SITI NURAINI RAHIM MASTER OF SCIENCE 2022

BIPOLAR NEUTROSOPHIC DEMATEL-MABAC FOR SUSTAINABLE ENERGY SELECTION

SITI NURAINI RAHIM

MASTER OF SCIENCE
UNIVERSITI MALAYSIA TERENGGANU
2022

BIPOLAR NEUTROSOPHIC DEMATEL-MABAC FOR SUSTAINABLE ENERGY SELECTION

SITI NURAINI RAHIM

Thesis Submitted in Fulfilment of the Requirements for the Degree of Master of Science in the Faculty of Ocean Engineering Technology and Informatics
Universiti Malaysia Terengganu

2022

This thesis is dedicated to:

My late father, my beloved mother and families,

my supervisor, Dr. Binyamin Yusoff,

my co-supervisor, Professor Mohd Lazim Abdullah .

For all their dedication, sacrifice, prayers and endless love.

Abstract of thesis presented to the Senate of Universiti Malaysia Terengganu in fulfilment of the requirements for the degree of Master of Science

BIPOLAR NEUTROSOPHIC DEMATEL-MABAC FOR SUSTAINABLE ENERGY SELECTION

SITI NURAINI RAHIM

2022

Main Supervisor	**:**	**Binyamin Yusoff, Ph.D**
Co-Supervisor	**:**	**Professor Mohd Lazim Abdullah, Ph.D**
Faculty	**:**	**Faculty of Ocean Engineering Technology and Informatics**

Multi-criteria decision-making (MCDM) methods have been experiencing significant growth in research interest from various scientific fields. Decision-making trial and evaluation laboratory (DEMATEL) method and multi-attributive border approximation area comparison (MABAC) method are two commonly used in MCDM methods where these methods are able to express a complex decision systematically. Previous literature has suggested the combination of DEMATEL and MABAC methods with fuzzy sets. This combination used one membership degree with a range of [0, 1] and deal with uncertainty information. Therefore, this research extends the DEMATEL-MABAC method based on the bipolar neutrosophic set that contains the positive and negative membership degrees of truth, indeterminacy and falsity. In order to achieve the main objective, firstly, the new linguistic variable of bipolar neutrosophic set was proposed. Then, this newly linguistic variable is integrated into bipolar neutrosophic DEMATEL and MABAC methods to deal with the indeterminacy information and bipolar information in the decision-making problem. The proposed DEMATEL-MABAC method under bipolar neutrosophic set is applied in the case study of sustainable energy selection. Fourteen criteria and seven alternatives in sustainable energy are the main MCDM structures that need to be solved using this proposed method. A group of decision-makers were invited to provide their judgments on criteria and alternatives in sustainable energy selection and defined in the new linguistic variable of bipolar neutrosophic set. The proposed bipolar neutrosophic DEMATEL method is used to determine the weight of criteria and apply it in the step of the weighted matrix in the bipolar neutrosophic MABAC method. The main output of this proposed method is to rank the alternatives based on the distances of alternatives of the border approximation area in bipolar neutrosophic MABAC. The outcome of this research reveals that biomass energy is the optimal alternative to sustainable energy selection. The selection of sustainable energy using this proposed method will assist the government, researchers or energy consultants in making a more comprehensive decision for a better planned project. Last sentence, a comparative analysis is presented to check the consistency and feasibility of the proposed method.

Abstrak tesis yang dikemukakan kepada Senat Universiti Malaysia Terengganu
sebagai memenuhi keperluan untuk Ijazah Sarjana Sains

DWI-KUTUB NEUTROSOFIK KAEDAH DEMATEL-MABAC UNTUK PEMILIHAN TENAGA LESTARI

SITI NURAINI RAHIM

2022

Penyelia Utama : Binyamin Yusoff, Ph.D

Penyelia Bersama : Profesor Mohd Lazim Abdullah, Ph.D

Fakulti : Fakulti Teknologi Kejuruteraan Kelautan dan Informatik

Kaedah pembuatan keputusan pelbagai kriteria (MCDM) telah mengalami peningkatan yang signifikan dalam kepentingan penyelidikan dari pelbagai bidang saintifik. Kaedah ujian keputusan dan makmal penilaian (DEMATEL) dan kaedah perbandingan kawasan sempadan pelbagai atribut (MABAC) adalah dua kaedah MCDM yang biasa digunakan dalam kaedah MCDM di mana kaedah ini dapat menyatakan keputusan yang kompleks secara sistematik. Literatur sebelumya telah mencadangkan gabungan kaedah DEMATEL dan kaedah MABAC dengan set kabur, Gabungan ini hanya menggunakan satu darjah keahlian dengan julat [0,1] dan hanya menangani maklumat ketidakpastian. Oleh itu, penyelidikan ini memanjangkan kaedah DEMATEL-MABAC berdasarkan dwi-kutub neutrosofik set yang mengandungi darjah keahlian positif dan negatif kebenaran, ketidakpastian dan kepalsuan. Untuk mencapai objektif utama, pertamanya, pembolehubah linguistik baru untuk dwi-kutub neutrosopik telah dicadangkan. Kemudian, pembolehubah linguistik baru ini disatukan ke dalam kaedah DEMATEL dan MABAC dwi-kutub neutrosopik untuk menangani maklumat ketidaktentuan dan maklumat dwi-kutub dalam masalah pembuat keputusan. Kaedah DEMATEL-MABAC yang dicadangkan di bawah set dwi-kutub neutrosopik digunakan dalam kajian kes pemilihan tenaga lestari. Empat belas kriteria dan tujuh alternatif dalam tenaga lestari adalah struktur utama MCDM yang perlu diselesaikan menggunakan kaedah yang dicadangkan ini. Sekumpulan pembuat keputusan telah dijemput untuk memberikan penilaian mereka mengenai kriteria dan alternatif dalam pemilihan tenaga lestari dan ditakrifkan dalam pembolehubah linguistik baru dwi-kutub neutrosopik set. Kaedah DEMATEL dwi-kutub neutrosopik yang dicadangkan digunakan untuk menentukan berat kriteria dan diterapkan ke dalam langkah matriks berwajaran dalam dwi-kutub neutrosopik kaedah MABAC. Output utama kaedah yang dicadangkan ini adalah untuk menyusun peringkat alternatif berdasarkan jarak alternatif dari kawasan penghampiran sempadan dalam dwi-kutub neutrosopik MABAC. Hasil penyelidikan ini menunjukkan bahawa tenaga biojisim adalah alternatif optimum kepada pemilihan tenaga lestari. Pemilihan tenaga lestari menggunakan kaedah yang dicadangkan ini akan membantu kerajaan, penyelidik atau perunding tenaga untuk mencapai keputusan untuk rancangan projek yang lebih baik. Akhir sekali, analisis perbandingan dipaparkan untuk memeriksa konsistensi dan kebolehlaksaan kaedah yang dicadangkan.

ACKNOWLEDGEMENTS

BismillahirRahmanirRahim. With the name of Allah S.W.T, the Most Gracious and the Most Merciful.

Alhamdulillah, all praise to Allah S.W.T for providing me with the strength and determination. With His blessing, I was able to successfully complete my thesis.

First of all, I would like to express my sincere gratitude to my supervisor, Dr. Binyamin bin Yusoff and my co-supervisor, Prof. Dr. Mohd Lazim bin Abdullah for their consistent guidance, monitoring and encouragement through this research. Their encouragement helped me concentrate and complete my research successfully. During my Master's studies, I have learned a lot from them, particularly about addressing scientific problems and writing scientific reports properly. They gave many valuable comments and suggestions through numerous discussions along this journey. I really appreciate their patience, help, support and time.

I am also thankful to my family, especially my mother, Azizah binti Ali and my late father, Rahim bin Haron, who passed away on February 1, 2021 during my master's studies. I thank them for their love, prayers, support and understanding especially regarding my decision to continue my studies. Their unwavering support for what I love doing is greatly appreciated. To my siblings and families, thank you for your prayers and endless support.

Besides that, I also want to thank my friends and colleagues especially Dr. Noor Azzah Awang, Dr. Hazwani Hashim and Dr. Norsyahida Zulkifli for their encouragement and guidance throughout this journey. I would like to thank the Faculty of Ocean Engineering Technology and Informatics, Universiti Malaysia Terengganu for their help and support during my studies.

Last but not least, I would like to express my sincere appreciation to all who have helped me in any way possible, but whose names are not mentioned.

APPROVAL

I certify that an Examination Committee has met on 9th February 2022 to conduct the final examination of Siti Nuraini Rahim, on her Master of Science thesis entitled "**Bipolar Neutrosophic DEMATEL-MABAC for Sustainable Energy Selection**" in accordance with the regulations approved by the Senate of Universiti Malaysia Terengganu. The Committee recommends that the candidate be awarded the relevant degree. The members of the Examination Committee are as follows:

Zabidin bin Salleh, Ph.D
Associate Professor
Faculty of Ocean Engineering Technology and Informatics
Universiti Malaysia Terengganu
(Chairperson)

Hanafi bin A.Rahim, Ph.D
Lecturer
Faculty of Ocean Engineering Technology and Informatics
Universiti Malaysia Terengganu
(Internal Examiner)

Ts. Mahmod bin Othman, Ph.D.
Professor
Department of Applied Sciences
Universiti Teknologi PETRONAS
(External Examiner)

Ir. MOHAMMAD FADHLI BIN AHMAD, Ph.D.
Professor/Dean
Faculty of Ocean Engineering Technology and Informatics
Universiti Malaysia Terengganu

Date:

This thesis has been accepted by the Senate of Universiti Malaysia Terengganu in fulfilment of the requirements for the degree of Master of Science.

Ir. MOHAMMAD FADHLI BIN AHMAD,
Ph.D.
Professor/Dean
Faculty of Ocean Engineering Technology and Informatics
Universiti Malaysia Terengganu

Date:

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UMT or other institutions.

SITI NURAINI RAHIM
Date:

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

i	Criteria i
j	Criteria j
k	Total number of decision maker
A	Set of alternative
C	Set of criteria
$s(\tilde{b}_1)$	Score function
$a(\tilde{b}_1)$	Accuracy function
$c(\tilde{b}_1)$	Certainty function
$\tilde{G}$	Border approximation area
$\tilde{G}^+$	Upper approximation area
$\tilde{G}^-$	Lower approximation area
A^+	Ideal alternative
A^-	Anti-ideal alternative
$\tilde{q}$	Distance from the border approximation area
$\tilde{p}_{ij}$	Normalized value of evaluation matrix
$\tilde{h}_{ij}$	Standardized value
$\tilde{w}_{dm}$	Weight of decision maker
$\tilde{a}_j$	Family of bipolar information number
$\tilde{A}g_w$	Bipolar neutrosophic average operator
$\tilde{A}_B(x)$	Deneutrosophication of bipolar neutrosophic set
d	Decision maker
D	Set of decision maker
$F^+(x)$	Degree of falsity
$F^-(x)$	Degree of falsity to some implicit counter-property

I'	Intuitionistic fuzzy set
$I^{-}(x)$	Degree of indeterminancy to some implicit counter-property
$I^{+}(x)$	Degree of indeterminancy
N	Neutrosophic set
S	Single valued neutrosophic
$T^{-}(x)$	Degree of truth to some implicit counter-propety
$T^{+}(x)$	Degree of truth
v	Degree of non-membership
X	Universe discourse
x	Generic elements
μ	Degree of membership
μ^{-}	Negative membership
μ^{+}	Positive membership
π	Degree of indeterminancy
$\tilde{A}$	Direct relation matrix
$\tilde{a}_{ij}$	Individual elements
$\tilde{D}$	Normalized direct-relation matrix
$\tilde{T}$	Total relation matrix
I	Identity matrix
$\tilde{R}$	Sum of rows
$\tilde{C}$	Sum of columns
$\tilde{R}+\tilde{C}$	Adding $\tilde{R}$ and $\tilde{C}$
$\tilde{R}-\tilde{C}$	Subtracting $\tilde{R}$ and $\tilde{C}$
$\tilde{w}_i$	Weight of criteria
$\tilde{W}_i$	Normalize the weight of criteria
$\tilde{N}$	Normalize decision matrix
$\tilde{x}_i^{+}$	Maximum value

$\tilde{x}_i^-$	Minimum value
$\tilde{V}$	Weighted matrix
$\tilde{W}_i$	Weight coefficients of the criteria
$\tilde{G}$	Border approximation area matrix
$\tilde{Q}$	Distance of the alternative
$\tilde{S}_i$	Rank the alternative
b	Bipolar fuzzy set
B	Bipolar neutrosophic set
F	Fuzzy set
m	Number of alternatives
n	Number of criteria

LIST OF ABBREVIATIONS

AHP	Analytical hierarchy process
ANP	Analytic network process
ARAS	Additive ratio assessment
BAA	Border approximation area
BFS	Bipolar fuzzy set
BNN	Bipolar neutrosophic number
BNS	Bipolar neutrosophic set
BWM	Best-worst method
CNS	Complex neutrosophic set
COPRAS	Complex proportional assessment
DEMATEL	Decision making trial and evaluation laboratory
DM	Decision maker
EDAS	Evaluation based on Distance from Average Solution
ELECTRE	Elimination and choice translating reality
FBWM	Fuzzy best-worst method
FS	Fuzzy set
GDM	Group decision making
GIS	Geographic information system
HFL	Hesitant fuzzy linguistic
IF-DEMATEL	Intuitionistic fuzzy decision making trial and evaluation laboratory
IF-ELECTRE	Intuitionistic fuzzy elimination and choice translating reality
IFS	Intuitionistic fuzzy set
INS	Interval-valued neutrosophic set
INVS	Interval neutrosophic vague sets
IR-MABAC	Interval rough multi-attributive border approximation area comparison
ISM	Interpretive structural modelling
IVIFS	Interval-valued intuitionistic fuzzy set
LAA	Lower approximation area

LBWA	Level-based weight assessment
MABAC	Multi-attributive border approximation area comparison
MADM	Multi-attribute decision-making
MAGDM	Multi-attribute group decision-making
MAIRCA	Multi-attribute ideal-real comparative analysis
MAUT	Multi-attribute utility theory
MCDA	Multi-criteria decision analysis
MCDM	Multi-criteria decision making
MCGDM	Multiple-criteria group decision-making
MOOSRA	Multi objective optimization on the basis of simple ratio analysis
MULTIMOORA	Multi objective optimization on the basis of ratio analysis plus full multiplicative form
MVNS	Multi-valued neutrosophic set
NS	Neutrosophic set
NSS	Neutrosophic soft set
PROMETHEE	Preference ranking organization method for enrichment evaluation
QUALIFLEX	Qualitative flexible multiple
SAW	Simple assistive weighting
SVNN	Single-valued neutrosophic numbers
SVNS	Single-valued neutrosophic set
SWARA	Stepwise weight assessment ratio analysis
SWOT	Strength, Weakness, Opportunities and Threats
TODIM	Interactive multi-criteria decision making
TOPSIS	Technique for order preference by similarity to ideal solution
UAA	Upper approximation area
VIKOR	VlseKriterijumska optimizacija I kompromisno resenje
WASPAS	Weighted aggregated sum product assessment

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

This chapter presents an introduction to the MSc thesis entitled "Bipolar Neutrosophic DEMATEL-MABAC for Sustainable Energy Selection". This chapter is divided into six sections. Section 1.1 provides the research background and Section 1.2 clarifies the research problem. Research objectives and research questions are addressed in Section 1.3. Then, Section 1.5 identifies the significance of the research. Lastly, the overall thesis outline is described in Section 1.6.

