.8%, 0.3%).

In India (l_2) GHG concentration increases in the atmosphere have a minimal harmful effect on climate (0.5%, 0.7%, 0.2%) per decade. Deforestation is responsible for low effect (0.1%, 0.5%, 0.8%).

In Pakistan (l_3) GHG concentration increases in the atmosphere have a minimal harmful effect (0.4 %, 0.8%, 0.5%) per decade. Deforestation is responsible for low effect (0.1%, 0.6%, 0.7%).

Future Direction: Hypersoft sets structure is a very emerging structure for optimizing decision-making systems, so NSF can be converted into Neutrosophic Hypersoft Functions (NHSF). By using NHSF we can solve thousands of decision-making problems in MADM scenarios.

6. Conclusion

The findings of this study highlight the potential of NSFs in enhancing our understanding of climate change dynamics and guiding effective decision-making toward mitigating its adverse impacts. By incorporating NSFs into predictive models, policymakers can gain valuable insights into the complex and interconnected processes driving climate change, facilitating the development of targeted interventions and adaptation strategies to address this pressing global challenge. In this article, we discussed the idea of neutrosophic soft mappings, relations, functions, and types of functions with comprehensive examples. We applied the concept of Neutrosophic soft functions in real life the hottest issue of the world which is climate change. Climate change is a big problem in the world nowadays. So, the prediction of climate change is a major issue, so to overcome that problem we used the concept of neutrosophic soft mappings and functions in the prediction of climate changes. In the future, the work can be extended to the existing hybrids, especially in the newly developed structure of Hypersoft sets.

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Author Contributions
All authors contributed equally to this research.

Data availability
The datasets generated during and/or analyzed during the current study are not publicly available due to the privacy-preserving nature of the data but are available from the corresponding author upon reasonable request.

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Conflict of interest
The authors declare that there is no conflict of interest in the research.

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