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Neutrosophic Perspective for the Causes of Iraq's Sectarian Strife in the Period (2014-2017)

Abdullah A. Khuder^{1,*} 

¹Independent Researcher; Email: abdullah079321@gmail.com.

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Abstract

The millstone of the contemporary history of Iraq was the events of sectarian strife, especially at the beginning of the millennium. The most important causes of the collapse of the ruling regime, the Ba'ath Party regime that Saddam Hussein had led for four decades in Iraq, were the monopolization of power and leading the country towards confrontation with global powers and neighbouring countries. The sectarian strife reached its peak when the Islamic State of Iraq and Syria (ISIS) occupied a third of Iraqi lands with the announcement of Abu Baker al-Baghdadi, his Islamic State, in June 2014. The occurrence of strife (sectarian, societal, between individuals, and between central, local, or regional governments) has repercussions and consequences of such strife. In this study, the researchers attempt to apply some modern approaches, specifically, the Neutrosophic mathematical tools of these causes and their repercussions, in addition to proposing some solutions to the problems suffered by society from the perspective of Iraqi researchers who experienced the events of sectarian strife in Iraq and who, at the same time, were advocates of the idea of spreading Neutrosophic logic through their management of the World Neutrosophic Scientific Academy / the Iraqi branch, whose headquarters in the United States of America are led by the Romanian founder of Neutrosophic Logic “Florentin Smarandache”. Neutrosophic Logic is a generalisation of Fuzzy Logic and is a powerful mathematical tool for analysis and interpretation of vagueness events and problems holding indeterminacy. Neutrosophic theory and logic is also characterised by the widespread dissemination of its scientific research across the globe, as hundreds of researchers worldwide have published rigorous scientific studies in internationally renowned journals, providing solutions to the problems addressed in these studies.

Keywords: Sectarian Strife, Armed Groups, Islamic State, Quasi-State, IF-THEN Statement, Mamdani Inference System, Sugeno Inference System, Neutrosophic Analysis.

1 | Problems Resulting from Sectarian Strife

Before addressing the mathematical tools proposed by the researchers in this study, which will focus on the classification of Islamic states and groups, this section will summarise the most significant problems resulting from sectarian strife in Iraq, as follows [1–5]:

1. The emergence of Al-Qaeda and the Islamic State, and the corresponding backlash these movements have received.
2. The spread of killing among the various components of the Iraqi people.



Corresponding Author: abdullah079321@gmail.com



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3. The theft of government and private funds.
4. The destruction of infrastructure in various regions.
5. The takeover of government military and civilian facilities by ISIS gangs.
6. The release of prisoners and convicts.
7. The displacement and migration of families from all sections of the Iraqi people.
8. The systematic killing of influential figures and scientists in Iraq.
9. Facilitating the entry of the organization's supporters into the geographical area under its control in Syria and Iraq.
10. Many orphans, widows, and missing people.
11. A high number of suicides.
12. The emigration of Iraqis from the country with no intention of returning.
13. The obliteration of cultural and archaeological landmarks in cities occupied by ISIS.
14. The loss of precious books and manuscripts that were lost during and after ISIS's control of the areas.
15. Large numbers of young people were misled into embracing terrorist ideology under the pretext of promoting the application of Islamic law, leading many young people, due to their ignorance of Islamic teachings, to be swept up in the conflict and subsequently to die in brutal wars or be imprisoned.
16. The US occupation of Iraq led to the emergence of parties and organizations with differing orientations and conflicting backgrounds, which prevented the establishment of a bureaucratic structure.

2 | The Constituents of Islamic Movements

One of the objectives of the United States and its policymakers is to undermine the credibility of any Islamic movement, particularly if that movement is armed. What methods do the United States and its close partners, particularly the key players in the Middle East, employ to achieve this objective? According to a publication by the RAND Corporation [1-4], Islamic movements are categorized into several levels, ranging from the lowest (a defunct Islamic group) to the highest (the state), as follows

1. A defunct Islamic group.
2. An Islamic group.
3. An Islamic quasi- state.
4. An Islamic state.

By reading the authors of this article and their opinions on these levels, a consensus was reached on the fundamental elements upon which each of the four aforementioned levels depends. From the perspective of Neutrosophic Logic, the existence of all the elements of a state with an Islamic character, along with all the surrounding factors and circumstances, can be considered to follow the desired Truth Function in Islamic societies. At the same time, this truth function will be against Western Countries interests and against the interests of some Arab governments in one way or another. Therefore, this same truth function represents a falsehood function from the perspective of Western countries or their representatives in some Arab governments. The existence of a quasi-Islamic state can be classified according to the "indeterminacy function" or "ambiguity function," which encompasses both positive and negative factors and components. If this quasi-Islamic state were to transform into an Islamic movement and then into a defunct group, this

might not be in the best interest of Muslim societies, thus following the "falsity function" Alternatively, it could be the desired outcome for Western countries, America, and their allies, thus following their "truth function." This would create a kind of conflict in understanding each of the four levels of Islamic movements. What we consider positive in our Muslim societies, the West might view as detrimental to its interests and detrimental to them. As for unarmed Islamic groups, they are not included in this study because they lack the objectives of creating a controlled Islamic environment, nor do they possess the elements necessary to establish themselves as a sovereign state with defined borders. Rather, they remain confined to carrying creed and ideas that are implemented according to the convictions of their individual supporters. It should be noted that the spread of the ideas of such Islamic groups may be an obstacle to creating a generation that believes that the empowerment of an Islamic state is based on elements including the existence of an Islamic army, weapons, controlled land, and leaders who wage wars to liberate Jerusalem and consider jihad an obligation.

3 | Neutrosophic Functions for Classifying the Levels of Islamic Movements According to Their Constituent Elements

It is well known that the Neutrosophic theory deals with issues where the data is largely characterized by ambiguity and vagueness; it is therefore an effective tool for studying and investigating the constituent elements of each Islamic group, in terms of its capabilities, the challenges it faces, the objectives it plans to achieve, and the developments it must address. We can therefore adopt the mathematical functions proposed by researchers to measure the effectiveness of each armed Islamic group [13–16].

The following are three scientific definitions of the variables and associated mathematical functions:

The variables $\mathbb{Y}_j, \mathbb{B}_i, \mu_f$ represent all the internal factors constituting each Islamic group, noting that these groups will be classified as follows:

- 1- An Islamic state following the truth function $\check{A}(\mathbb{Y}_j)$.
- 2- A quasi-Islamic state following the function of indeterminacy $\mathbb{B}(\mathbb{B}_i)$.
- 3- An armed Islamic group following the falsity function $\mathbb{E}(\mu_f)$.