1.1 Research Background

This section is divided into four sub-sections. The first sub-section discusses multi-criteria decision making (MCDM). The second sub-section presents the linguistic variable. The next sub-section focuses on the development of the sets. The application of sustainable energy is discussed in the last sub-section.

1.1.1 Multi-Criteria Decision Making

Decision-making is one of the most basic and important choices by identifying decisions, gathering information and assessing alternatives in dealing with real-world problems. In decision making, one of the sources of evaluation information is based on the preferences provided by decision makers. The evaluation of multiple decision-makers can provide a variety of opinions that can be considered in obtaining the best solution of the decision compared to the evaluation by a single person. There are several decision-making methods that have been proposed in the literature and have been applied in many areas of study, for example, in engineering, economics, management and others.

In recent years, MCDM is one of the most well-known branches of Operations Research to deal with decision-making. It has become an important research topic that helps to improve the quality of decisions to be more explicit, rational and efficient in the decision-making process. Besides that, MCDM methods help to reconcile contradictory questions and choose the best solution based on the selected criteria or alternatives (Siksnelyte *et al*., 2018). The wide purpose of MCDM methods are ranking and design the alternative with respect to multiple conflicting criteria. Therefore, the MCDM method applies to choose the best alternative where many criteria have come into existence, i.e., the best can be obtained by analysing the different scopes, weights of the criteria and select the optimum using any MCDM techniques. Jayant and Sharma (2018) described MCDM methods as more explicit, rational and efficient models where they can help to improve the quality of decisions in the decision-making process. There are some well-known MCDM methods that have been introduced to solve the MCDM problems such as analytical hierarchy process (AHP), elimination and choice translating reality (ELECTRE), preference ranking organization method for enrichment evaluation (PROMETHEE), the technique for order preference by similarity to ideal solution (TOPSIS), decision making trial and evaluation laboratory (DEMATEL), multi-attributive border approximation area comparison (MABAC) and others.

DEMATEL method was originally developed based on the project in the Science and Human Affairs Program at Battelle Memorial Institute of Geneva between 1972 and 1976 (Fontela and Gabus, 1972). Gabus and Fontela (1973) introduced the DEMATEL method to solve difficult and complex problems in the real world. The DEMATEL method is a systematic method that can be used to build and analyze the structure of complicated casual relations between a set of factors with matrices or diagraphs that identify the key barriers in the various systems (Wang *et al*., 2017).

According to the researchers, the DEMATEL methods can be classified into three purposes. Firstly, this method clarifies the interrelationship between the criteria through the influential relationship map. Next, the structure of complicated causal relationships through matrices or digraphs can be visualized in the DEMATEL method. Lastly, the DEMATEL method also determines the weight of criteria by analysing the interrelationship and impact levels of criteria. Moreover, there are two groups in the DEMATEL method which are cause group and effect group. The main advantage of the DEMATEL method is determining the structure and relationship between criteria includes the cause-effect model (Tseng and Lin, 2009). The cause group has an influence on the effect group where it used to estimate the criteria weights (Dalalah et al., 2011). There are several authors that have discussed the DEMATEL method as a weighting method for the criteria (Baykasoğlu *et al*., 2013; Kobryń, 2017; Suh *et al*., 2019) . Hence, the weight of criteria plays an important role in the MCDM method problem which reflects the relative importance or reliability of criteria.

Meanwhile, MABAC method defined the distance of the criterion function of each alternative from the border approximation area (BAA) that was proposed by a group of researchers at the research centre in University of Defence in Belgrade. The MABAC method is a particularly pragmatic and reliable tool for rational decision-making because it has simple computation and stable solutions (Pamučar and Ćirović, 2015). It divides the performance of each criterion function into upper approximation area (UAA), containing ideal alternatives and lower approximation area (LAA), containing anti-ideal alternatives. Performance of alternative is subjected to the proportion of these UAA and LAA. Hence, the MABAC method is applicable to be used to select the optimal alternative or for the ranking process.

1.1.2 Linguistic Variable

The linguistic variable is a variable whose values are not numbers but words or sentences in a natural or artificial language (Zadeh, 1975). Then, it is a linguistic expression which is one or more words labelling information granular. In other words, the linguistic variable is a variable made up of a number of words called linguistic terms with an associated degree of membership. A linguistic term is one of a set of linguistic terms which are subjective categories for linguistic variables each described by a membership function.

For example, a variable that represents some characteristics of an element such as “food” at the restaurant is a linguistic variable, then decision maker can easily express the evaluation by linguistic terms as “bad”, “medium” and “good”. Based on example by Bordogna *et al.* (1997) and Levrat *et al.* (1997) when evaluating the “comfort” or “design” of a car, linguistic terms like “good”, “fair” and “poor” are usually used, then for evaluating a car’s speed, linguistic terms like “very fast, “fast” and “slow” can be used.

In the real world, the decision maker prefer to evaluate criteria or alternative by using linguistic variable rather than exact values because of partial knowledge and lack of information processing capabilities of the problem. Most of decision makers cannot give accurate numerical values to represent opinions based on human experience and use the linguistic assessments as opposed to numerical values to be more practical (Herrera and Herrera-Viedma, 2000; Lin and Lee, 2008). There is a lot of qualitative information in complex decision-making problems due to uncertainty of decision environment and differences of decision makers’ cultural and knowledge background, therefore the evaluation results of decision makers can be expressed easily by linguistics variables (Ye, 2014).

Decision-makers normally expressed their preferences using linguistic variables due to the complexity of decision-making problems. Therefore, the linguistic variable can be efficiently used to provide the reliability and flexibility in the decision-making problem especially in the fields of artificial intelligence, medical diagnosis, economics, transportation, management and other related areas. Linguistic variables are valid tools because the use of linguistic information reinforces the flexibility and reliability of classical decision models (Martínez *et al.*, 2009).

1.1.3 Development of Sets

The concept of Yin and Yang in traditional Chinese medicine are two sides, which is Yang as the masculine or positive side of a system and Yin as the feminine or negative side of a system (Zhang, 1998). Therefore, most human decision-making is based on double-sided or bipolar judgment thinking which is the positive side and negative side. In real-life situations, this concept is useful to handle the complex problems and the wide variety of human decision-making based on double-sided or bipolar judgment thinking. Moreover, the tendency of human brain to make decisions is based on good and bad sides which respect to positive and negative values. According to Zhang (1998), almost all the decision-making are based on both, positive and negative sides which called as bipolar judgmental thinking. Bosc and Pivert (2013) stated that bipolarity refers to the propensity of the human mind to reason and make decisions on the basis of positive and negative effects. For example, effect and side effect, cooperation and competition, likelihood and unlikelihood, friendship and hostility, common interests and conflicts of interests, feed-forward and feedback and so forth.

Bipolar information which is positive information represents all about possible, satisfactory, permitted, desired or considered that being acceptable while negative information represents impossible, rejected or forbidden. For the bipolar preference problem, positive preferences correspond to the wishes as they specify which objects are more desirable than others without rejecting those that do not meet the wishes. Other than that, negative preferences correspond to constraints as they specify which values or objects have to be rejected (Bosc and Pivert, 2013). Furthermore, bipolar is important in several domains such as multi-criteria decision making, artificial intelligence, psychology, qualitative reasoning and others.

Then, human decision-making is uncertain and hard to be defined by a crisp value. Therefore, the concept of fuzzy set (FS) was introduced by Zadeh (1965) to deal with uncertainty of information in the real-life problems. Besides that, it only expresses membership degree with a range in [0, 1]. But, FS cannot deal efficiently with some complicated information because FS only has one membership degree. From FS, Atanassov (1986) proposed an intuitionistic fuzzy set (IFS) which considers a membership degree and a non-membership degree simultaneously. The theory of IFS is more useful to handle uncertainty and incompleteness in decision situations than FS. Every component in IFS shows the membership value which defined as truth-membership and non-membership value which defined as falsity-membership and they are satisfying the conditions of [0, 1]. The sum of membership degree and non-membership degree in IFS need equal or less than 1. For example, when we ask the opinion from the decision-maker about the certain statement, he or she may state the possibility that the statement is true is 0.5 and the statement is false is 0.3 and the degree that he or she is not sure is 0.2.

However, IFS cannot solve some application problems that have positive and negative characteristics. Almost all the decision-making problems have positive and negative characteristics, Zhang (1998) introduced the idea of bipolarity into a fuzzy set named bipolar fuzzy set (BFS). BFS is proved to deal with uncertain real-life problems which can characterize not only the positive membership degree but also the negative membership degree. Also, the range of membership degree of the BFS is [-1, 1]. The membership degree [0, 1] of an element indicates the element somewhat satisfies the property and the membership degree [-1, 0] of an element indicates the element somewhat satisfies the implicit counter-property. Besides that, the membership degree 0 of an element indicates the element is irrelevant to the corresponding property. To sum up, BFS formalized polarity and fuzziness and captures the bipolar or double-sided nature of human perception and cognition.

In the recent era, the decision-making information often has incomplete, indeterminate and inconsistent information where IFS can handle incomplete information but not inconsistent information. Therefore, Smarandache (1998) proposed the neutrosophic set (NS) as extensions the concept of classical set, fuzzy set, intuitionistic fuzzy set and interval-valued intuitionistic fuzzy set (IVIFS). Neutrosophic set is a part of neutrosophy, a branch of philosophy that studies the origin, nature and scope of neutralities and their interactions with different ideational spectra. There are three elements of the neutrosophic set which are truth-membership degree, indeterminacy-membership degree and falsity-membership degree which are within real standard or non-standard unit interval $]^-0,1^+[$. To summarize, neutrosophic sets can be easier and better to express incomplete, indeterminate and inconsistent. Then, the neutrosophic set also have greater adaptability, accuracy and similarity to the framework than fuzzy set.

Since the neutrosophic set was hard to be applied in some real problems because of the truth membership degree, indeterminacy membership degree and falsity membership degree lie in $]^-0, 1^+[$. Therefore, single-valued neutrosophic set (SVNS) was proposed by Wang *et al*. (2010) as an extension of the neutrosophic set which takes the value from the subset [0, 1]. Recently, the concept of bipolar neutrosophic set (BNS) was introduced by Deli *et al*. (2015) from the extension of the ideas of bipolar fuzzy set and neutrosophic set. It can describe bipolar, uncertain, incomplete and inconsistent information. BNS has positive membership degree and negative membership degree where the positive membership degree denotes the truth membership degree, indeterminacy membership degree and falsity membership degree of an element corresponding to the BNS while negative membership degree denotes the truth membership degree, indeterminacy membership degree and falsity membership degree of an element to some implicit counter-property corresponding to BNS.

To sum up, the chronological of development sets from the classical set to bipolar neutrosophic set can be illustrated in Figure 1.1. From the development of sets, the characteristics for each set are summarized in Table 1.1.