The variable $\mathbb{Y}_j$ is defined as one of the factors for the establishment of an Islamic state; according to this scale, it represents five factors or components, namely $\mathbb{Y}_1, \mathbb{Y}_2, \mathbb{Y}_3, \mathbb{Y}_4, \mathbb{Y}_5$. For standardizing each factor, the researchers assigned a weight to each component equal to 0.2. Thus:

$$\mathbb{Y}_1 = \mathbb{Y}_2 = \mathbb{Y}_3 = \mathbb{Y}_4 = \mathbb{Y}_5 = 0.2, \sum_{j=1}^5 \mathbb{Y}_j = 1.$$

Conversely, the variable ' $\mathbb{B}_i$ ' has been defined as a factor in the transformation of an Islamic state into an Islamic quasi- state, and this is represented by five factors or components too: $\mathbb{B}_1, \mathbb{B}_2, \mathbb{B}_3, \mathbb{B}_4, \mathbb{B}_5$. The researchers proposed assigning the same weights as above to the variable ' $\mathbb{Y}_j$ ', so that:

$$\mathbb{B}_1 = \mathbb{B}_2 = \mathbb{B}_3 = \mathbb{B}_4 = \mathbb{B}_5 = 0.2, \sum_{i=1}^5 \mathbb{B}_i = 1.$$

Finally, the variable μ_f is defined as a factor in the transformation of an Islamic quasi-state into an armed Islamic group, and naturally, will have the same definition as the two previous factors $\mathbb{Y}_j, \mathbb{B}_i$, i.e.:

$$\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5 = 0.2, \sum_{f=1}^5 \mu_f = 1.$$

The researchers have chosen to provide mathematical definitions for the truth function, the indeterminate function and the falsity function, in accordance with their corresponding meanings, namely: the constituent elements of an Islamic state, the constituent elements of an Islamic quasi-state, and the constituent elements of an armed Islamic group, alternatively, as follows:

1.1 | Constituents of an Islamic state

As mentioned above, these comprise five elements or factors, namely:

- 1- $\mathbb{Y}_1$ This represents the fulfilment of the condition of empowerment to establish legitimate borders and protect the frontiers.
- 2- $\mathbb{Y}_2$ This variable represents controlled territories and the capacity to manage state affairs.
- 3- $\mathbb{Y}_3$ This variable represents owned assets as well as sources of funding.
- 4- $\mathbb{Y}_4$ This variable represents the state's possession of recruits and fighters under wise leadership and theoretical and field commanders.
- 5- $\mathbb{Y}_5$ This variable represents efforts to increase the state's credibility by increasing the number of its supporters.

1.2 | Elements of an Islamic Quasi-state

In this section, we also have five components of what is known as an Islamic quasi- state, which can be defined as follows:

- 1- $\mathbb{B}_1$ This variable represents a partial loss of its ability to establish legitimate borders and protect its frontiers.
- 2- $\mathbb{B}_2$ This variable represents the loss of part of the territory it once held.
- 3- $\mathbb{B}_3$ This variable represents the loss of many sources of funding and the loss of some of its hoarded funds.
- 4- $\mathbb{B}_4$ It is a variable representing the remaining number of recruits, fighters, and ideological leaders, whose numbers are in constant decline due to the wars it has fought.
- 5- $\mathbb{B}_5$ This variable represents a partial loss of its credibility and supporters.

1.3 | The Components of an Armed Islamic Group

As in the above two previous subsections, we find that there are five factors that led to the transformation of a quasi-Islamic state into what is known as an armed Islamic group:

- 1- μ_1 A variable representing a total loss of its ability to establish legitimate borders and protect its frontiers.
- 2- μ_2 A variable representing the loss of all territories under the group's control, with the exception of the remote areas where they are hiding.
- 3- μ_3 A variable representing the almost complete loss of funds and sources of financing.
- 4- μ_4 A factor representing the loss of key ideological and field commanders and a large number of fighters.
- 5- μ_5 A variable representing the loss of most of the credibility it once enjoyed.

We remind the reader that in this study, we will disregard the defunct Islamic Group, as it is not relevant to use as live or influential data in our society.

2 | Mathematical Representation of the Issue

As explained earlier, the researchers have proposed a graded mathematical description for each classification level (Islamic state, quasi-Islamic state, armed Islamic group), and for the reader familiar with mathematical functions, which will be discussed later, there is a gradient space occupied by an Islamic state, an opposite space occupied by an armed Islamic group, and a space between them in which a quasi-Islamic state is situated, It should be noted that these spaces do not preclude the sharing of certain characteristics or the convergence of certain levels in overlapping areas and locations that escalate to a peak and then begin to decline, depending on the circumstances and variables governing the society comprising each level of these classifications [6–16], Note that the corresponding mathematical functions are as follows:

- 1- The function $\check{A}(\mathbb{Y}_j)$ represents the correctness function for the constituents of an Islamic state, and the authors have defined it as follows:

$$\check{A}(\mathbb{Y}_j) = \begin{cases} 0 & 0 < \sum_{j=1}^5 \mathbb{Y}_j \leq 0.2 \\ (\frac{\mathbb{Y}_j - 0.2}{0.8})^2 & 0.2 < \sum_{j=1}^5 \mathbb{Y}_j \leq 0.8 \\ 1 & 0.8 < \sum_{j=1}^5 \mathbb{Y}_j \leq 1 \end{cases} \quad (4.1)$$

We note that the function $\check{A}(\mathbb{Y}_j)$ has three parts; its first part has a value of zero, which it takes on when an Islamic state possesses one of the five components, albeit partially. The second part is a fractional value represented by a quadratic equation, indicating the presence of four of the state's components and being close to perfection. The third and final part, with a value of (1), represents the ideal state, achieved when all five components are present in a near-perfect manner.

- 2- The function $\mathbb{B}(\mathbb{B}_i)$ represents the indeterminacy function for the elements of an Islamic quasi-state, and its mathematical form is:

$$\mathbb{B}(\mathbb{B}_i) = \begin{cases} (\frac{\mathbb{B}_i - 0.2}{0.6})^2 & 0.2 < \sum_{i=1}^5 \mathbb{B}_i \leq 0.6 \\ \frac{1}{2} - (\frac{\mathbb{B}_i - 0.6}{0.8})^2 & 0.6 < \sum_{i=1}^5 \mathbb{B}_i \leq 0.8 \\ 0 & 0.8 < \sum_{i=1}^5 \mathbb{B}_i \leq 1 \end{cases} \quad (4.2)$$

- 3- The function $\mathbb{E}(\mu_f)$ represents the error function for the components of an armed Islamic group, and its mathematical definition is:

$$\mathbb{E}(\mu_f) = \begin{cases} 1 & 0.8 < \sum_{f=1}^5 \mu_f \leq 1 \\ 1 - (\frac{\mu_f - 0.2}{0.8})^2 & 0.2 < \sum_{f=1}^5 \mu_f \leq 0.8 \\ 0 & 0 < \sum_{f=1}^5 \mu_f \leq 0.2 \end{cases} \quad (4.3)$$

Researchers believe that this type of Islamic group, as represented by the mathematical function (falsity function) in the form proposed above $\mathbb{E}(\mu_f)$, is a harmful and unhelpful function in stable and prosperous Islamic societies with a balanced religious framework; At the same time, they are beneficial in Islamic societies that are under attack by their enemies, who seek to fragment these societies from within and without. Thus, such Islamic groups serve as a pressure paper and a source of strength in collapsing Islamic societies, and a factor of weakness, fragmentation and a source of strife in stable Islamic societies, which has left researchers perplexed. Therefore, researchers have chosen to leave the interpretation of the proposed mathematical problems to the reader's judgement. If the reader is a citizen of a stable and prosperous Islamic state with a conscious religious order that is firmly in control, the mathematical function $\mathbb{E}(\mu_f)$ will be the falsity function and may rightly be termed the harmful and useless function, Otherwise, the reader may reverse the mathematical functions $\check{A}(\mathbb{Y}_j)$, and $\mathbb{E}(\mu_f)$ so that one is adopted in place of the other, whilst retaining the undefined function $\mathbb{B}(\mathbb{B}_i)$ to retain the same meaning and designation. For example, (the Hamas movement) in Palestinian society is viewed by the international community as a harmful and useless armed Islamic group, the aim being to end it, eliminate it and render it extinct, However, for Palestinian society in particular and the Islamic world in general, it shifts from its affiliation with the 'false' function as perceived by the international community to the 'true' function for Islamic societies, because Hamas currently represents the legitimate resistance to the abhorrent Zionist occupation.

3 | Neutrosophic systems of Inference

It is well known among experts that there are inference systems, including the “Mamdani inference system” in its first and second types, and the “Sugeno inference system” in its first and second types. These systems were developed in the 1970s for the purpose of controlling the operation of machines and motors through fuzzy control systems. In very simple terms, we can define control systems, whether fuzzy or neutrosophic system, as consisting of data and inputs, followed by methods for processing these inputs, thereby obtaining results that are subsequently interpreted [6,7].

The greatest challenge encountered in programming within the above-mentioned reasoning systems is how to translate realistic textual and narrative statements into mathematical and programming expressions that enable the reasoning systems to analyze them realistically. It is well known among users of reasoning systems that they employ the rule:

IF there are (causes), THEN there are (effects)

This type of sentence, known as an ‘IF-THEN statement’, will be very useful to us in this research for the purpose of analyzing the risk priorities of Islamic states transforming into quasi-Islamic states and then into armed groups. It is self-evident to users of inference systems that these systems are designed to study failure scenarios and analyze the impact of such scenarios, in addition to analyzing the parameters and metrics of the causes that increase the risk of failure of any Islamic entity and subsequently its demise.

We can summarize the above by stating that the authors of this article aim to answer the following question:

Q: What measures and procedures increase the reliability of the continuity of countries and entities?

As mathematicians, we need to identify the inputs of Neutrosophic inference systems, which will serve as the mathematical tool for risk assessment and management. The inputs of Neutrosophic inference systems specific to problems of this nature, which will be taken into account in this research, are:

- Positive inputs (defined as inputs that must be provided without fail, and maintained if they exist)
- Negative inputs (defined as inputs which, if present, must be addressed, and which must be kept absent if society is free of them)
- Unidentified factors (namely those factors that will be identified at a later stage following the hardships endured by people; in this case, stable countries must conduct thorough studies into the causes of the collapse of similar people who share the same cultures and characteristics, with a view to avoiding such a fate; thus, prevention is better than exposure followed by treatment).

4 | Establishing the Rules of Neutrosophic Inference

Neutrosophic expressions with connotations (Truth, Indeterminacy, falsity) – that is, expressions containing terms such as (approximately, about to, barely, around, mostly, to some extent, to a large extent, very little, to the extreme, excessively, a little) possess gradations of intensity, and their definitions vary depending on the contexts in which these terms are used.

It is worth noting that all inference rules are based, in principle, on three inputs, namely:

- ❖ Inference rules that depend on the intensity of each of these inputs.
- ❖ Inference rules that depend on the probability of each of these inputs occurring.
- ❖ Inference rules that depend on investigating the causes of failure for each of these inputs.

We shall therefore attempt to define these rules through the following three tables, which will demonstrate the ability of Neutrosophic Logic to analyse the elements of (severity), (occurrence), and (detection) for all input factors, whether they are positive, unspecified or negative inputs.

Table 1: Neutrosophic inference rules for risk severity governing the state's situation

Bias	IF-THEN Statement
Correct	If the state can perform its core functions and there are secondary aspects of the state's structure in need of reform, then the severity of the risk to the state is very low
Undetermined	If the state can perform its core functions and there are aspects of the state that require urgent reforms, the severity of the threat to the state is somewhat low
Incorrect	If the state can perform its core functions and there are areas within the state that require very urgent reforms, then the severity of the threat to the state is low
Correct	If there is a slight decline in the state's ability to perform its core functions, the severity of the threat to the state is marginal and minimal
Not applicable	If there is a qualitative decline in the state's ability to perform its core functions, the severity of the threat to the state is somewhat marginal
Incorrect	If there is a sharp decline in the state's ability to perform its core functions in only certain areas, the severity of the threat to the state is marginal
Correct	If the existing problem does not cause the state to lose its ability to perform its core functions, then the state's situation is not critical
Undetermined	If the existing problem causes the state to lose some of its ability to perform its core functions, the state's situation is somewhat critical
Incorrect	If the existing problem causes the state to lose its ability to perform its basic functions entirely, then the state's situation is critical.
Correct	If the ruling regime becomes partially ineffective, the state's situation is not catastrophic
Undecided	If the ruling regime becomes ineffective, the state's situation is somewhat catastrophic.
Incorrect	If the ruling regime becomes completely ineffective, the state's situation is utterly catastrophic.

Thus and depending on the example of the above Table 1, we can construct two further tables: one to serve the Neutrosophic laws of inference regarding to the severity of risks governing the quasi-state situation, and another to serve the Neutrosophic laws of inference regarding the severity of risks governing the situation of an armed group. In this study, we shall focus on analysing the risks of state failure solely through three factors: severity, occurrence, and investigation. Below is a table in which we shall set out the Neutrosophic rules of inference regarding the possibility of failure affecting the state's situation alone. However, as we have stated, applying the same concept to a quasi-state or an armed Islamist group would require a more detailed and comprehensive analysis, which the scope of this study does not permit. We shall therefore leave the door open for readers to address these topics as potential avenues for future research.

Table 2: Neutrosophic inference rules for the possibility of failure in a joint or group of joints of the state

Bias	IF-THEN Statement
Truth at Level-1	If the probability of a single failure occurring in the joints of the state is less than 0.001, then the probability of danger to the state occurring is extremely low.
Truth at Level-2	If the probability of a single failure occurring in the joints of the state is less than 0.01, then the probability of the risk to the state occurring is unlikely.
indeterminate at Level-1	If the probability of a single failure occurring in the joints of the state is less than 0.1, then the probability of the danger to the state occurring is accidental (i.e., sometimes).
Indeterminate at Level-2	If the probability of a single failure occurring in the joints of the state is less than 0.2, then the probability of the risk to the state occurring is reasonable.
Falsity at Level-1	If the probability of a single failure occurring in the joints of the state is greater than 0.2, then the probability of the danger to the state occurring is a recurring probability.
Falsity at Level- 2	If the probability of a single failure occurring in the joints of the state is greater than 0.3, then the probability of the danger to the state occurring is a consistently recurring probability.

We reiterate that we can construct two additional tables, like Table (2) above, to facilitate the development of Neutrosophic inference laws regarding the potential for failure affecting quasi-states and armed groups. Finally, the definition of Neutrosophic inference laws for investigating the causes of state failure will be summarized in the following table:

Table 3: Neutrosophic inference rules for investigating the causes of a particular state's failure

Bias	IF-THEN Statement
Truth at level-1	If the problem is well-defined, then it will be completely resolved before it spreads to other parts of the country or before society is affected by it.
Truth at the level-2	If the problem is defined adequately, then it will be solved (either immediately or partially) before it spreads to other parts of the state or before society is affected by it.
indeterminate at Level-1	If the problem is detected early and roughly identified, then it will be roughly resolved before it spreads to other parts of the country or before society is affected.
indeterminate at Level-2	If the probability of a single failure occurring in the joints of the state is less than 0.2, then the probability of the risk to the state occurring is reasonable.
Falsity at level-1	If the probability of a single failure occurring in the joints of the state is greater than 0.2, then the probability of the danger to the state occurring is a recurring probability.
Falsity at Level-2	If the probability of a single failure occurring in the joints of the state is greater than 0.3, then the probability of the danger to the state is a recurring and permanent probability.