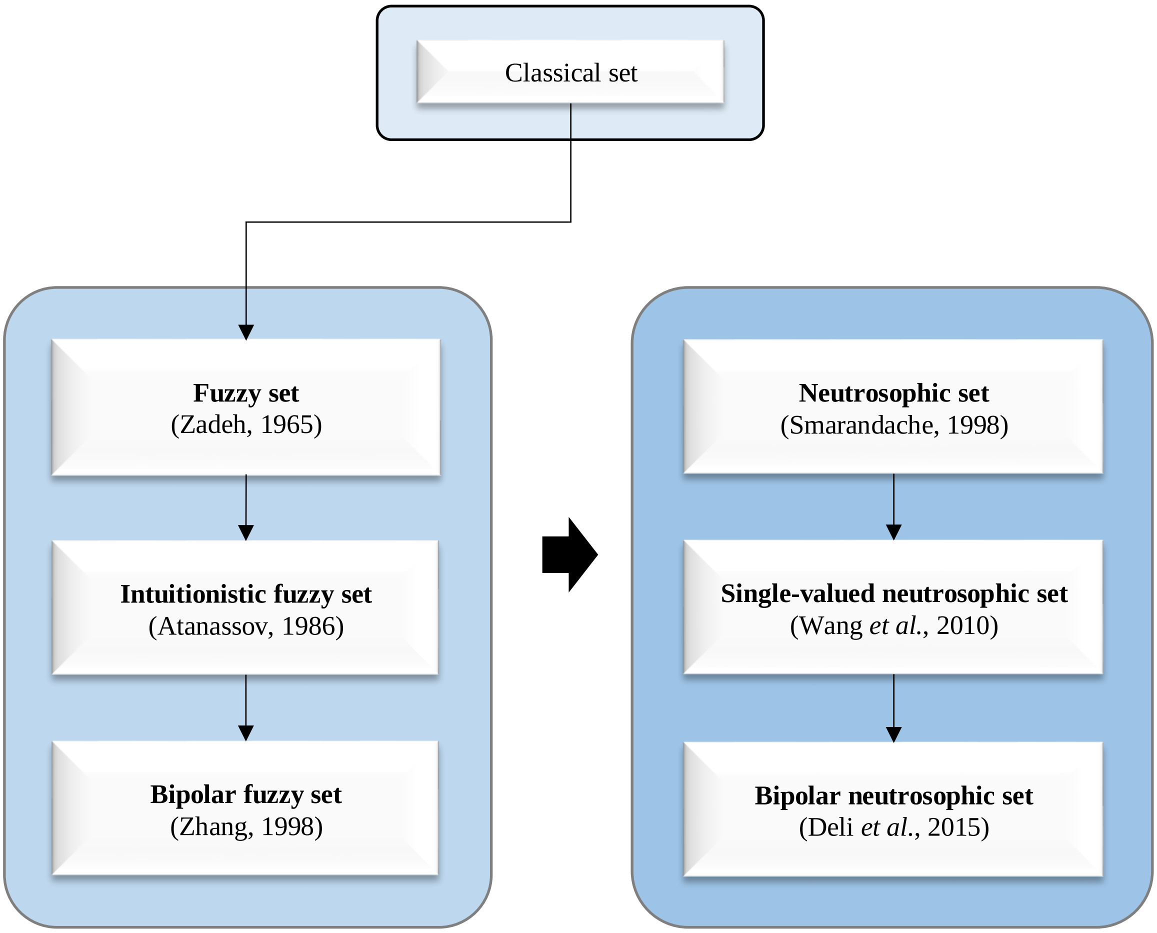

Figure 1.1: Chronological of development sets

Table 1.1: Summary of characteristics for each set

Sets	**Uncertainty information**	**Incomplete or indeterminate information**	**Inconsistent information**	**Positive and negative information**
Fuzzy Set	√	X	X	X
Intuitionistic Fuzzy Set	√	√	X	X
Bipolar Fuzzy Set	√	X	X	√
Neutrosophic Set	√	√	√	X

Single Valued Neutrosophic Set	√	√	√	X
Bipolar Neutrosophic Set	√	√	√	√

1.1.4 Sustainable Energy

MCDM studies have been applied in various field. One of the most significant field in environmental studies is sustainable energy. Energy is the most important needs of humans in daily lives and all living organisms especially for the development of economy, social growth, sector transport, telecommunication, industry, agriculture, household, education and others. Due to energy crisis, sustainable energy is introduced that can be defined as energy sources that are not expected to be depleted in a time frame relevant to the human and contribute to the sustainability of all species. Sustainable energy also defines as the provision of energy such that it meets the needs of the present without compromising the ability of future generations to meet their needs (Lemaire, 2004). In other words, sustainable energy is able to replenish human life and no cause long-term damage to the environment.

Sustainable energy is one of the global goals in the 2030 Agenda for Sustainable Development, and plays a key role in ensuring accessibility to affordable, reliable, sustainable and modern energy for all (United Nations, 2015). Besides that, sustainable energy plays an important role in the economic growth and social development of a country and the living quality of people (Yuan *et al*., 2008). The sector of sustainable energy has to balance energy production and consumption, and has no or minimal, negative impact on the environment, but at the same time, gives the opportunity for a country to increase the productivity of its social and economic activities (Wang *et al*., 2009).

Sustainable energy includes all renewable energy sources such as biomass energy, geothermal energy, hydro energy, solar energy, tidal energy, wave energy and wind energy. Each sustainable energy source has its ability to replenish naturally. For example, solar energy is constantly replenished and will never run out where can be used directly from the sun for heating and lighting homes and other building for generating electricity, hot water heating, solar cooling and variety of commercial and industrial uses (Alrikabi, 2014).

1.2 Problem Statement

Nowadays, decision-making problems have increased in complexity due to multiple conflicting criteria and involve many available alternatives. Since criteria may have different degrees of importance or reliability, hence, the determination of criteria weights is very crucial for the optimal decision-making process. The most prominent part is the ranking of alternatives with respect to the criteria. There are many decision-making methods in the literature to deal with the weighting of criteria and ranking the alternatives. Under the MCDM approach, DEMATEL and MABAC methods are among the most well-known methods. DEMATEL method has been used mostly in weight determination, while MABAC method has been proposed for the ranking of alternatives. In this study, the focus will be given to the improvement of the integrated method of DEMATEL-MABAC method to overcome the problems in decision-making.

From the limitation of previous studies, the combination of DEMATEL-MABAC method is still insufficient strength due to considering the crisp or fuzzy numbers and neglecting the bipolarity information during decision-making assessment. A great challenge here is to choose the most suitable linguistic variable to model judgment or opinion provided by the decision makers. In real-life problems, criteria and alternatives can be characterized into effect and side effects (positive and negative sides). Hence, bipolar concept is vital to capture the more precise judgment of the decision-making process. To make this judgment more specific, the bipolar information can be further specified to truth, false and indeterminacy under the neutrosophic set theory. Therefore, the integration of these ideas in the new linguistic variable to better model the judgment of decision makers is very meaningful.

Moreover, when implemented in multi-criteria decision-making, it will make the final decision more decisive and conclusive. The highlighted issues and ideas are main the motivation of this study, which is in proposing the linguistic variable based on bipolar neutrosophic set. Then, this new linguistic variable based on bipolar neutrosophic set will be integrated into DEMATEL-MABAC method as the proposed method.

MCDM has been solved in several decision-making problems including management, manufacturing industry, environmental science, energy, medical, and engineering problems. However, limited studies from the previous research use bipolar neutrosophic DEMATEL-MABAC method to select sustainable energy. Therefore, this research inspired to apply the proposed method that provides the weight of criteria and rank the alternatives to solve the sustainable energy selection.

The summary of problem statement in this research is given in Figure 1.2.

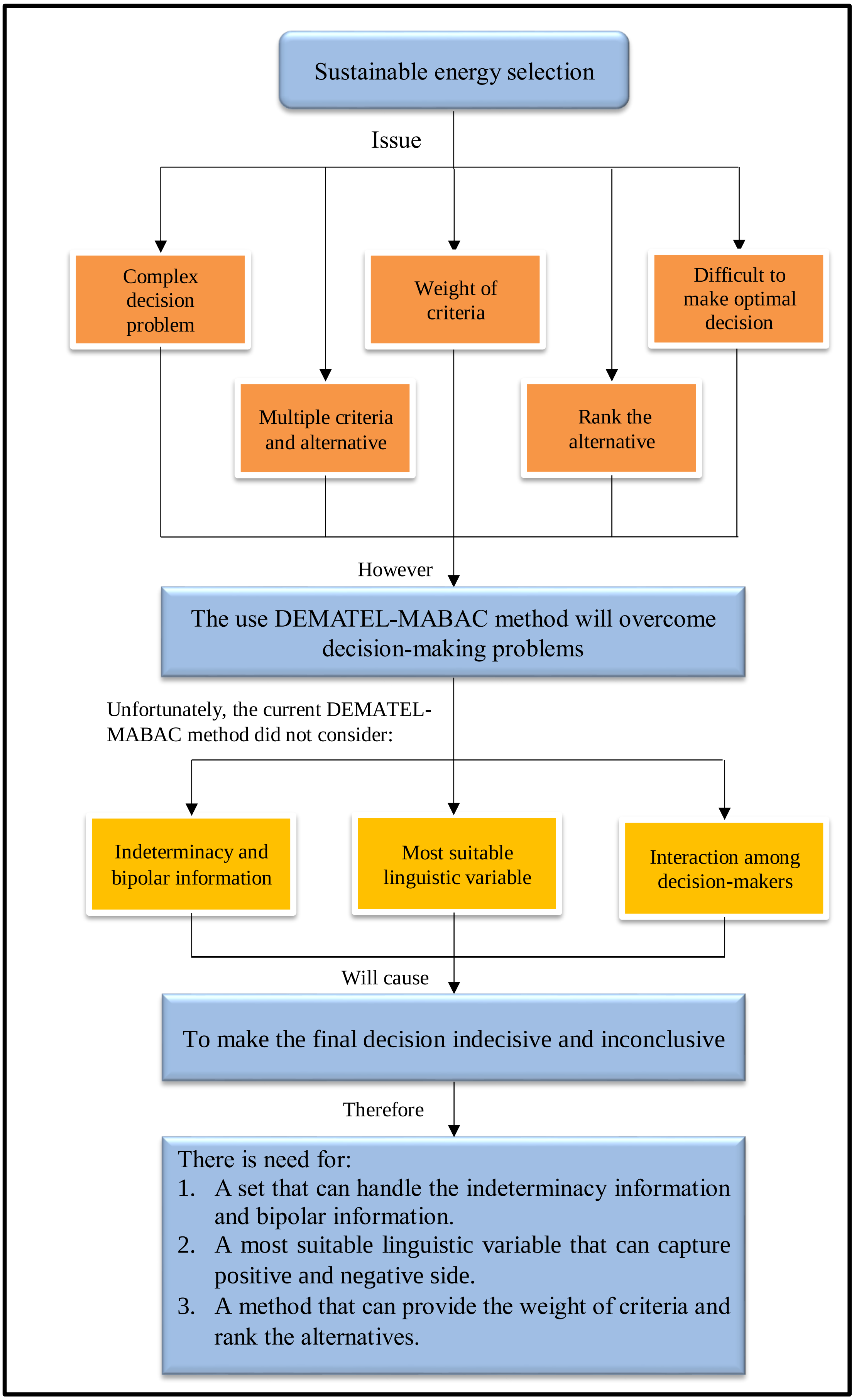

Figure 1.2: Problem statement of the research

1.3 Research Objectives and Research Questions

The ultimate aim of this research is to propose DEMATEL and MABAC methods under bipolar neutrosophic to solve decision-making problems. The modification is done based on the problem statement stated in the previous section.

The specific objectives of this research are:

1. To propose a new linguistic variable for bipolar neutrosophic set.
2. To integrate the bipolar neutrosophic DEMATEL and MABAC methods based on the newly defined linguistic variable.
3. To apply the proposed method for sustainable energy selection.
4. To analysis the comparative results between the proposed methods and the existing methods.

This research identifies the main research questions. The questions are listed as below:

1. How to model and define linguistic variables based on bipolar neutrosophic sets?
2. How to integrate the bipolar neutrosophic DEMATEL and MABAC methods based on the newly defined linguistic variable?
3. How these proposed methods be used to solve MCDM problems?
4. How efficient and useful are this proposed methods in solving MCDM problems?

1.4 Research Significance

This research has been significant to the field of knowledge in the form of theoretical and practical contributions. This research is introducing new bipolar neutrosophic linguistic variable to accurately and consistently represent expert preferences. The weight of criteria and ranking of alternatives will be generated using the DEMATEL-MABAC method. It is important to consider the interrelation between multiple criteria and alternatives during the evaluation process. For example to buy the house, price depends on the quality of house. Then, the comparative analysis between the proposed method and existing methods are conducted in this research.

In term of practical contribution, the proposed methods are implemented to a case study to select the optimal of sustainable energy. This case study is conducted to identify the weight of criteria and ranking of alternatives to select the optimal alternatives and suggest a schematic planning for the improvement in sustainable energy especially for researcher. The researcher from this field can used the ranking list of the alternative in order to focus their research for select sustainable energy. Therefore, the sustainable energy can be improved and eventually helps in the energy problem in the world.

1.5 Thesis Outline

This section briefly explains the outline of the thesis. The thesis consists of seven chapters. The description of each chapter is explained as follows:

CHAPTER 1: INTRODUCTION

This chapter provides an introductory statement regarding the research. It gives an insight into the research field and the main purposes of the research. This chapter explains the background of the research, the problem statements, the objectives and scope of the research, the significance of the research and finally presents the outline of the thesis.

CHAPTER 2: LITERATURE REVIEW

The relevant literature is divided into four sections. The review of MCDM methods is provided in the first section. Next, the second section review the related linguistic variable and the neutrosophic sets in the third section. The fourth section highlights the review of sustainable energy in decision-making problem. The identification of gaps in the literature presents in the last section this chapter.

CHAPTER 3: PRELIMINARIES

This chapter is divided into four sections which comprises the preliminaries of related set theories and methods involving the definitions, properties and fundamentals of concept. The first section presents the related definitions include fuzzy set, intuitionistic fuzzy set, bipolar fuzzy set, neutrosophic set, single-valued neutrosophic set and bipolar neutrosophic, followed by the properties of bipolar neutrosophic set in the second section. The fundamental concept of DEMATEL is defined in the third section. In the section four, the fundamental concept of MABAC is presented.

CHAPTER 4: PROPOSED BIPOLAR NEUTROSOPHIC DEMATEL-MABAC

In this chapter, the step-by-step of the proposed method is described in four phases. The first phase describes the framework of the proposed method and introduces the new linguistic variable for the bipolar neutrosophic set in second phase. The aggregation and deneutrosophication for the bipolar neutrosophic information are determined in the third phase. In the fourth phase, the detailed computational procedure of bipolar neutrosophic DEMATEL-MABAC method is given and illustrative example is presented in the fourth phase.

CHAPTER 5: APPLICATION TO SUSTAINABLE ENERGY SELECTION

This chapter demonstrates the application of proposed method to sustainable energy selection as a case study. The introduction of the case study is explained in the first section. In the second section, data collection process including the selection of criteria, alternatives and group of decision makers and decision makers' evaluation. Then, the aggregation and deneutrosophication is determined. Meanwhile, the computational of proposed method which is bipolar neutrosophic DEMATEL-MABAC method based on the data collection is showed. The result and discussion are discussed in the last section of this chapter.

CHAPTER 6: COMPARATIVE ANALYSIS

This chapter discusses the comparative analysis of the DEMATEL-MABAC method with respect to several existing sets including classical set, fuzzy set and neutrosophic set. Then, the comparative analysing between the proposed methods with another MCDM are provided. The result of the proposed method is compared and validated to verify its effectiveness and feasibility.

CHAPTER 7: CONCLUSION

This chapter concludes this research. The objectives and outcomes were recaps and the contributions were discusses for this research. Next, the limitation and recommendations for future research are described and suggested. Lastly, the final word is discussed. The outline of this thesis presents in Figure 1.3.