To further clarify, the researchers wish to explain the meaning of the term "identified," which appears in Table 3. This means that the source or location of the problem has been identified through rigorous tests and validated measures. The term "detected," on the other hand, indicates that the problem exists, but this does not necessarily mean that it has been identified through rigorous tests or validated measures. It is worth noting that a set of logical statements constructed using the IF-THEN statement can be linked using the well-known logical relations (and, or, negation using a negation tool). We will now explain the mathematical meaning of these logical relations, as follows:

- The 'AND' relation: This means that we select the lowest weight carried by all the logical statements linked by this relation.
- The "OR" relation: This means that we select the greatest weight borne by all the logical statements linked by this relation.
- The 'NOT' relation: The authors propose that the following equation be used to deduce the values of logical statements that carry the negation:

Suppose the logical statement is A . Therefore, the negation of this statement is $NOT A$

$$NOT A = 1 - \frac{AND\ operator + OR\ operator}{2}$$

Likewise, the mathematical membership functions rely on a known set of shapes, including the trigonometric function, the trapezoidal function, the bell-shaped function, and other mathematical shapes, which may number from three to seven functions that are generally sufficient for the required purpose, which is to represent the input values in fuzzy reasoning systems. However, in neutrosophic logic, and given that every statement will be split based on bias (towards truth, indeterminacy, or falsehood), the required number of functions and their different shapes in fuzzy reasoning systems will not be sufficient. Rather, the number of these functions in neutrosophic reasoning systems will be three times what the researcher needs in fuzzy reasoning systems. If this indicates anything, it indicates the breadth and accuracy of the information that reasoning systems deal with in a society whose data is interpreted according to neutrosophic theory, which is characterized by ambiguity and obscurity at times or inconsistency at other times. We emphasize that the interpretation of inputs and outputs will be according to a spectrum of (truth, indeterminacy, falsehood).

5 | The Use of the MATLAB Toolbox in Programming Neutrosophication Inference Systems

5.1 Method of distributing logical statements according to the domains to which they belong

First of all, before we programme any logical expressions and before attempting to determine the effect of all the data mentioned in tables (1, 2, 3), we need to draw up a table clarifying the affiliations of the parts of the logical expressions mentioned in table (1) according to the affiliations through which we can assign the membership function for each part, and we leave it to the reader to apply the same strategy to the remaining two tables (2, 3):

Table 4: The intensity rules taken from table 1, distributed according to their neutrosophic alignment

Neutrosophic alignment	If + the following clause	And + the phrase that follows	Then + the phrase that follows	The membership function with neutrosophic alignments for the corresponding statements
Truth	If the country can perform its basic functions	and there are secondary aspects of the country that require reform	then the severity of the threat to the country is very low	All logical statements mentioned in this row will follow the truth function represented by function (4.1)
Indeterminate	If the country can perform its core functions	and there are aspects of the country that require urgent reforms	then the severity of the threat to the country is somewhat low	The last two logical statements in this row will follow the membership function of indeterminacy (4.2), whilst the first logical statement in this line follows the membership function of truth (4.1)
Falsity	If the country can perform its basic functions	and there were areas within the country in need of very urgent reforms	then the severity of the threat to the country is low	The last two logical statements in this row will follow the false membership function (4.3), whilst the first logical statement in this line follows the truth membership function (4.1)
Truth	If there is a slight decline in the country's ability to perform its basic functions		then the severity of the threat to the country is marginal and slight	All the logical statements in this row will follow the truth membership function (4.1)
Indeterminacy	If there is a qualitative decline in the country's ability to perform its core functions		then the severity of the threat to the country is somewhat marginal	All logical statements in this row will adhere to the application of the membership function of indeterminacy (4.2)
Falsity	If there is a sharp decline in the country's ability to perform its core functions in only certain areas		then the severity of the threat to the state is marginal	All logical statements in this row will satisfy the falsity membership function (4.3)
Truth	If the existing problem does not cause the country to lose its ability to perform its core functions		then the country is not in a critical condition	All logical expressions in this row will satisfy the truth-functional formula (4.1)

Indeterminacy	If the existing problem causes the country to suffer a partial loss of its ability to perform its essential functions		then the country's situation is somewhat critical	All logical statements in this row will satisfy the membership function of indeterminacy (4.2)
Falsity	If the existing problem causes the country to lose all its ability to perform its basic functions		then the country's situation is critical.	All logical statements in this row will satisfy the membership function of the falsity (4.3)
Truth	If the ruling regime becomes partially ineffective		then the state's situation is not catastrophic	All logical statements in this row will satisfy the membership function of truth (4.1)
Indeterminacy	If the governing system becomes ineffective (i.e. non-functional)		then the state of the country is somewhat disastrous.	All logical statements in this row will satisfy the membership function of indeterminacy (4.2)
Falsity	If the governing system becomes completely ineffective		then the country's situation is utterly disastrous.	All logical statements in this row will satisfy the membership function of falsity (4.3)

As mentioned previously, the reader may, following the example of Table 4, draw up tables showing how the logical propositions relating to the possibility of failure occurrence in a particular aspect of the country are distributed (corresponding to the propositions in table 2), and those relating to the detection of the causes of problems that may lead to failure in a particular aspect of the country (corresponding to the statements in table 3). The reader may also classify these statements according to their truth values (truth, indeterminate, falsity), thereby providing a clear understanding of how to handle these logical statements pertaining to the three factors (severity, detection, occurrence) whilst drawing up the flow chart to analyse the impact of the neutrosophic failure scenario on the foundations of a specific state.

5.2 | Flow chart for analysing the Neutrosophic failure scenario:

Naturally, we know that every country is built on a vast number of foundations, and that all these foundations are susceptible to problems. All country's institutions face failures and challenges daily. If an observer of a particular country were to prioritize addressing the risks arising from these failures or challenges, the analyst—whether an economic analyst, political analyst, security advisor, or the experts upon whom the country relies to manage its affairs and facilitate the resolution of its problems in general—would themselves encounter a set of obstacles and ambiguities that may remain unresolved for a period, leading to their exacerbation. In this research, we will attempt to derive a mathematical number that frames all risks within priorities for subsequent addressing. This is known in scientific circles as the "Risk Priority Number" [6,8]. Through this number, we can group the levels and priorities of risks arising from these problems. The authors of this research intend to obtain this number by proposing an algorithm that discusses the neutrosophic inference system. In this article,

while maintaining the generality of accountability, we will adopt the inference system method known as (Mamdani type -1-), which we will present through flowchart No. (1), with the allocation of membership functions for inputs and outputs with (true, indeterminate, false) domains, as follows:

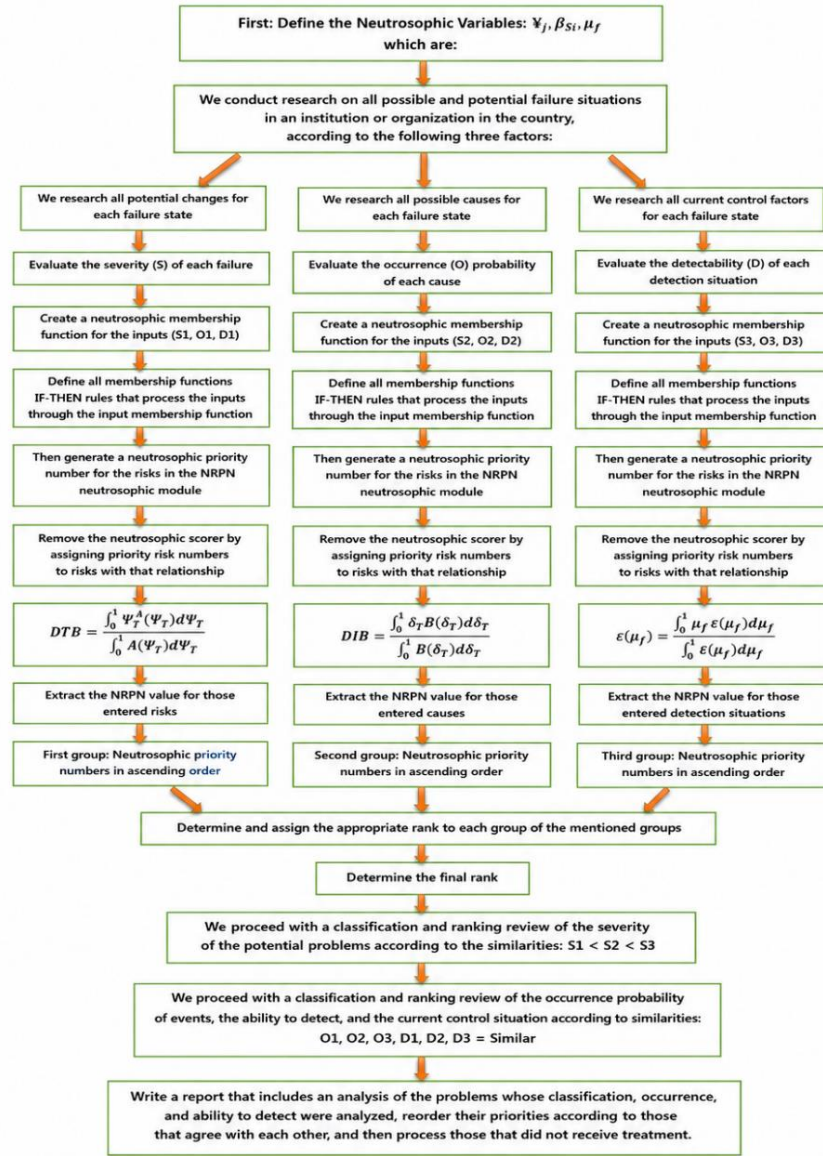


Figure 1. Methodological flowchart for analyzing the impact of neutrosophic failure situation and uncertainty.

6 | A set of real-world problems faced by Iraqi society

The reader may apply the algorithm presented in this study to problems that have been identified and have emerged in Iraqi society through four main realities: (the political reality, the economic and financial reality, the demographic and security reality, and the social reality), as these realities have imposed themselves on Iraqi society, thereby affecting its stability. Given that each of these realities entails a vast number of interrelated problems of varying dimensions, we shall identify a specific set of problems through which we can construct logical propositions specific to them, and then classify these propositions as true, indeterminate, or false.

We are aware that Iraqi society is characterised by cultural, religious, tribal, sectarian and linguistic diversity. Consequently, there are differences in the culture and characteristics of Iraqis between the Arabs of the north and those of the south, between the Arabs of the south and those of the west, as well as between Sunni and

Shia Muslims, in addition to the differences between Arabs, Kurds, Turkmens, Christians and other minorities. The majority of the population consists of Arabs: Sunnis and Shias account for 75 percent, Kurds for 18 percent, Turkmen for 2 percent, and Christians for 3 percent, whilst other groups (Sabeans, Mandaeans, Armenians, Circassians, Yazidis and others) make up approximately 2 percent [5].

The political repression practiced by the regime that ruled Iraq since the 1970s and its crackdown on political parties—whether left-wing, nationalist or Islamist—as well as the successive wars and the resulting economic embargo that completely exhausted Iraqi society, exacerbating conditions and leading to the regime's rapid collapse during the US invasion in 2003, which in turn led to the emergence of sectarian, ethnic, religious and tribal conflict, alongside fighting over sub-identities [5].

This article encourages Iraqi leaders to contain the sectarian violence, doctrinal and religious conflict, and political strife that have existed within Iraqi society. Furthermore, in this study, we wish for Iraq to achieve political stability and economic prosperity through researchers' attempts to formulate some of the problems suffered by Iraqi society in logical mathematical terms that we can convert into mathematical formulas which can subsequently be programmed so that we may apply the inference system shown in flowchart no. (1). We aim to prioritize the risks arising from these problems, which can be addressed according to their severity and likelihood of recurrence, or to investigate the causes of these problems, which are as follows:

- 1- If both the government and parliament are unable to contain the signs of sectarian and ethnic strife, political stability and economic prosperity will not be achieved.
- 2- If there are massive protest demonstrations, this will lead to the risk of the government's resignation.
- 3- If there are sporadic mass protests, this will cause significant concern for the government.
- 4- If there is a rise in unemployment and poverty, protests and demonstrations will increase and may spiral out of control.
- 5- If there is a lack of security and safety, there is a real risk that chaos may ensue.
- 6- If there is rampant administrative, financial and political corruption, there is a real danger to the state.
- 7- If there is limited or specific administrative, financial and political corruption, there is a threat to the state.
- 8- If Iraq's major cities suffer from a lack of development, urban expansion and social urbanisation, these cities will suffer from overpopulation and pseudo-urbanization.
- 9- If farmers are not supported and protected by laws to preserve agricultural land, the project to preserve agricultural wealth will be under threat.
- 10- If there are political conflicts and sectarian strife, the fabric of Iraqi society will be threatened with fracture and disintegration.
- 11- If tribal and sectarian loyalties take root to the extent that they overshadow the urban character of Iraqi society, most members of society will resort to tribal arbitration to resolve their social problems rather than turning to the courts and the rule of law.
- 12- If the concept of citizenship and Iraqi identity is strengthened, there is great hope for building a strong state.
- 13- If political and security stability and social peace are achieved, Iraq will become an attractive environment for local capital and an environment conducive to the inflow of foreign investment.
- 14- If the Iraqi economy is transformed from a one-dimensional economy into a diversified one, inflation rates will fall and the exchange rate of the Iraqi dinar will improve.
- 15- If strategies are adopted to reduce the gap in income and wealth disparities among members of society and to reduce public debt and foreign loans, this will enhance economic stability.
- 16- If the high per capita consumption rate in Iraq and the increasing imports of consumer goods are curbed, this will enhance economic stability.
- 17- If there is no clear population policy, the likelihood of undesirable demographic changes is high.
- 18- If there is a clear population policy, population growth in line with available resources and in the long term will be possible.
- 19- If there are genuine decision-makers capable of expanding employment opportunities, eradicating poverty and addressing environmental challenges, progress towards achieving Iraq's development goals will be realised.

The authors have attempted to arrange the nineteen statements above using the 'TF-THEN Statement' method; thus, we can easily deduce the bias of each phrase comprising these statements, as shown in Table 5.

It should be noted that these problems are a sample selected according to the authors' opinion and do not encompass all the problems suffered by Iraqi society; consequently, this study could be expanded to include more precise, complex and interrelated problems in order to obtain results that correspond to the problems presented.