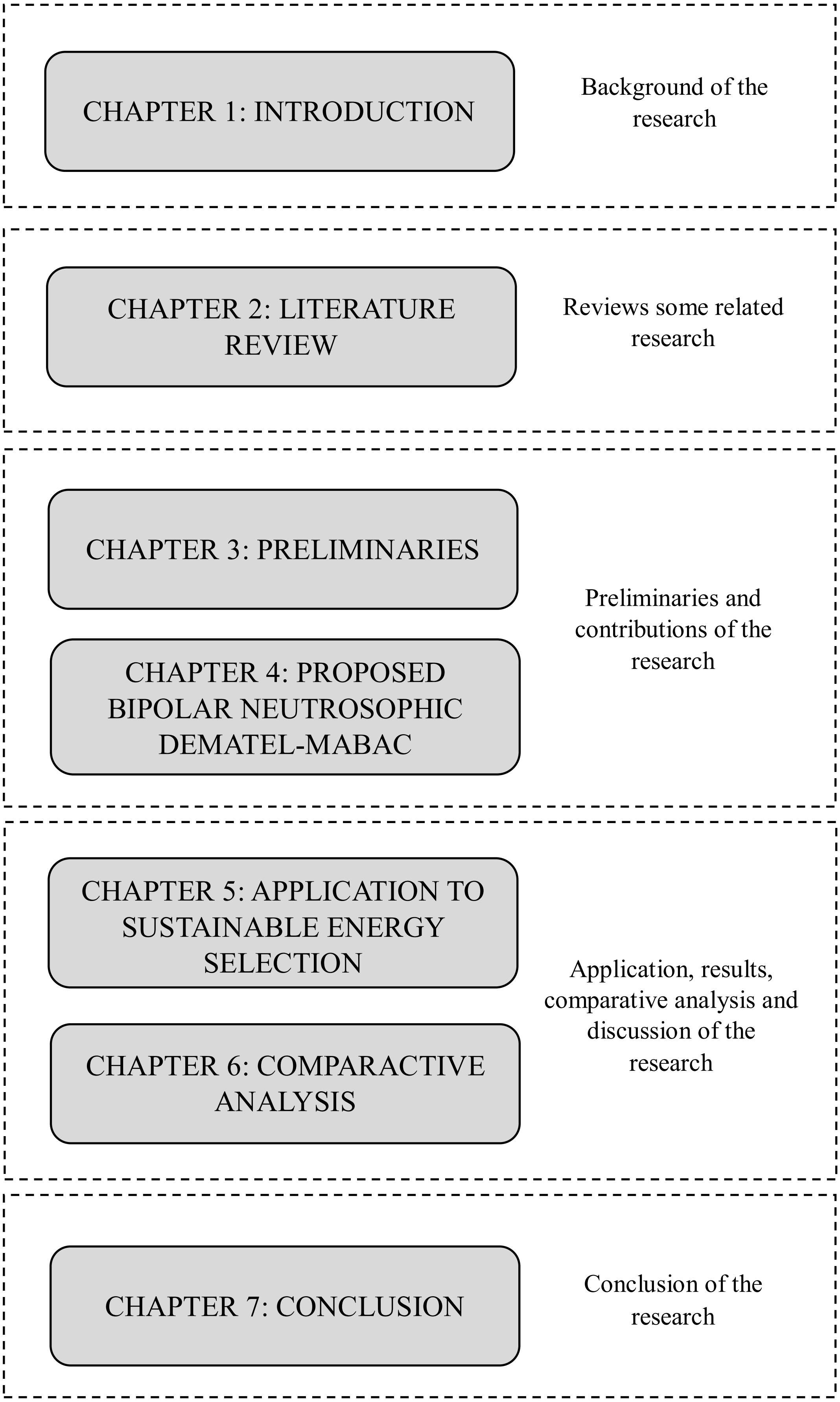

Figure 1.3: Thesis outline

Figure 1.4 shows the framework of the research including research objective and research contribution.

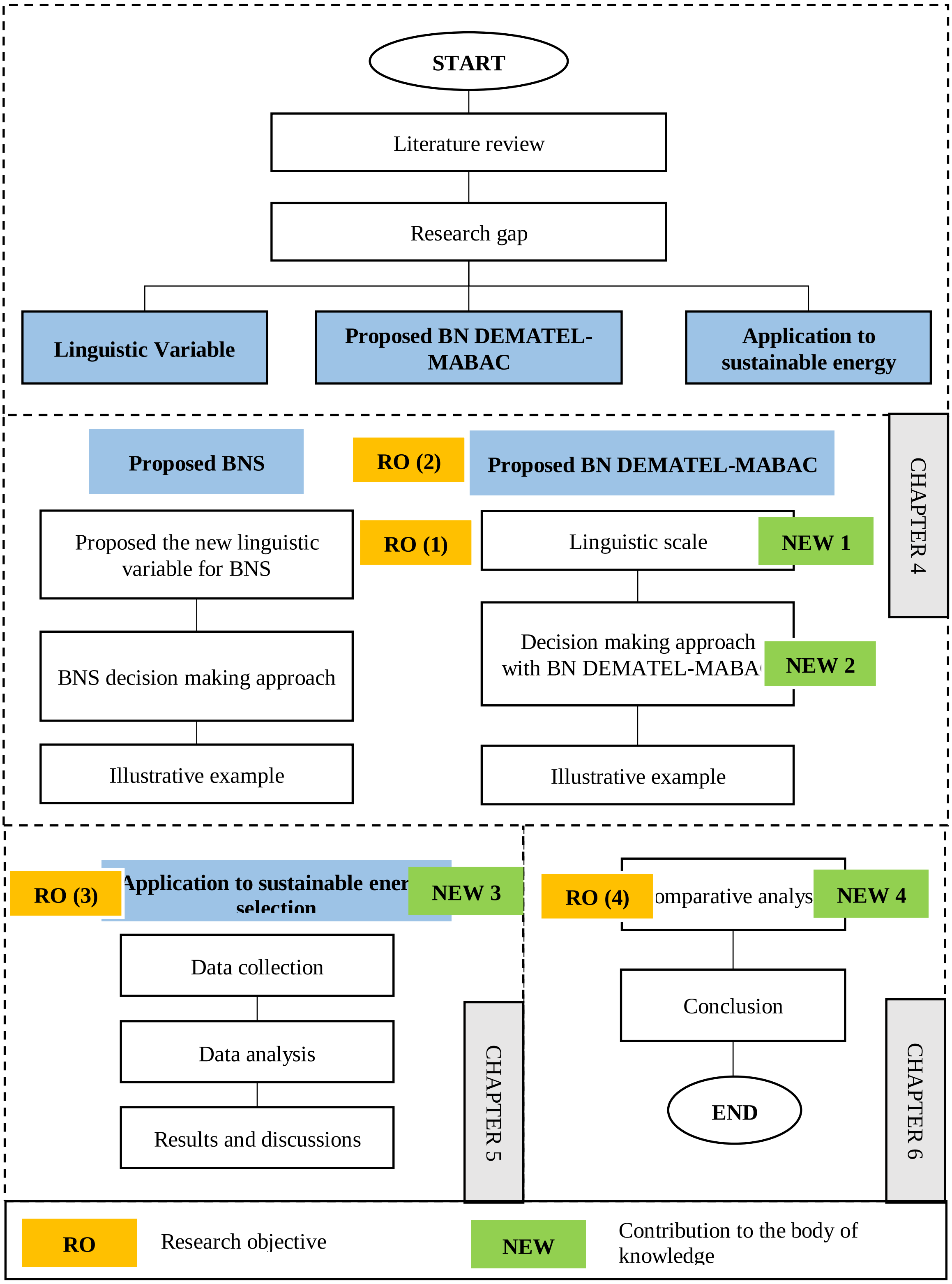

Figure 1.4: Research framework

CHAPTER 2

LITERATURE REVIEW

This chapter attempts to review the relevant literature which can be divided into four sections. In Section 2.1, the review of the MCDM methods is carried out. Section 2.2 discusses the review of the neutrosophic set and the review of linguistic variable is focused in Section 2.3. Section 2.4 provides the review of the related applications of sustainable energy. This chapter ends with the analysis of the research gap and will be presented in Section 2.5.

2.1 Review of MCDM Methods

In recent years, the DEMATEL method solved the problems in various theories, concepts and applicants related to MCDM methods that have been successfully carried out in numerous complex real-world. At first, the DEMATEL method focused on the interrelationship between the criteria through the influential relationship map and visualized the structure of complicated causal relationships through matrices or digraphs. For the review, Tseng (2009) proposed the fuzzy set theory and extension of the DEMATEL method to evaluate the interrelationship of service quality evaluation criteria and compromised the group perceptions into cause and effect model in uncertainty. DEMATEL method applied by Hsu *et al.* (2013) to deal with the importance and causal relationships by considering the interrelationship among the evaluation criteria of supplier selection in green supply chain management. DEMATEL method and fuzzy Analytic Network Process (ANP) identified the thin film transistor liquid crystal display and established an integrated model of new product development performance evaluation for enterprises where the DEMATEL method determined the interrelationship among factors (Chen *et al*., 2015). Govindan and Chaudhuri (2016) used the DEMATEL method to analyse the interrelationship of risks faced by third party logistics service providers. DEMATEL and ANP also obtained the interrelationship structure and priority of each dimension and each criterion in green project management (Chou *et al*., 2017). The combination of failure mode and effects analysis with DEMATEL models proposed by Tsai *et al*. (2017) to facilitate the identification of core problems and prioritization of solutions in the Chinese photovoltaic cell industry where DEMATEL examined the interactive effects and causal relationships. Si *et al*. (2017) presented the DEMATEL technique to build an interactive network and visualize the causal relationships between the performance indicators and identified key performance indicators for holistic hospital management. Then, Hatefi and Tamošaitienė (2018) developed fuzzy DEMATEL to determine interrelationship among risk factors combined with fuzzy ANP models to evaluate construction projects by considering intertwined relations among risk factors. The fuzzy synthetic method based on hierarchical structure and DEMATEL method conducted the interrelationship among the attributed by providing a visual interrelationship map in sustainable development performance for small and medium enterprises (Wu *et al*., 2019). Fuzzy DEMATEL method proposed by Ataei and Norouzi Masir (2020) to study and analyse eleven impacting factor interrelationship based sustainable development index in open-pit mining. Hassan and Asghar (2021) presented interpretive structural modelling (ISM) and DEMATEL.

Other than that, some researchers also discussed the DEMATEL method to determine the weight of criteria by analysing the interrelationship and impact levels of criteria. Dalalah (2009) determined the weight of criteria based on the separate cause-effect assessment of group professionals using the fuzzy DEMATEL method and applied it to the fuzzy TOPSIS method to estimate the alternative in the decision-making process. The combination of fuzzy DEMATEL and fuzzy VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) methods introduced by Lin et al. (2011) where fuzzy DEMATEL determined the weight of criteria and the result of criteria weight apply in the fuzzy VIKOR to find the best alternative that satisfies the evaluation of criteria among of candidate solutions. Baykasoğlu *et al*. (2013) presented the fuzzy DEMATEL method to evaluate the weights of criteria and the fuzzy hierarchical TOPSIS method to access the alternatives according to the criteria. The fuzzy DEMATEL method to assign weights of criteria and sub-criteria, then TOPSIS method used to rank GREENEX companies (Visalakshmi *et al*., 2015). Zhao *et al*. (2017) proposed the fuzzy DEMATEL method to determine the value of the criteria weights and the fuzzy TOPSIS method to rate the importance degree of alternative components. Tian *et al*. (2019) integrated the grey method and DEMATEL to determine the weights of nine criteria and fuzzy VIKOR adopted to rank the three patterns based on expert evaluations for selection of the take-back pattern of vehicle reverse logistics in China. The combination of fuzzy DEMATEL and TOPSIS where 2-tuple linguistics method and DEMATEL method demonstrated the relations among participant's attributes and determined their weights, then TOPSIS presented to evaluate and rank the alternative participants in knowledge-intensive crowdsourcing (Zhang and Su, 2019). Dinçer *et al*. (2019) studied interval type-2 DEMATEL to the weight of criteria and interval type-2 qualitative flexible multiple (QUALIFLEX) to rank the alternatives for Kano-based measurement of customer expectations in the retail service industry into the fuzzy numbers. The hybrid of DEMATEL and ELECTRE methods based on the intuitionistic fuzzy (IF) environment where the IF-DEMATEL method employed to obtain the importance weights of the criteria and the IF-ELECTRE method applied to rank the candidates based on cardinal and ordinal evaluations (Kilic *et al*., 2020). The combination of rough DEMATEL method and fuzzy VIKOR method proposed by Zhang *et al*. (2021) to solve sustainable supplier selection problem where the rough DEMATEL determined the weight of evaluation indicators and fuzzy VIKOR method determined supplier rankings by converting the fuzzy linguistic term into precise information. Chen *et al*. (2021) integrated the hesitant fuzzy linguistic term set, DEMATEL method and multi objective optimization on the basis of ratio analysis plus full multiplicative form (MULTIMOORA) under an uncertainty environment for quality function deployment where fuzzy DEMATEL captured the influence weights.

Meanwhile, Hosseini and Tarokh (2011) extended the DEMATEL method to obtain the weight of criteria based on the interval type-2 fuzzy sets in decision making.

The fuzzy DEMATEL based on type-2 fuzzy sets was further by Hosseini and Tarokh (2013) to obtain the weights of dependent criteria based on the words and combines with perceptual computing for decision making. Keskin (2015) introduced integrated model of fuzzy DEMATEL and fuzzy c-means algorithm for increasing the supplier selection and evaluation quality where fuzzy DEMATEL used in the interactions between the evaluations criteria and computed the criteria weight, then fuzzy c-means algorithm classified the vendors according the performances. The hybrid of fuzzy DEMATEL with the geographic information system (GIS) and the multi-criteria decision analysis (MCDA) presented by Jeong *et al*. (2016) for the planning of rural housings in reservoir areas under (mass) tourism where fuzzy DEMATEL method applied the groups/criteria weight coefficients calculation regarding with their influence. Gigović *et al*. (2016) applied the fuzzy DEMATEL method for expert calculation of the weight of all criteria in relation to their impact on the development of ecotourism combined with GIS and MCDA to estimate and map the suitability classes of ecotourism potentials in the study area of “Dunavski kljuc” region (Serbia). The fuzzy axiomatic design and fuzzy DEMATEL methods was integrated to select the dental material. Another novelty of the DEMATEL method is determined the weights of the criteria based on interactions among criteria and fuzzy axiomatic design method evaluated alternative materials (Candan *et al*., 2017). DEMATEL and fuzzy MCDM proposed by Gopal *et al*. (2018) to determine priority weights of each evaluation criterion and rate knowledge transfer effectiveness on the global software development project outcome from software service outsourcing perspective into product success and service quality. Shahi *et al*. (2018) investigated the cause and effect relationship among effective criteria and ultimate weight for each criterion using fuzzy DEMATEL and GIS applied spatial combination process for the best model to build a nuclear power plant in Bushehr Province, Iran. The application of GIS-MCDA and fuzzy DEMATEL presented by Jeong and Ramírez-Gómez (2018) to identify suitable and favourable sites for biomass facilities in terms of long-term sustainability where fuzzy DEMATEL calculated the weight coefficients regarding the influence. Ghadami *et al*. (2021) utilized the fuzzy DEMATEL technique to rank and weight the categories, subcategories and standards of hospital accreditation. The fuzzy DEMATEL method classified and calculated the weight of selected criteria for the selection of sustainable suppliers in sustainable development (El Mariouli and Abouabdellah, 2020). Abdullah and Rahim (2020a) evaluated fuzzy DEMATEL to propose the relative weight coefficients of fifteen sub-criteria for urban sustainable development.

Besides that, Dey *et al*. (2012) explained the various weights using the DEMATEL method and integrated the Quality Function Deployment to select the most suitable supplier. Huang *et al*. (2016) constructed the DEMATEL method based on the network process to demonstrate the influence relationship and derived the influence weight of criteria for evaluating the electronic service quality of group buying websites. The hybrid MCDM of DEMATEL and Multi-Attribute Ideal-Real Comparative Analysis (MAIRCA) introduced by Pamucar *et al*. (2018) where DEMATEL determined the weight coefficients of the criteria and MAIRCA selected a location for the development of a multimodal logistics centre by the Danube River. Chatterjee *et al*. (2018) implemented the grey DEMATEL method to obtain the weights of criteria and the grey additive ratio assessment (ARAS) method to evaluate and rank the green supply chain management performance of alternative suppliers. DEMATEL method determined the weights of the criteria and Complex Proportional Assessment (COPRAS) method calculated the ranking of the alternatives to select the best alternative fuel for control of the impact of greenhouse gas emissions (Narayanamoorthy *et al*., 2021). Birgün and Ulu (2021) applied the DEMATEL method to determine the weight of the criteria and the COPRAS method to evaluate the alternatives based on the weighted criteria and select the site of establishment for a training centre focused on industry 4.0.

Next, the researchers also have been designed the DEMATEL method in the different types of neutrosophic sets. Yang and Pang (2018) introduced the DEMATEL method and TOPSIS method under multi-valued interval neutrosophic sets where the DEMATEL method determined the dependencies among attribute and weight of criteria and TOPSIS used to rank the alternatives. The interval-valued neutrosophic set of the DEMATEL method and ELECTRE III method applied to select suitable shopping mall photovoltaic plans Feng *et al*. (2018). The single-valued neutrosophic set into the DEMATEL method proposed by Awang *et al*. (2018a) to obtain the importance and cause-effect relationships among the influential factors of coastal erosion. Liu *et al*. (2018) integrated single-valued neutrosophic sets with the

DEMATEL method for the selecting of the transport service provider. The Shapley weighting vector based on single-valued neutrosophic aggregating operator into the DEMATEL method and applied the proposed method to the coastal erosion problem Awang *et al*. (2018b). The neutrosophic DEMATEL and TOPSIS methods presented by Kilic and Yalcin (2021) for the performance comparison of municipalities. Tan and Zhang (2020) integrated the DEMATEL method and fuzzy distance of trapezoidal fuzzy neutrosophic numbers where the DEMATEL method obtained the weight of attribute for the application of typhoon disaster assessment. Abdullah and Rahim (2020b) introduced DEMATEL method under bipolar neutrosophic set to enhance decisions in urban sustainable energy. The DEMATEL method with neutrosophic set applied by Pantoja *et al*. (2020) for the prioritization of internal factors in the emergency services. Díaz *et al*. (2020) developed the neutrosophic DEMATEL method to prioritize the factors that influence teenage pregnancy. The combination of interval neutrosophic vague sets and the DEMATEL method with a new linguistic variable explored by Al-Quran *et al*. (2020) and demonstrated the proposed approach to evaluate the quality of hospital service. Abdullah *et al*. (2021) utilized the single-valued neutrosophic sets with DEMATEL method for segregating types of criteria in the subcontractor selection problem. The neutrosophic DEMATEL method studied for evaluating the leanness assessment methodology to aid the company's lean transformation (Kilic *et al*., 2021).

MABAC method is one of the well-known and particularly useful in ranking the alternative in solving MCDM problems. Božanić *et al*. (2016) presented the application of MABAC to support in making a decision on using forces in a defensive operation of Land Forces and formulation of a decision strategy. The hybrid method encompassing factor relationship and MABAC proposed by Chatterjee *et al*. (2017) for selection and evaluation of non-traditional machining processes. Debnath *et al*. (2017) used several decision-making aspects in the unique mechanism of the MABAC method. The MABAC, evaluation based on Distance from Average Solution (EDAS) and new similarity measure to solve interval-valued fuzzy soft decision making problem (Peng *et al*., 2017). Xue *et al*. (2016) studied IVIFS and MABAC for handling material selection problems with incomplete weight information. The similarity of interval type-2 fuzzy based on the MABAC method proposed by Hu *et al*. (2019) for the selection of the most suitable medical treatment under a patient-centered environment. The combination of the heterogeneous information environment and MABAC method applied by Xue-Guo *et al*. (2019) to develop a new green supplier evaluation and selection model. Wei *et al*. (2019) obtained MABAC under probabilistic linguistic sets for the supplier selection of medical consumption products. MABAC method with Z-number integrated by Fan *et al*. (2020) for the selection of third-party logistics suppliers. The stepwise weight assessment ratio analysis (SWARA) method and MABAC method under bipolar fuzzy sets (BFS) for the risk assessment of occupational health and safety where BFSs deal the vague and uncertain assessment information by experts, SWARA method obtained the weights of risk criteria and MABAC method determined the risk ranking of hazards (Liu *et al*., 2020). The intuitionistic fuzzy sets and MABAC method designed by Li (2021) to evaluate the intelligent transportation system. A novel hybrid method of fuzzy best-worst method (FBWM) and MABAC method where FBWM determined the weight and importance of each criterion and MABAC method used to rank sustainable public transport alternatives (Keshavarz-Ghorabaee *et al*., 2021). Hristov *et al*. (2021) developed D-number of level-based weight assessment (LBWA) and interval MABAC model for the selection of an automotive cannon for integration into combat vehicles.

Furthermore, the MABAC method also combined with other MCDM methods to solve decision-making problems. Peng and Yang (2016) proposed Choquet integral operator for Pythagorean fuzzy aggregation operators based on MABAC methods. The combination of four tools; Geographic Information Systems, DEMATEL, ANP and MABAC was proposed by Gigović *et al*. (2017) to identify locations for the installation of wind farms, which will provide significant support to planners in the strategy for the development and management of wind energy. Peng and Dai (2017b) developed the Weighted Aggregated Sum Product Assessment (WASPAS), MABAC method, and COPRAS method under hesitant fuzzy soft sets with combined weights. The MABAC method, best-worst method (BWM), preferences ranking organization method for enrichment evaluation (PROMETHEE), and personnel selection with linguistic value for personnel selection in enterprises (Luo and Xing, 2019). The analytic hierarchy process (AHP) and MABAC method in a rough number proposed by Roy *et al*. (2017) for assessing and prioritizing medical tourism destinations in an uncertain environment. Pamučar *et al*. (2018) presented the hybrid interval rough AHP-MABAC (IR-AHP-MABAC) where IR-AHP determined the weight of coefficients of the criteria in the group decision-making process and IR-MABAC for evaluating the university websites. The rough AHP-MABAC model modified by Sharma *et al*. (2018) for ranking the Indian railway stations based on the decision maker's performance. The fuzzy AHP-MABAC used to select and rank a group of battery electric vehicles (Biswas and Das, 2019). The fuzzy AHP-Z and fuzzy MABAC presented by Bobar *et al*. (2020) for ranking and evaluation of the effectiveness of social media. Büyüközkan *et al*. (2021) integrated hesitant fuzzy linguistic (HFL) AHP and HFL MABAC where HFL AHP determine the weight of Strength, Weakness, Opportunities and Threats (SWOT) factors and HFL MABAC used to select the best health tourism strategy.

In addition, the extension of neutrosophic sets also applied in the MABAC method to evaluate decision-making problems. The MABAC method, evaluation based on distance from average solution (EDAS) and similarity measure presented by Peng and Dai (2017a) to solve interval neutrosophic in decision-making problems. Peng and Dai (2018) also developed three new approaches which is are MABAC, TOPSIS and similarity measure with score function under single-valued neutrosophic environment to deal with the real multi-attribute decision-making (MADM) problems. The MABAC and elimination and choice translating reality (ELECTRE) methods under single-valued neutrosophic linguistic environment to select an outsourcing provider (Ji *et al*., 2018b). Wang *et al*. (2019) combined the MABAC with 2-tuple linguistic neutrosophic sets for multiple attribute group decision making (MAGDM). Pamučar and Božanić (2019) integrated single-valued neutrosophic MABAC to select the optimal location for the development of multimodal logistics center. Xu *et al*. (2020a) presented TOPSIS-MABAC methods with interval neutrosophic set where TOPSIS method obtained the combined weight of attributes and MABAC method developed to rank the alternatives in MADM problem. The new single-valued neutrosophic distance for three methods which are TOPSIS, MABAC and similarity measure introduced by Xu *et al.* (2020b) to solve the MADM problem. Liu and Cheng (2020) improved the MABAC method and regret theory combined with likelihood under probability multi-valued neutrosophic set in MAGDM. The combination of the

MABAC method with the triangular fuzzy neutrosophic number discussed by Irvanizam *et al*. (2020) for multiple-criteria group decision-making (MCGDM) problems. Şahin and Altun (2020) defined probabilistic single-valued neutrosophic hesitant fuzzy sets with MABAC methods to solve the decision-making problem.

Moreover, the researchers also have been reviewed the combination of the DEMATEL method and MABAC method in different fields of decision-making problems. Pamučar and Ćirović (2015) proposed the application of the new combination DEMATEL with MABAC models to select the optimal transport handling units in the logistics centre. The hybrid DEMATEL and MABAC methods also studied by Estiri *et al*. (2021) where the DEMATEL method calculated the weight of criteria and the MABAC method used to rank the alternatives for selecting high-performance work systems in the banking industry. In the latest literature, Agarwal *et al*. (2020) presented the combination of DEMATEL and MABAC methods for grading and evaluating the Tossa Jute fibers.

2.2 Review of Linguistic Variable

At the first, Zadeh (1975) introduced the concept of the linguistic variable and applied it to fuzzy reasoning. Meanwhile, Herrera *et al*. (2000) presented linguistic assessments consensus model in group decision making with linguistic information. The linguistic aggregation operators for multi-attribute group decision making proposed by Xu (2006) based on linguistic preference relations.

After the passing of years, the linguistic variable in neutrosophic sets is one of the important topics discussed by the researcher. Liu and Tang (2016) presented the interval neutrosophic uncertain linguistic variable with multi-criteria group decision-making based on the Choquet integral. Ye (2017) also proposed multi-attribute group decision-making combined with uncertain linguistic variables and interval neutrosophic set where the evaluation information is expressed by the form of interval neutrosophic uncertain linguistic variable under linguistic term, “extremely poor, very poor, poor, medium, good, very good and extremely good". Then, Q-linguistic neutrosophic variable set corresponding two-dimensional universal sets and vector similarity measures studied by Ye *et al*. (2018) where Q-linguistic neutrosophic variable set expressed the linguistic evaluation problems of the truth, falsity and indeterminacy over two-dimensional universal sets from the predefined linguistic term set, "'extremely low, very low, low, slightly low, medium, slightly high, high, very high and extremely high". The new linguistic variable for interval neutrosophic vague sets (INVS) and DEMATEL method defined by Al-Quran *et al.* (2020) that consist 5-degree scale of linguistic variable INVS with linguistic term, "no influence, influence, very low influence, medium influence, high influence and absolutely influence". Other than that, Fan *et al*. (2018) developed single-valued neutrosophic uncertain linguistic variables and application in multiple attribute group decision-making with linguistic term "very low, low, medium low, fair, medium good, good and very good". Next, the linguistic variable of single-valued neutrosophic sets in the prospect theory extended by Guo and Sun (2019).

Additionally, the uncertain linguistic variable with VIKOR method focused by Wang and Liu (2011) for investment risk assessment of real estate. Zamri and Abdullah (2014) constructed the new linguistic variable that has positive sides and negative sides for the interval type-2 fuzzy TOPSIS. The linguistic variable for the new fuzzy AHP characterized by interval type-2 fuzzy sets proposed by Abdullah and Najib (2014).

2.3 Review of Neutrosophic Sets

The theories of the neutrosophic set have become major interest by researchers since 1998 but the neutrosophic set not able to be applied in real problems. Hence, Wang *et al*. (2010) defined the single-valued neutrosophic set to facilitate its practical use in real-world decision problems. The single-valued set is a subclass of neutrosophic sets proposed in recent years to solve MCDM problems. Biswas *et al*. (2016) proposed the TOPSIS method for MAGDM problems under single-valued neutrosophic environment for rating the alternatives with respect to each attribute and considered single-valued neutrosophic to make decision maker's opinion based on the provided information. The Interactive Multi-Criteria Decision Making (TODIM) method with the single-valued neutrosophic numbers extended by Xu *et al*. (2017) to solve MADM problems where single-valued neutrosophic numbers used to depict the uncertainty of the MADM. The MCGDM model using the single-valued neutrosophic set developed to select a contractor for the construction of a public or government work (Das and Saha, 2020). Long *et al*. (2020) utilized the TODIM method under single-valued neutrosophic set to prioritize restoration methods for wood components of Chinese ancient architectures. Lu and Luo (2020) applied single-valued neutrosophic set to transform the emergency transportation problem into MADM problem in ambiguous and uncertain environments. The single-valued neutrosophic set developed by Mahmud *et al*. (2020) to measure factors that impact student engagement and attitude in mathematics achievement.