Table 5: The domains to which the logical statements of the nineteen sentences belong

No.	Four main categories into which the logical statements are divided (political events, economic and financial events, demographic events, and social events)	Logical statement	The domain to which the logical statement belongs and the mathematical equation that will be affected by it
1	Political events	Both the government and parliament are unable to contain signs of sectarian and ethnic strife.	falsity domain, equation (4.3)
2	Political events	Political stability and economic wealth development will not be achieved.	Falsity domain, equation No. (4.3)
3	Political events	There are massive public protest demonstrations.	falsity domain, equation No. (4.3)
4	Political events	This will lead to the risk of the government resigning.	falsity domain, equation No. (4.3)
5	Political events	There are scattered mass protest demonstrations	Indeterminate domain, equation No. (4.2)
6	Political events	This will cause a certain level of concern for the government.	Indeterminate domain, equation No. (4.2)
7	Political events	There is a rise in unemployment and poverty	Indeterminate domain, Equation No. (4.2)
8	Political developments	The protests and demonstrations will increase and may get out of control.	Indeterminate domain, equation (4.2)
9	Political events	Lack of security and safety	falsity domain, equation No. (4.3)
10	Political events	There is a real risk that this could lead to chaos.	Falsity domain, equation (4.3)
11	Economic and financial events	There is widespread administrative, financial, and political corruption.	Falsity domain, equation (4.3).
12	Economic and financial events	There is a real danger to the country.	Falsity domain, equation (4.3)
13	Economic and financial events + political events	There is limited or specific types of administrative, financial, and political corruption.	Indeterminate domain, Equation (4.2)
14	Economic and financial events + political events	There is a threat to the country.	Indeterminate domain, equation (4.2)

15	Demographic events + social events	Major Iraqi cities suffer from a lack of development, urban expansion, and social and behavioral progress.	Falsity domain, equation No. (4.3)
16	Demographic events + social events	Iraqi cities will suffer from overpopulation and false urbanization.	Falsity domain, equation No. (4.3)
17	Economic events	Farmers were not supported and were restricted by laws to preserve agricultural land.	Falsity domain, equation No. (4.3)
18	Economic events	The project to preserve agricultural wealth will be threatened	Falsity domain, equation No. (4.3)
19	Social events	There are political conflicts and sectarian tensions	Falsity domain, equation No. (4.3)
20	Social events	The social fabric of Iraq will be threatened with fracturing and tearing apart.	Falsity domain, equation No. (4.3)
21	Social events	Tribal and sectarian affiliations have become more entrenched, overshadowing the urban character of Iraqi society.	Falsity domain, equation No. (4.3)
22	Social events	Most members of society will resort to tribal arbitration to resolve their social problems instead of resorting to the courts and enforcing the law.	Falsity domain, equation No. (4.3)
23	Social events	The concept of Iraqi citizenship and identity was strengthened.	Truth domain, equation No. (4.1)
24	Social events	There is great hope for building a strong country.	Truth domain, Equation No. (4.1)
25	Political events + social events	Political stability and social peace have been achieved.	Truth domain, Equation No. (4.1)
26	Economic events	Iraq will be an attractive environment for local capital, and an encouraging environment for the flow of foreign investments.	Truth domain, Equation No. (4.1)
27	Economic events	The Iraqi economy has been transformed from a single-sector economy to a diversified one.	Truth domain, Equation No. (4.1)
28	Economic events	Inflation rates will decrease and the exchange rate of the Iraqi dinar will improve.	Truth domain, Equation No. (4.1)
29	Economic events	Strategies were adopted to reduce the gap in income and wealth inequality among members of society and to reduce public debt and foreign loans.	Truth domain, Equation No. (4.1)
30	Economic Developments	Economic stability will be enhanced.	Truth domain, equation (4.1)
31	Economic events	The high rate of consumption per capita in Iraq and the increasing	Truth domain, Equation (4.1)

		imports of consumer products have been curbed.	
32	Economic events	Economic stability will be strengthened.	Truth domain, Equation No. (4.1)
33	Demographic factors + social factors	There was no clear population policy.	Falsity domain, equation (4.3)
34	Demographic factors + social factors	The likelihood of undesirable population changes is high.	Falsity domain, equation (4.3)
35	Demographic factors + social factors	There was a clear population policy.	Truth domain, equation (4.1)
36	Demographic factors + social factors	Population growth will be possible in the long term, in accordance with available resources.	Truth domain, Equation (4.1)
37	Economic and financial events + social events	We have found genuine decision-makers capable of expanding job opportunities, eradicating poverty, and addressing environmental challenges.	Truth domain, Equation No. (4.1)
38	Economic and financial events	Progress towards achieving development goals in Iraq will be achieved.	Truth domain, Equation No. (4.1)

From the logical statements distributed in table (5), it becomes clear that there are thirty-eight logical connections that can be used in programming the Neutrosophic inference system for the nineteen statements. These statements, according to the researchers, identified a set of problems plaguing the Iraqi state. Therefore, the first type of inference system (Mamdani type-1) can be used through the toolbox called FuzzyLogicDesigner. One might ask why we didn't use a toolbox specifically for the neutrosophic logic and theory itself. It is our duty to inform the reader that the Neutrosophic theory is a relatively recent theory, established in 1995 by the Romanian-born, American scientist Florentin Smarandac. It has not yet been widely adopted by well-known software companies that produce large-scale software for the market. Consequently, we find, for example, Maple Toolboxes and MATLAB Toolboxes lacking functions and software that support this logic, unlike fuzzy logic, which was established in 1965 by the scientist Professor Lutfi Askarzadeh, of Azerbaijani origin and American nationality, may God have mercy on him.

Therefore, the authors agreed to adapt the fuzzy inference system found in FuzzyLogicDesigner as one of the effective inference tools in MATLAB to meet the requirements of Neutrosophic theory by classifying the functions into three sections: truth functions that occupy certain spaces, followed by false functions that we will deliberately choose to be the opposite of truth functions and occupy a space completely opposite to them, and indeterminate functions that we will choose to be in a region between truth and false.

The reader should also be aware that the logical operators are in English language, as FuzzyLogicDesigner does not support another language.

6.1 | Use of the Mamdani Type-1 inference system for statements with a bias towards error

Once all the data has been prepared as inputs for the inference system, the system will be fed with the mathematical functions after they have been programmed, as well as the logical statements mentioned above; this is known amongst programmers as ‘customizing the inference system’.

Finally, to simplify the entries, we will label each of the thirty-eight logical statements mentioned in table 5 as R1, R2, ..., R38 in sequence.

In this section, we will provide an analysis of the logical statements that follow the falsity function, namely: R1, R2, R3, R4, R9, R10, R11, R12, R15, R16, R17, R18, R19, R21, R22, R33, R34

Note that we have adopted the following format for writing the inputs:

If R1 Then R2, If R3 Then R4,..., If R33 Then R34

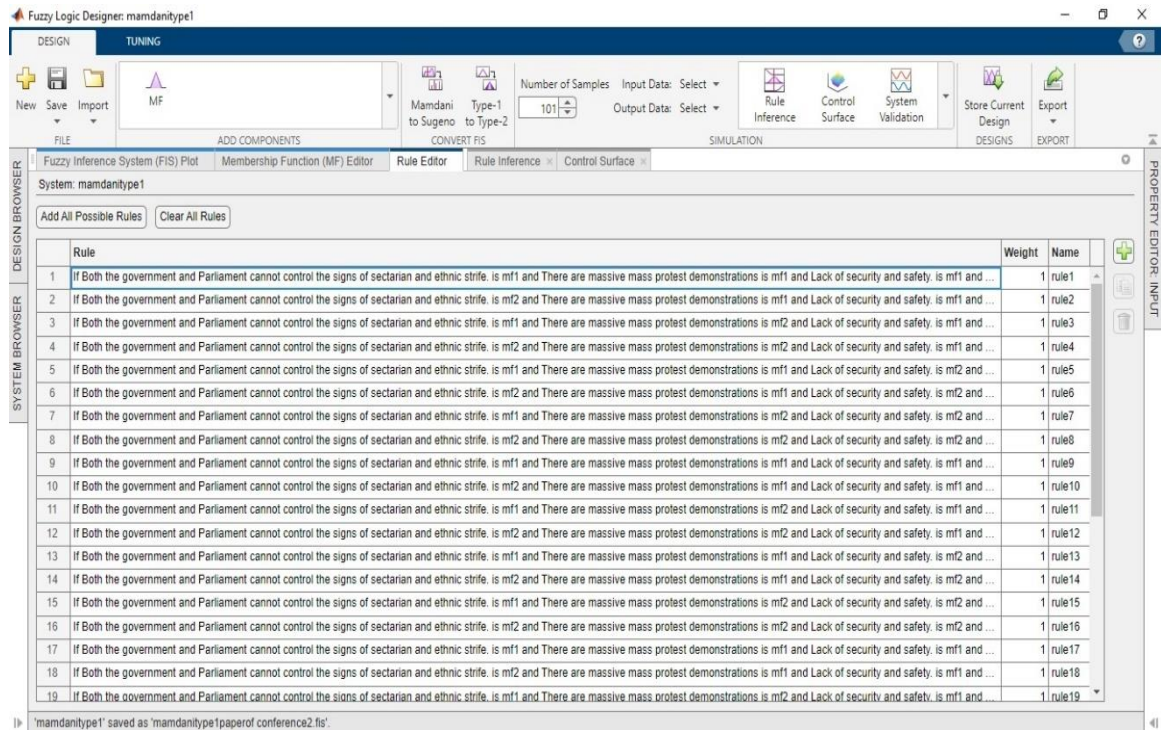
Based on the distribution of the biases for the logical connections, we find that the following table classifies these connections according to the bias adhered to by the nineteen logical statements:

Table 6: Coding of logical statements according to their bias

Truth Bias	Indeterminacy Bias	Falsity Bias
		If R1 Then R2
		If R3 Then R4
	If R5 then R6	
	If R7 then R8	
		If R9 then R10
		If R11 then R12
	If R13 then R14	
		If R15 then R16
		If R17 then R18
		If R19 then R20
		If R21 Then R22
If R23 Then R24		
If R25 then R26		
If R27 then R28		
If R29 then R30		
If R31 then R32		
		If R33 Then R34
If R35 Then R36		
If R37 Then R38		

Given that delving into the inference of all biases (truth, indeterminacy, falsity) would broaden the scope of the research, thereby exceeding the journal’s publication guidelines, the researchers agreed to subject statements with a bias towards error to Neutrosophic analysis and inference. In other words, the focus will be on the negative causes of the destabilization of a state’s system and its transformation from a state with solid foundations into a fragile state or a quasi-state.

Consequently, after using MATLAB 2023a®, we were able to create 32 inference rules covering all the aforementioned- logical connections that adhere to the bias towards error. Examples of these inference rules are shown in Figure 2, Figure 3, meanwhile, illustrates the surface area generated by the interaction of membership functions for inputs and outputs, which also favor the false side. Finally, all the membership functions relied upon by the logical connections of the inputs and outputs are clearly shown on the 'Rules Inference' page, and Figure 4 shows a portion of them



Rule	Weight	Name
1 If Both the government and Parliament cannot control the signs of sectarian and ethnic strife. is mf1 and There are massive mass protest demonstrations is mf1 and Lack of security and safety. is mf1 and ...	1	rule1
2 If Both the government and Parliament cannot control the signs of sectarian and ethnic strife. is mf2 and There are massive mass protest demonstrations is mf1 and Lack of security and safety. is mf1 and ...	1	rule2
3 If Both the government and Parliament cannot control the signs of sectarian and ethnic strife. is mf1 and There are massive mass protest demonstrations is mf2 and Lack of security and safety. is mf1 and ...	1	rule3
4 If Both the government and Parliament cannot control the signs of sectarian and ethnic strife. is mf2 and There are massive mass protest demonstrations is mf2 and Lack of security and safety. is mf1 and ...	1	rule4
5 If Both the government and Parliament cannot control the signs of sectarian and ethnic strife. is mf1 and There are massive mass protest demonstrations is mf1 and Lack of security and safety. is mf2 and ...	1	rule5
6 If Both the government and Parliament cannot control the signs of sectarian and ethnic strife. is mf2 and There are massive mass protest demonstrations is mf1 and Lack of security and safety. is mf2 and ...	1	rule6
7 If Both the government and Parliament cannot control the signs of sectarian and ethnic strife. is mf1 and There are massive mass protest demonstrations is mf2 and Lack of security and safety. is mf2 and ...	1	rule7
8 If Both the government and Parliament cannot control the signs of sectarian and ethnic strife. is mf2 and There are massive mass protest demonstrations is mf2 and Lack of security and safety. is mf2 and ...	1	rule8
9 If Both the government and Parliament cannot control the signs of sectarian and ethnic strife. is mf1 and There are massive mass protest demonstrations is mf1 and Lack of security and safety. is mf1 and ...	1	rule9
10 If Both the government and Parliament cannot control the signs of sectarian and ethnic strife. is mf2 and There are massive mass protest demonstrations is mf1 and Lack of security and safety. is mf1 and ...	1	rule10
11 If Both the government and Parliament cannot control the signs of sectarian and ethnic strife. is mf1 and There are massive mass protest demonstrations is mf2 and Lack of security and safety. is mf1 and ...	1	rule11
12 If Both the government and Parliament cannot control the signs of sectarian and ethnic strife. is mf2 and There are massive mass protest demonstrations is mf2 and Lack of security and safety. is mf1 and ...	1	rule12
13 If Both the government and Parliament cannot control the signs of sectarian and ethnic strife. is mf1 and There are massive mass protest demonstrations is mf1 and Lack of security and safety. is mf2 and ...	1	rule13
14 If Both the government and Parliament cannot control the signs of sectarian and ethnic strife. is mf2 and There are massive mass protest demonstrations is mf1 and Lack of security and safety. is mf2 and ...	1	rule14
15 If Both the government and Parliament cannot control the signs of sectarian and ethnic strife. is mf1 and There are massive mass protest demonstrations is mf2 and Lack of security and safety. is mf2 and ...	1	rule15
16 If Both the government and Parliament cannot control the signs of sectarian and ethnic strife. is mf2 and There are massive mass protest demonstrations is mf2 and Lack of security and safety. is mf2 and ...	1	rule16
17 If Both the government and Parliament cannot control the signs of sectarian and ethnic strife. is mf1 and There are massive mass protest demonstrations is mf1 and Lack of security and safety. is mf1 and ...	1	rule17
18 If Both the government and Parliament cannot control the signs of sectarian and ethnic strife. is mf2 and There are massive mass protest demonstrations is mf1 and Lack of security and safety. is mf1 and ...	1	rule18
19 If Both the government and Parliament cannot control the signs of sectarian and ethnic strife. is mf1 and There are massive mass protest demonstrations is mf2 and Lack of security and safety. is mf1 and ...	1	rule19

Figure 2: A portion of the 32 inference rules, generated from the interaction and overlap of all logical connections for inputs and outputs with error bias