Besides that, Dung *et al*. (2018) proposed TOPSIS method using an interval neutrosophic set to solve the personnel selection problem. The group MADM based on interval neutrosophic sets determined the weights and evaluated values of the attributes with respect to the available alternatives where interval neutrosophic sets not only handle incomplete information but also indeterminate and inconsistent information Nafei *et al*. (2019). Then, Ali *et al*. (2016) presented the concept of neutrosophic cubic set and defined some new properties of neutrosophic cubic set to apply in pattern recognition. The TODIM under neutrosophic cubic set developed by Pramanik *et al*. (2017) for solving MAGDM where neutrosophic cubic set express the hybrid information of interval neutrosophic set and single-valued neutrosophic set. Pramanik *et al*. (2018a) also defined VIKOR method based on neutrosophic cubic set to handle MAGDM problems. In addition, Peng *et al*. (2016) studied simplified neutrosophic sets for addressing issues with a set of specific numbers. The simplified neutrosophic with present worth analysis method developed to overcome difficulties in defining the membership functions for evaluation of investment alternatives (Aydin *et al*., 2018). The simplified neutrosophic multiplicative set based on TODIM method introduced by Köseoğlu *et al*. (2020) based on water-filling algorithm for determining criteria weights. Also, the complex neutrosophic set is an extension of the neutrosophic set proposed by Ali and Smarandache (2017) and defined the theoretic operations of complex neutrosophic set. Jha *et al*. (2019) described neutrosophic soft sets consisting of true, uncertain and false to deal with the exact state of data for stock trending analysis. Next, Wang and Li (2015) presented multi-valued neutrosophic set with TODIM method to find the ranking order of all alternatives. Ji et al. (2018a) suggested multi-valued neutrosophic sets with TODIM method for personal selection. Multi-valued neutrosophic sets and distance measure based on QUALIFLEX method proposed by Peng and Tian (2018) to handle MCDM problems for selection of medical diagnosis plan. Zhang *et al*. (2020) developed the probability multi-valued neutrosophic ELECTRE method for logistics outsourcing provider selection.

There are many researchers developed the concept, theories and application in bipolar neutrosophic sets to solve MCDM problems. At the first, Deli *et al*. (2015) introduced the concept of bipolar neutrosophic sets and developed bipolar neutrosophic weighted average and geometric operators including score, uncertainty and accuracy functions based on MCDM problems. The interval-valued bipolar fuzzy weighted neutrosophic proposed by Deli *et al*. (2016) can handle uncertain information more flexibly in the process of decision making. Ali *et al*. (2017) presented bipolar neutrosophic soft sets that combine soft sets and neutrosophic sets and develop a decision-making algorithm. Akram and Sarwar (2017) described bipolar neutrosophic sets and bipolar neutrosophic graphs in multiple criteria decision-making methods. The Frank Choquet Bonferroni Mean Operators under bipolar neutrosophic set proposed by Wang *et al*. (2018) in MCDM problems. Pramanik *et al*. (2018b) defined the correlation coefficient, weighted correlation coefficient measures of interval bipolar neutrosophic sets to solve MADM problems. The combination of VIKOR strategy with the bipolar neutrosophic set environment to deal multi-attribute group decision making (Pramanik *et al*., 2018c). Bipolar neutrosophic TOPSIS method and bipolar neutrosophic ELECTRE-I method were proposed by Akram *et al*. (2018) and applied to select the best possible alternative in MCDM problems. Uluçay *et al*. (2018) introduced some similarity measures for bipolar neutrosophic sets and their application to multiple criteria decision making. The neutrosophic bipolar fuzzy sets developed by Hashim *et al*. (2018) in HOPE foundation for planning to build a children hospital with different types of similarity measures. Broumi *et al*. (2019) focused on the combination of bipolar and complex neutrosophic sets to determine the similarity among bipolar complex neutrosophic sets. The similarity and entropy measurements of bipolar neutrosophic sets discussed by Arulpandy and Trinita Pricilla (2019) in image analysis. Hussain *et al*. (2019) presented the new concept of neutrosophic bipolar vague sets to the neutrosophic bipolar vague graphs. The combination of bipolar neutrosophic sets and hesitant fuzzy sets introduced by Awang *et al*. (2019) and defined the formulation, theory and application of hesitant bipolar-valued neutrosophic sets. The bipolar neutrosophic set under cosine similarity measures applied by Abdel-Basset *et al*. (2019) for diagnosing bipolar disorder disease The neutrosophic bipolar fuzzy set with the MAGDM problem developed for selecting the best medicine to cure some particular diseases (Hashim *et al*., 2020). The concept of neutrosophic bipolar vague soft sets studied by Mukherjee and Das (2020) for decision making problems. The generalization of quadripartitioned single valued neutrosophic set and bipolar neutrosophic set with similarity measure defined by Roy *et al*. (2020) in MCDM problems. Gulfam *et al*. (2021) discussed new Dombi aggregation operators based on bipolar neutrosophic set to solve MADM problems.

2.4 Review of Sustainable Energy

The sustainable energy problems especially global warming, environmental pollution and climate change are increasing the emissions of carbon dioxide and greenhouse gases that can affect Earth’s climate and health. Therefore, Kazemi *et al*. (2013) applied DEMATEL method to select the most effective sustainable strategies and assessing the impact on reducing carbon dioxide. Due to energy crisis, environmental pollution and climate change, the clean renewable energy of biomass power generation analysed by Tan *et al*. (2016) to explore the factors that affect the industry development based on DEMATEL method. Büyüközkan and Güleryüz (2016) integrated DEMATEL method and ANP method for selecting the most appropriate renewable energy resources in Turkey where investors need to consider renewable energy resources for sustainable development because of limited reserves and negative environmental impacts of fossil fuels. The overview of green technology presented by Al-Obaidi and Nguyenhuynh (2018) and discussed the adoption of green technology into the current conventional energy industry. Hashemizadeh *et al*. (2021)

presented the renewable energy investment risk assessment in the belt and road initiative countries under uncertainty conditions.

Other than that, Barry *et al*. (2009a) studied the identification of the most important factors that can be used by decision makers to ensure better selection of sustainable energy technologies and projects in Africa by applying the Delphi technique. Sustainable community construction focused by Hsueh and Yan (2011) using Delphi method, AHP and fuzzy logic in building quantitative model to enhance sustainable community developments. Venier and Yabar (2017) identified the potential sites for location of the biogas plants based on geographical, environment and socioeconomic criteria by using the GIS suitability analysis and statistics and taking into account cattle farm size and economically feasible transportation distances. The hybrid model of SWOT analysis and an integrated entropy TOPSIS selected the optimum green energy sources for sustainable energy planning from a given set of alternatives (Bhowmik *et al*., 2018). The most sustainable renewable energy system selected to analyse whole environment and/or economic impacts of the energy production process and used life cycle assessment and life cycle cost to determine drawbacks and benefits of different renewable energy systems considering long term environment and economic impacts (Oğuz and Şentürk, 2019). Okokpujie *et al*. (2020) implemented MCDM which are AHP and TOPSIS method for the material selection process of suitable material for developing horizontal wind turbine blade for sustainable energy generation due to the challenge faces with low wind speed variations. The selection of the most appropriate sustainable energy technology studied by Büyüközkan *et al*. (2020) using fuzzy AHP and fuzzy VIKOR to calculate the weights of the evaluation criteria and choosing the most appropriate alternative in the decision-making process. Bose *et al*. (2020) applied ARAS, MABAC, COPRAS and MOOSRA methods to select and experiment the best hybrid green composite for clean sustainable energy recovery. In short, the literature have been drawn that the MCDM methods are increasingly used to deal with various problems particularly for sustainable energy selection.

2.5 Identification of Gaps in the Literature

This section outlines the gap in the literature concerning the MCDM method, neutrosophic set and sustainable energy for the framework in this study. The literature on standalone MCDM methods reveals that the previous studies on MCDM methods limited considering the weight of criteria and rank the alternatives in complex decision making problem. Then, we notice there further few number of studies on the combination of DEMATEL and MABAC methods. Therefore, these issue can be overcome by proposing the DEMATEL method that able to determine the weight of criteria and applied in MABAC method to obtain the rank the alternatives. The gaps of MCDM method of literature review summarized in Appendix 1.

Based upon the literature reviews of the existing sets: NS, SVNS, INS, NSS, MVNS and CNS, there is limited number of studies that inquire to overcome the limitations of positive membership degree and negative membership degree sets. Most of the current sets only incorporate one of the positive information and disregard positive and negative information. Also, we noticed a limited number of studies developed positive and negative information under neutrosophic environment. Hence, we apply the bipolar neutrosophic sets which could provide a wider range including positive and negative membership degree in defining judgements. Appendix 2 summarizes the gaps literature review in neutrosophic sets.

Last but not least, the reviews on sustainable energy based on MCDM methods discover that very few of studies implement DEMATEL method and MABAC method in finding the weight of criteria and rank the alternatives. Unfortunately, most of the studies could not apply the bipolar information. Hence, this study aims to apply DEMATEL-MABAC methods under bipolar neutrosophic sets in a case study sustainable energy. Appendix 3 recaps the literature review on sustainable energy.

CHAPTER 3

PRELIMINARIES

This chapter is focused on the definitions and some concepts related to this research. Section 3.1 described the definitions of fuzzy set, intuitionistic fuzzy set, bipolar fuzzy set, neutrosophic set, single-valued neutrosophic set and bipolar neutrosophic set. The properties of the bipolar neutrosophic set are discussed in Section 3.2. The fundamental concept of the DEMATEL method is provided in Section 3.3 and Section 3.4 presents the fundamental concept of the MABAC method.

3.1 Definitions of Sets

This section explains the development of sets from fuzzy set to bipolar neutrosophic set. All these sets were proposed mainly to deal with uncertainty problem.

Definition 3.1. (Zadeh, 1965) Let X be a nonempty set. A fuzzy set F drawn from X is defined as:

$$F = \{\langle x, \mu_F(x) \rangle : x \in X\}$$

where $\mu_F(x): X \to [0,1]$ is the membership function of the F .

Definition 3.2. (Atanassov, 1986) Let X be a nonempty set. An intuitionistic fuzzy set $\tilde{I}$ in X is an object defined as:

$$\tilde{I} = \{\langle x, \mu_{\tilde{I}}(x), \nu_{\tilde{I}}(x)\rangle : x \in X\}$$

where the functions

$$\mu_{\tilde{I}}(x), \nu_{\tilde{I}}(x) : X \rightarrow [0,1]$$

where $\mu_{\tilde{I}}(x)$ is the degree of membership and $\nu_{\tilde{I}}(x)$ is the degree of non-membership of an element $x \in X$ to the set $\tilde{I}$. For every element $x \in X$,

$$0 \leq \mu_{\tilde{I}}(x) + \nu_{\tilde{I}}(x) \leq 1$$

Furthermore, we have

$$\pi_{\tilde{I}}(x) = 1 - \mu_{\tilde{I}}(x) - \nu_{\tilde{I}}(x)$$

called as the intuitionistic fuzzy set index or hesitation on margin of x in $\tilde{I}$. $\pi_{\tilde{I}}(x)$ is degree of indeterminacy of $x \in X$ to the $\tilde{I}$ and

$$\pi_{\tilde{I}} : X \rightarrow [0,1]$$

for every $x \in X$. $\pi_{\tilde{I}}(x)$ expresses the lack of knowledge of whether x belongs to $\tilde{I}$ or not.

Definition 3.3. (Zhang, 1998) Let X be any nonempty set. A bipolar fuzzy set b is an object defined as:

$$b = \{\langle x, \mu^+(x), \mu^-(x)\rangle : x \in X\}$$

where $\mu^+(x) \rightarrow [0,1]$ and $\mu^-(x) \rightarrow [-1,0]$. $\mu^+(x)$ is a positive membership and $\mu^-(x)$ is a negative membership of $x \in X$.

Definition 3.4. (Smarandache, 1998) Let X be a space of points (objects) with generic elements in X denoted by x . A neutrosophic set N in X is defined as:

$$N = \{\langle x, T_N(x), I_N(x), F_N(x)\rangle : x \in X\}$$

which is characterized by a truth-membership function $T_N(x) \rightarrow]0^-,1^+[$, an indeterminacy-membership function $I_N(x) \rightarrow]0^-,1^+[$ and a falsity-membership function. $F_N(x) \to]0^-, 1^+[$ There is no restriction on the sum of $T_N(x)$, $I_N(x)$ and $F_N(x)$, so

$$0^- \leq \sup T_N(x) + \sup I_N(x) + \sup F_N(x) \leq 3^+$$

Definition 3.5 (Wang *et al.*, 2010) Let X be a universal space of points with generic elements in X denoted by x. A single-valued neutrosophic set S in X is defined as:

$$S = \{\langle x, T_S(x), I_S(x), F_S(x)\rangle : x \in X\}$$

which is characterized by a truth-membership function $T_S(x) \to [0,1]$, an indeterminacy-membership function $I_S(x) \to [0,1]$ and a falsity-membership function $F_S \to [0,1]$. There is no restriction on the sum of $T_S(x)$, $I_S(x)$ and $F_S(x)$, so

$$0 \leq \sup T_S(x), \sup I_S(x), \sup F_S(x) \leq 3$$

Definition 3.6. (Deli *et al.*, 2015) Let X be a universal space of points with generic elements in X denoted by x. A bipolar neutrosophic set B in X is defined as:

$$B = \{\langle x, T_B^+(x), I_B^+(x), F_B^+(x), T_B^-(x), I_B^-(x), F_B^-(x)\rangle : x \in X\}$$

where $T^+, I^+, F^+ : X \to [0,1]$ and $T^-, I^-, F^- : X \to [-1,0]$. The positive membership degree $T^+(x)$, $I^+(x)$, $F^+(x)$ denotes a truth-membership, an indeterminacy-membership and a falsity-membership of an element $x \in X$ corresponding to B. The negative membership degree $T^-(x), I^-(x), F^-(x)$ denotes a truth-membership, an indeterminacy-membership and a falsity-membership of an element $x \in X$ to some implicit counter property corresponding to B.

3.2 Properties of Bipolar Neutrosophic Set

According to the clarification from Smarandache in Appendix 4 as a corrected version of inequality property which defined in and Deli *et al*. (2015), the properties of the bipolar neutrosophic set can defined as follows:

Definition 3.7. (refer to Appendix 4) Let

$B_1 = \{x, \langle T_1^+(x), I_1^+(x), F_1^+(x), T_1^-(x), I_1^-(x), F_1^-(x)\rangle\}$

and $B_2 = \{x, \langle T_2^+(x), I_2^+(x), F_2^+(x), T_2^-(x), I_2^-(x), F_2^-(x)\}$ be two bipolar neutrosophic sets. The inequality property is defined as $B_1 \subseteq B_2$ if and only if $T_1^+ \le T_2^+$, $I_1^+ \ge I_2^+$, $F_1^+ \ge F_2^+$ and $T_1^- \ge T_2^-$, $I_1^- \le I_2^-$, $F_1^- \le F_2^-$ for all $x \in X$.

Definition 3.8. (Deli *et al*., 2015) Let

$B_1 = \{x, \langle T_1^+(x), I_1^+(x), F_1^+(x), T_1^-(x), I_1^-(x), F_1^-(x)\rangle\}$

and $B_2 = \{x, \langle T_2^+(x), I_2^+(x), F_2^+(x), T_2^-(x), I_2^-(x), F_2^-(x)\}$ be two bipolar neutrosophic sets. The equality property defined as $B_1 = B_2$ if and only if $T_1^+ = T_2^+, I_1^+ = I_2^+$, $F_1^+ = F_2^+$ and $T_1^- = T_2^-$, $I_1^- = I_2^-$, $F_1^- = F_2^-$ for all $x \in X$.

Definition 3.9. (Deli *et al*., 2015) Let

$B_1 = \{x, \langle T_1^+(x), I_1^+(x), F_1^+(x), T_1^-(x), I_1^-(x), F_1^-(x)\rangle\}$

and $B_2 = \{x, \langle T_2^+(x), I_2^+(x), F_2^+(x), T_2^-(x), I_2^-(x), F_2^-(x)\}$ be two bipolar neutrosophic sets. The union defined as:

$$B_1 \cup B_2 = \begin{pmatrix} \max\left(T_1^+(x), T_2^+(x)\right), \dfrac{\left(I_1^+(x) + I_2^+(x)\right)}{2}, \min\left(F_1^+(x), F_2^+(x)\right), \\ \min\left(T_1^-(x), T_2^-(x)\right), \dfrac{\left(I_1^-(x) + I_2^-(x)\right)}{2}, \max\left(F_1^-(x), F_2^-(x)\right) \end{pmatrix} \text{ for all } x \in X.$$

Definition 3.10. (Deli *et al*., 2015) Let

$B_1 = \{x, \langle T_1^+(x), I_1^+(x), F_1^+(x), T_1^-(x), I_1^-(x), F_1^-(x)\rangle\}$

and $B_2 = \{x, \langle T_2^+(x), I_2^+(x), F_2^+(x), T_2^-(x), I_2^-(x), F_2^-(x)\}$ be two bipolar neutrosophic sets. The intersection is defined as:

$$B_1 \cap B_2 = \begin{pmatrix} \min\left(T_1^+(x), T_2^+(x)\right), \dfrac{\left(I_1^+(x) + I_2^+(x)\right)}{2}, \max\left(F_1^+(x), F_2^+(x)\right), \\ \max\left(T_1^-(x), T_2^-(x)\right), \dfrac{\left(I_1^-(x) + I_2^-(x)\right)}{2}, \min\left(F_1^-(x), F_2^-(x)\right) \end{pmatrix}$$

Definition 3.11. (Deli *et al.*, 2015) Let $B_1 = \{x, \langle T_1^+(x), I_1^+(x), F_1^+(x), T_1^-(x), I_1^-(x), F_1^-(x)\rangle\}$ be bipolar neutrosophic sets in X. The complement of B is denoted by B^C and defined as:

$T_{B^C}^+(x) = \{1^+\} - T_B^+(x)$, $I_{B^C}^+(x) = \{1^+\} - I_B^+(x)$, $F_{B^C}^+(x) = \{1^+\} - F_B^+(x)$ and

$T_{B^C}^-(x) = \{1^-\} - T_B^-(x)$, $I_{B^C}^-(x) = \{1^-\} - I_B^-(x)$, $F_{B^C}^-(x) = \{1^-\} - F_B^-(x)$ for all $x \in X$.

Definition 3.12. (Deli *et al.*, 2015) Let $\tilde{b}_1 = \left\langle T_1^+, I_1^+, F_1^+, T_1^-, I_1^-, F_1^- \right\rangle$ and $\tilde{b}_2 = \left\langle T_2^+, I_2^+, F_2^+, T_2^-, I_2^-, F_2^- \right\rangle$ two bipolar neutrosophic numbers. Then,

i. Addition

$$\tilde{b}_1 \oplus \tilde{b}_2 = \left\langle \begin{matrix} T_1^+ + T_2^+ - T_1^+ T_2^+, I_1^+ I_2^+, F_1^+ F_2^+, \\ -T_1^- T_2^-, -\left(I_1^- - I_2^- - I_1^- I_2^-\right), -\left(F_1^- - F_2^- - F_1^- F_2^-\right) \end{matrix} \right\rangle$$

ii. Multiplication

$$\tilde{b}_1 \otimes \tilde{b}_2 = \left\langle \begin{matrix} T_1^+ T_2^+, I_1^+ + I_2^+ - I_1^+ I_2^+, F_1^+ + F_2^+ - F_1^+ F_2^+, \\ -\left(-T_1^- - T_2^- - T_1^- I_2^-\right), -I_1^- I_2^-, -F_1^- F_2^- \end{matrix} \right\rangle$$

iii. Power

$$\tilde{b}_1^{\lambda} = \left\langle \left(T_1^+\right)^{\lambda}, 1 - \left(1 - I_1^+\right)^{\lambda}, 1 - \left(1 - F_1^+\right)^{\lambda}, -\left(1 - \left(1 - \left(-T_1^-\right)\right)\right)^{\lambda}, -\left(-I_1^-\right)^{\lambda}, -\left(-F_1^-\right)^{\lambda} \right\rangle$$

iv. Scalar multiplication

$$\lambda \tilde{b}_1 = \left\langle 1 - \left(1 - T_1^+\right)^{\lambda}, \left(I_1^+\right)^{\lambda}, \left(F_1^+\right)^{\lambda}, -\left(-T_1^-\right)^{\lambda}, -\left(-I_1^-\right)^{\lambda}, -\left(1 - \left(1 - \left(F_1^-\right)\right)\right)^{\lambda} \right\rangle$$

where $\lambda > 0$.

Definition 3.13. (Deli *et al*., 2015) Let $\tilde{b}_1 = \langle T_1^+, I_1^+, F_1^+, T_1^-, I_1^-, F_1^- \rangle$ be a bipolar neutrosophic number. The score function $s(\tilde{b}_1)$, accuracy function $a(\tilde{b}_1)$ and certainty function $c(\tilde{b}_1)$ are defined as:

i. Score function

$$s(\tilde{b}_1) = \left(T_1^+ + 1 - I_1^+ + 1 - F_1^+ + 1 + T_1^- - I_1^- - F_1^-\right)/6$$

ii. Accuracy function

$$a(\tilde{b}_1) = \left(T_1^+ - F_1^+\right) + \left(T_1^- - F_1^-\right)$$

iii. Certainty function

$$c(\tilde{b}_1) = T_1^+ - F_1^-$$

3.3 Fundamental Concept of DEMATEL Method

The fundamental concept of DEMATEL method is presented as below:

Definition 3.14: (Si *et al*., 2018) The summation of rows and columns of the total relation matrix is developed by vectors R and C. $R+C$ is the horizontal axis vector named “Prominence” showed the importance of a criterion while $R-C$ is the vertical axis called “Relation’. $R-C$ will be divided into cause and effect group. If $R-C$ is a positive value, the factors belong to the cause group. Otherwise, if the $R-C$ is a negative value, the factors belong to the effect group. In addition, developing perceived benefits is a positive $R+C$ while perceived risks is a negative $R+C$. The casual diagram is illustrated by mapping the data set ($R+C, R-C$) that shown in Figure 3.1.

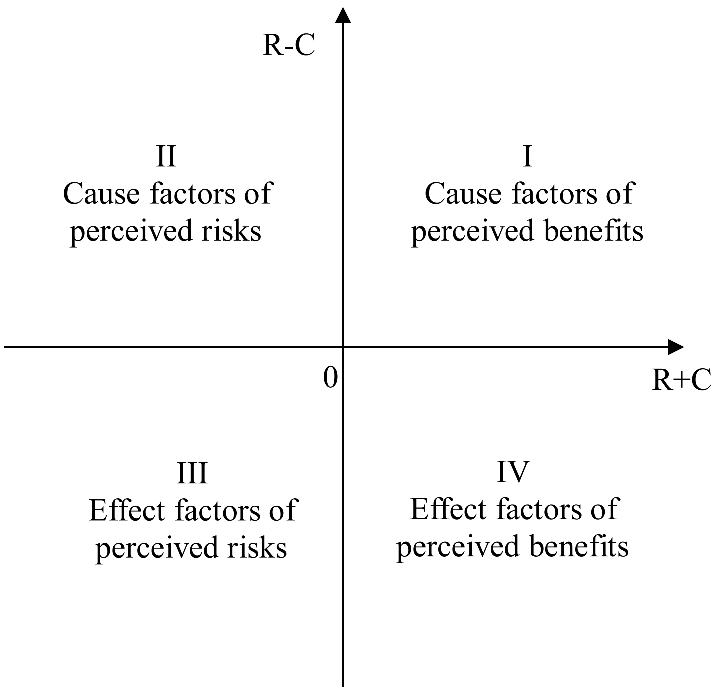

Figure 3.1: Causal diagram

Definition 3.15. (Chien *et al*., 2014; Chuang *et al*., 2013; W. Hwang *et al*., 2016) The influential relation map is divided into four quadrants by calculating the $R+C$. Based on quadrant positions of $R+C$, the factors can be divided into the following:

i. Factors in quadrant I

   This indicates that core factors or intertwined givers which have high prominence and high relation.

ii. The factors in quadrant II

   This indicates that driving factors or autonomous givers because have low prominence but high relation.

iii. The factors in quadrant III

   This indicates that independent factors or autonomous receivers which have low prominence and relation and are relatively disconnected from the system.

iv. The factors in quadrant IV

   This indicates that impact factors or intertwined receivers because have high prominence but low relation which are impacted by other factors and cannot be directly improved.

Figure 3.2 shows the four quadrant of influential relation map. Based on the Figure 3.2, decision makers can visually detect the complex causal relationships among factors and further spotlight valuable insights for decision making.

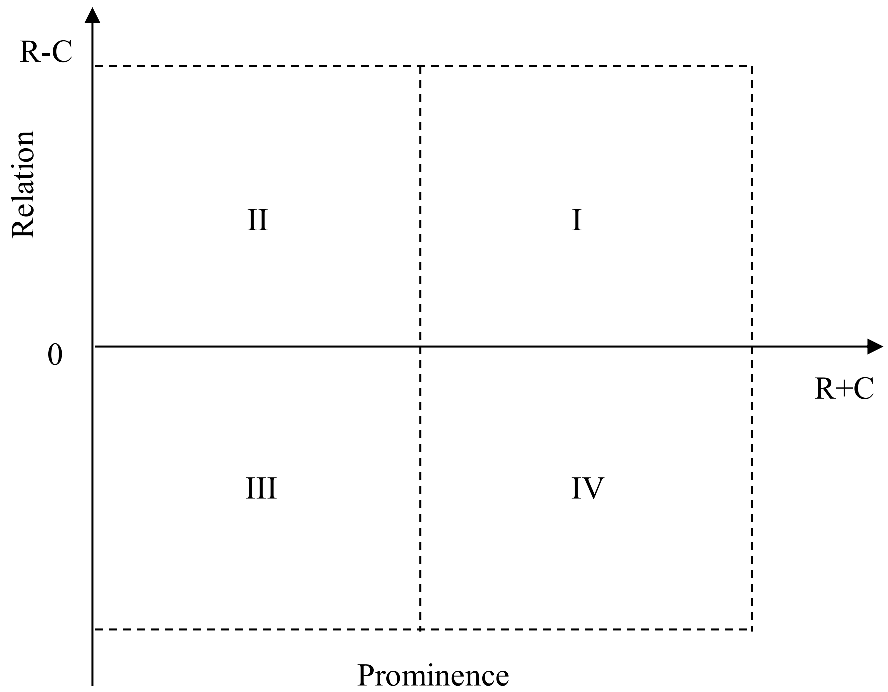

Figure 3.2: Four-quadrant influential relation map

Definition 3.16. (Dalalah *et al*., 2011) The causal diagram is used to set the criteria weights that will be used in the decision making process. From the equation of weight criteria, the length of the vector starting from the origin to each criterion is represented and demonstrated in Figure 3.3.