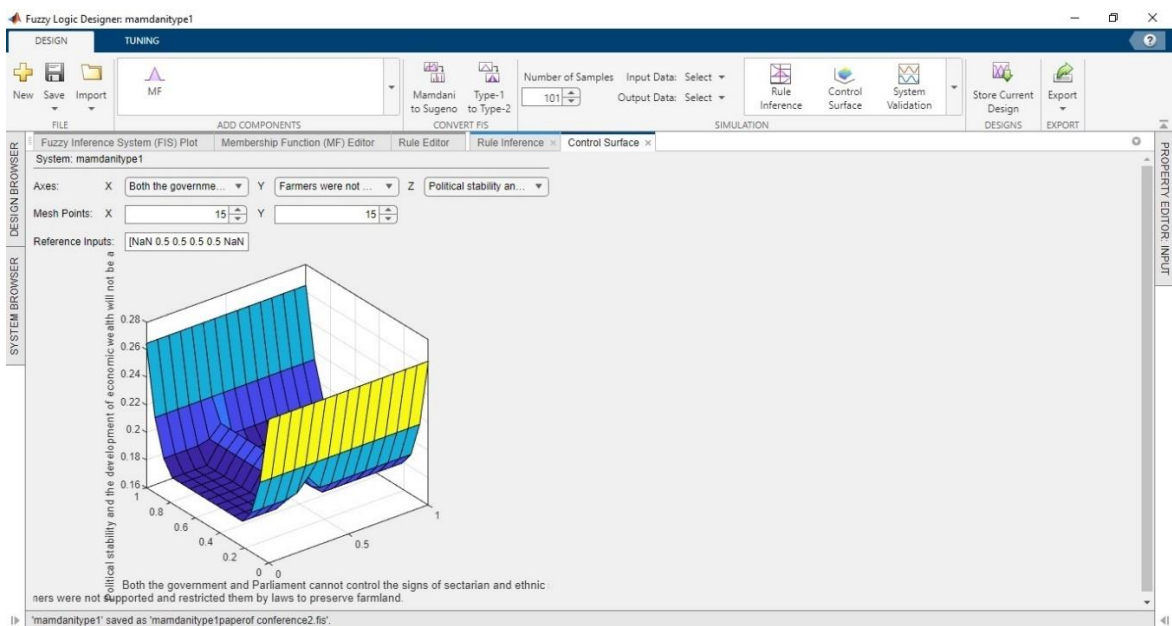


Figure 3: The surface area representing all 32 rules that have overlapped to form a pattern illustrating the distribution of the impact of economic, social, demographic and political issues.

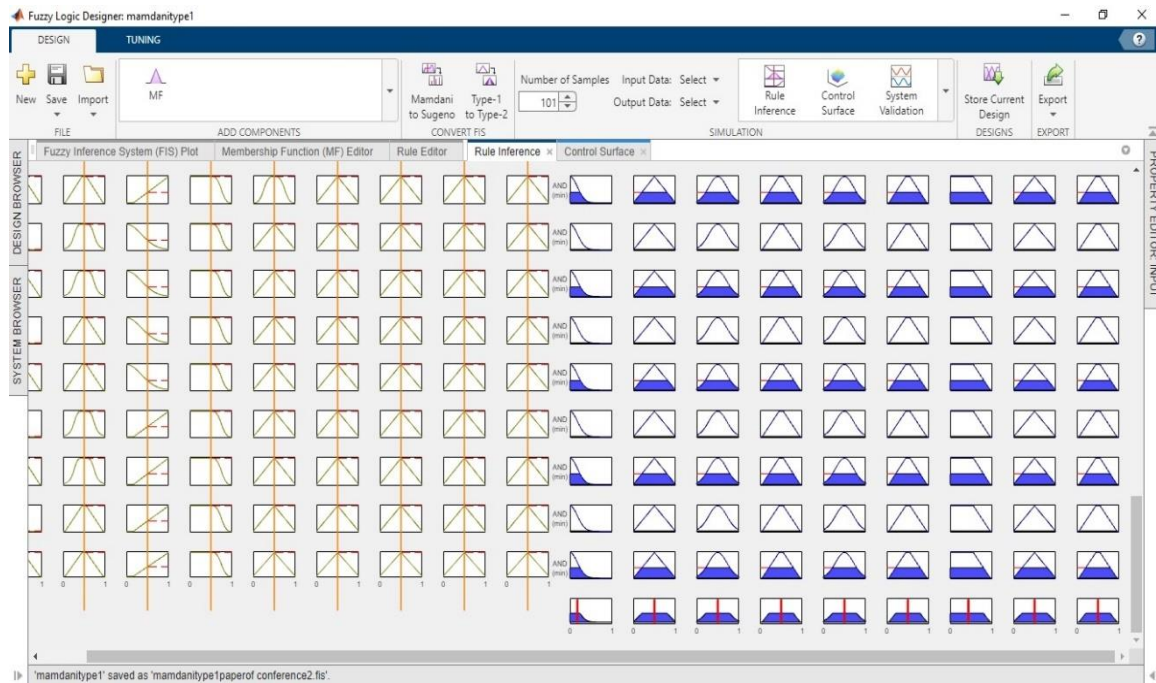


Figure 4: Part of the membership functions of the error-prone logical statements expressing all 32 rules that have overlapped with one another to create a framework illustrating how the impact of economic, social, demographic and political problems is distributed.

7 | Analysis and Conclusions

The impact of the failure mode, using Neutrosophic theory, will lead to the assignment of numerical values to each risk associated with a cause of failure, using the concepts of severity, occurrence, and detection of failure before it occurs, i.e. (Severity, Occurrence, Detection) by calculating what is known as the Neutrosophic Risk Priority Number (NRPN) for each cause of failure or for each failure mode (Failure Mode and Effects Analysis/FMEA).

It should be noted that in Neutrosophic Failure Mode and Effects Analysis (NFMEA), the failure modes, their causes and their effects at the level of mathematical and deductive analysis will change in priority, because as the analysis progresses and problems of higher priority are discovered and then effectively resolved as a priority, the system will update its priorities so that, for example, a particular problem—which we will denote as ' x '—may have had a lesser impact and lower severity in the first round of analysis, but the same problem— x —will be found to have a higher severity level after a set of problems within the same system has been resolved.

From Table 6, it is clear that there are nine logical statements that are false, but we wish to subject them, along with their logical connections, to the inference rule in a segmented manner to derive 32 inference rules with varying severity values. Accordingly, based on the results obtained, the following table shows the priority ranking of these problems' risks, from the highest value of NRPN=6 to the lowest value of NRPN=1 in descending order, as follows:

In fault-tolerant logical expressions, the values (R1, R3, R9, R11, R15, R17, R19, R21, R33) will be the antecedents, i.e. those that come after the conditional operator (if), whilst the logical expressions (R2, R4, R10, R12, R16, R18, R20, R22, R34) are considered the consequents, i.e. those that follow the conjunction (then), thus the logical connectives of the inferred rules of inference will be arranged as follows:

Table 7: Sequence of risk priority from highest to lowest

Sequence	Logical links for problems	Order of NRPN values according to the associated problem
1	R1, R2	6
2	R1, R4	6
3	R1, R10	5
4	R1, R12	5
5	R1, R18	3
6	R1, R20	5
7	R1, R22	4
8	R1, R34	3
9	R3, R4	6
10	R3, R2	5
11	R3, R10	5
12	R3, R12	4
13	R9, R10	6
14	R9, R2	4
15	R9, R12	4
16	R9, R20	3
17	R9, R4	5
18	R11, R12	6
19	R11, R2	3
20	R11, R10	4
21	R11, R20	2
22	R15, R16	6
23	R15, R18	2
24	R15, R34	3
25	R19, R20	6
26	R19, R2	5
27	R19, R4	5
28	R19, R10	6
29	R21, R22	6
30	R21, R20	1
31	R33, R34	6
32	R33, R18	1

It is clear that the problems requiring urgent resolution are those listed in sequences (1, 2, 9, 13, 18, 22, 25, 28, 29, 31), whilst the problems with a risk priority of 5 are those listed in sequences (3, 4, 6, 10, 11, 17, 26, 27), and those with a risk priority of 4 are those listed in sequences (7, 12, 14, 15, 20). Finally, the problems with a risk priority of 1, 2 or 3 are those listed in sequences (5, 8, 16, 19, 21, 23, 24, 30, 32), and these can be deferred as a lower priority compared to those problems that have been assigned a high risk priority.

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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.

Conflicts of Interest

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

Ethical Approval

This article does not contain any studies with human participants or animals performed by any of the authors.

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