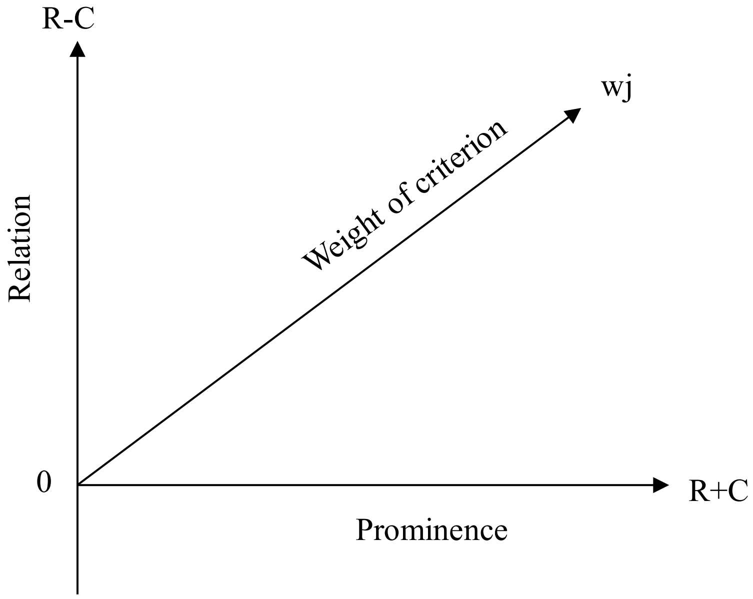

Figure 3.3: Weight of criterion

3.4 Fundamental Concept of MABAC Method

The fundamental concept of MABAC method is presented based on Pamučar and Ćirović (2015) as follow:

Definition 3.17. (Pamučar and Ćirović, 2015) The alternative could belong to the border approximation area $(\tilde{G})$ upper approximation area $(\tilde{G}^{+})$ or lower approximation area (G^{-}) that is $A_i \in \{\tilde{G} \vee \tilde{G}^{+} \vee \tilde{G}^{-}\}$. The $\tilde{G}^{+}$ presents the area where ideal alternative is located A^{+} and the $\tilde{G}^{-}$ presents the area where the anti-ideal alternative is located A^{-}. The illustration of border approximation area is shown in Figure 3.4.

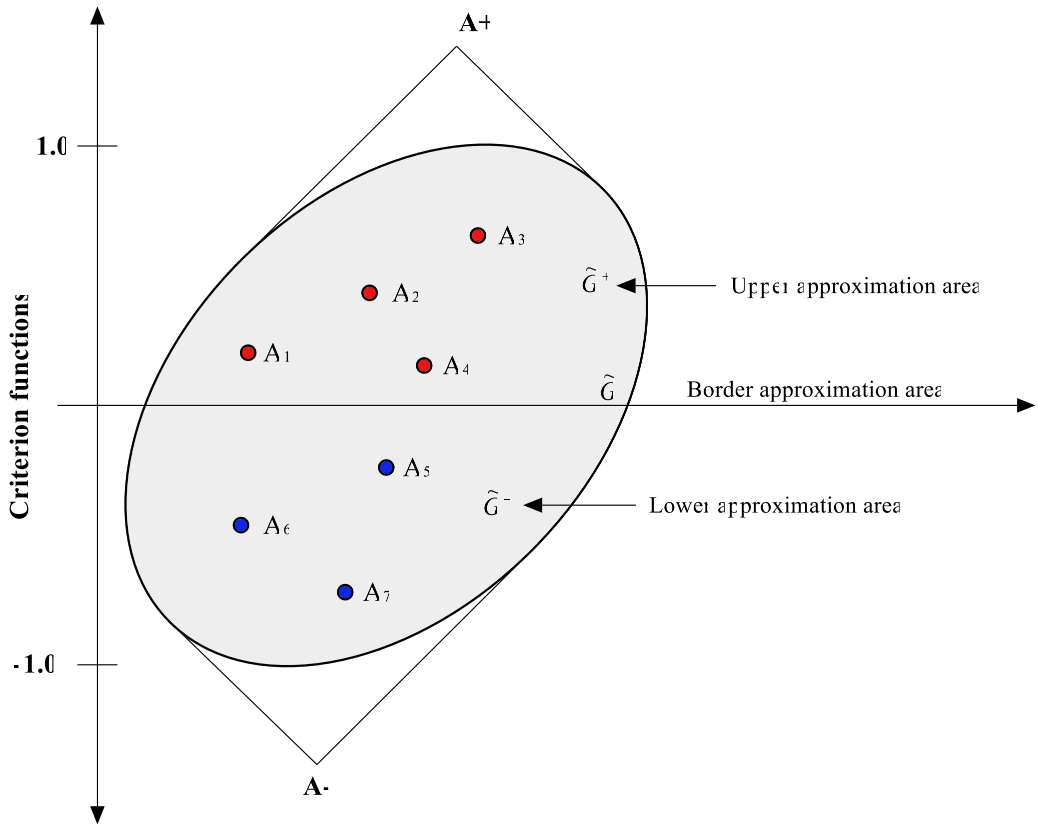

Figure 3.4: Presentation of border approximation area

The belonging of alternative to the approximation of $\tilde{G}, \tilde{G}^{+}$ or $\tilde{G}^{-}$ is determined as follow:

$$A_i \in \begin{cases} \tilde{G}^{+}, \tilde{q} > 0 \\ \tilde{G}, \tilde{q} = 0 \\ \tilde{G}^{-}, \tilde{q} < 0 \end{cases}$$

where $\tilde{q}$ is the distance from the border approximation area $(\tilde{q}_{ij})$. According the principle of MABAC method, we know that if $\tilde{q} = 0$, the alternative could belong to the $\tilde{G}$, if $\tilde{q} > 0$, the alternative belongs to $\tilde{G}^{+}$ and if $\tilde{q} < 0$, the alternative belongs to the $\tilde{G}^{-}$.

CHAPTER 4

PROPOSED BIPOLAR NEUTROSOPHIC DEMATEL-MABAC

This chapter provides detailed explanations of the proposed method. This consist of a new linguistic variable and DEMATEL-MABAC method under the bipolar neutrosophic set. For a clear understanding, each proposed method is presented in separate section.

Firstly, the new linguistic variable based on bipolar neutrosophic set is introduced. Then, this method is integrated into DEMATEL and MABAC method. Section 4.1 presents the general framework of the proposed method. Section 4.2 provides the development of the new linguistic variable based on bipolar neutrosophic set. Then, aggregation and deneutrosophication of bipolar neutrosophic set are explained in Section 4.3. The detailed computational procedure from the DEMATEL method and MABAC method is presented in Section 4.4. Finally, the illustrative example is given in Section 4.5.

4.1 Framework of Proposed Method

This proposed method comprises of four parts where the new linguistic variable for bipolar neutrosophic set is proposed in the first part. In the second part, the weight of the decision maker is determined. The third part, aggregation and deneutrosophication for the bipolar neutrosophic information are calculated. Next, DEMATEL-MABAC method is presented where DEMATEL obtain the weight of criteria and it will be used to calculate the elements from the weighted matrix in the MABAC method. Then, the MABAC method is used to obtain the rank of alternative. Figure 4.1 provides the overall framework of the proposed method. The detailed computational procedures for each phase are shown in the next section.

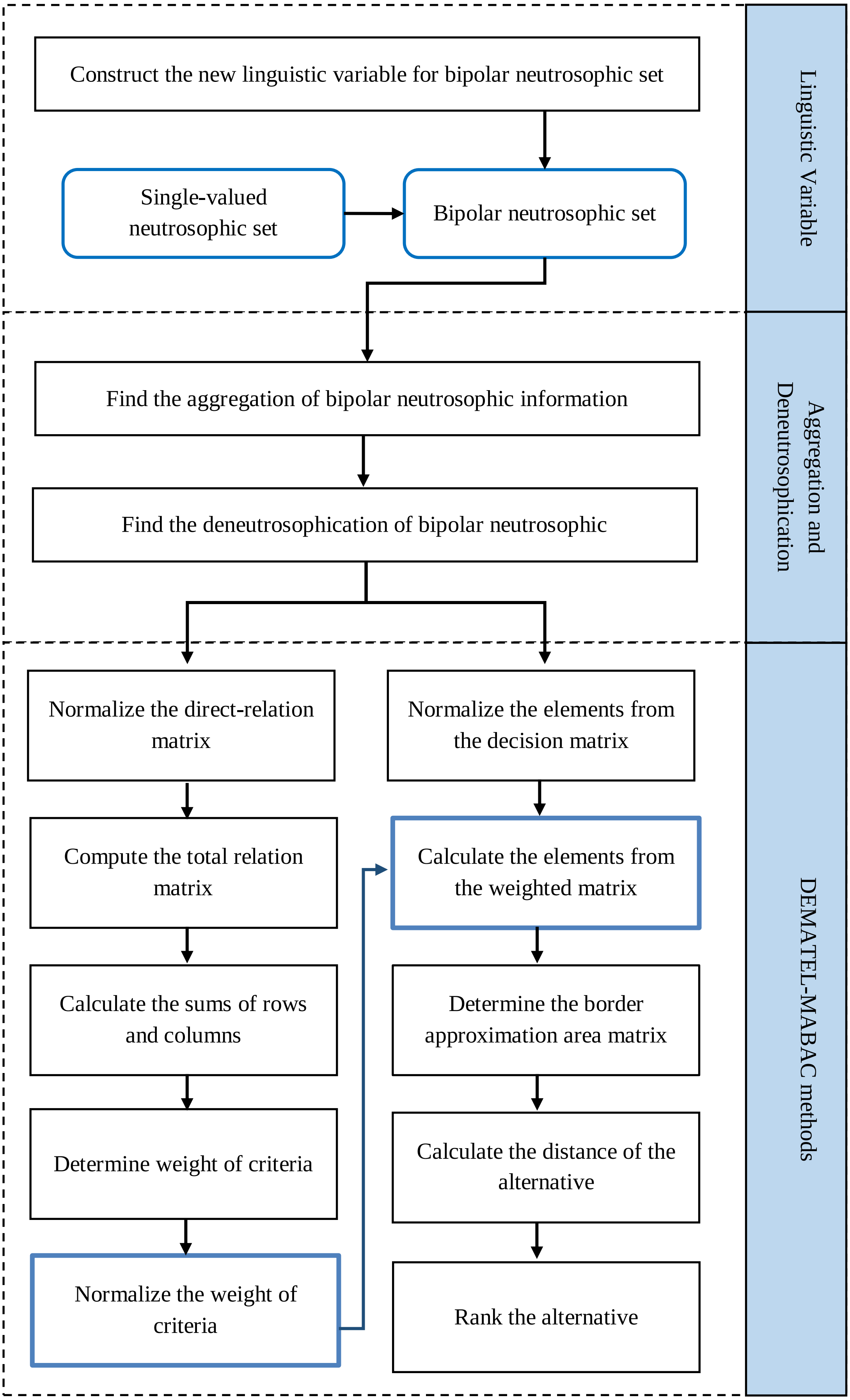

Figure 4.1: Framework of the proposed method

4.2 New Linguistic Variable of Bipolar Neutrosophic Set

Decision-makers normally expressed their assessments using linguistic variable for the decision making process. Therefore, the linguistic variable for bipolar neutrosophic set is proposed to deal with uncertainty, incomplete and inconsistent information, i.e., to represent the truth, indeterminacy and falsity in single representation. In the early days, most researches used to adopt 3-scale linguistic variable and 4-scale linguistic variable. For example, Gabus and Fontela (1973) adopted a 4-scale linguistic variable that was used for the DEMATEL method. However, the other linguistic variables such as the 5-scale linguistic variable or even the 8-scale linguistic variable have been used by many researchers. In this research, the linguistic variable "influence" is used with the 5-scale linguistic variable which characterized by "no influence", "low influence", "medium influence", "high influence" and "very high influence".

The new bipolar neutrosophic linguistic variable is developed based on single-valued neutrosophic number (SVNN) by Biswas *et al*. (2016) and Awang *et al*. (2018a) where 5-scale linguistic variable is used. Based on Biswas *et al*. (2016), it is assumed the rating of each alternative with respect to each criteria which is expressed as SVNN for MCDM problem. Table 4.1 shows the linguistic variable and its respective single-valued neutrosophic number where $< T_{ij}, I_{ij}, F_{ij} >$ denote the degree of truth-membership (T_{ij}), indeterminacy-membership (I_{ij}) and falsity-membership (F_{ij}) that satisfying the following properties under single-valued neutrosophic environment.

Table 4.1: Single-valued neutrosophic number (Biswas *et al*., 2016)

Linguistic Variable	**SVNN**
No Influence (NI)	<0.10, 0.80, 0.90>
Low Influence (LI)	<0.35, 0.60, 0.70>
Medium Influence (MI)	<0.50, 0.40, 0.45>
High Influence (HI)	<0.80, 0.20, 0.15>
Very High Influence (VHI)	<0.90, 0.10, 0.10>

Based on the information in Table 4.1, SVNN has become the basic idea of constructing the new linguistic variable of bipolar neutrosophic number (BNN). The new bipolar neutrosophic linguistic variable is shown in Table 4.2.

Table 4.2: New linguistic variable of bipolar neutrosophic

Linguistic Variable	**BNN**
No Influence (NI)	<0.10, 0.80, 0.90, -0.10, -0.80, -0.90>
Low Influence (LI)	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>
Medium Influence (MI)	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>
High Influence (HI)	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
Very High Influence (VHI)	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>

As a formal definition, let $X = \{x_1, x_2, x_3, x_4, x_5\}$ is a 5-scale linguistic variable, then

$$B = \begin{Bmatrix} \langle x_1, 0.10,\ 0.80,\ 0.90,\ \text{-}0.10,\ \text{-}0.80,\ \text{-}0.90 \rangle \\ \langle x_2, 0.35,\ 0.60,\ 0.70,\ \text{-}0.35,\ \text{-}0.60,\ \text{-}0.70 \rangle \\ \langle x_3, 0.50,\ 0.40,\ 0.45,\ \text{-}0.50,\ \text{-}0.40,\ \text{-}0.45 \rangle \\ \langle x_4, 0.80,\ 0.20,\ 0.15,\ \text{-}0.80,\ \text{-}0.20,\ \text{-}0.15 \rangle \\ \langle x_5, 0.90,\ 0.10,\ 0.10,\ \text{-}0.90,\ \text{-}0.10,\ \text{-}0.10 \rangle \end{Bmatrix}$$

is a bipolar neutrosophic subset of X where $T^+, I^+, F^+ : X \to [0,1]$ and $T^-, I^-, F^- : X \to [-1,0]$.

The proposed linguistic variable can be shown to fulfill some properties of bipolar neutrosophic set.

Based on clarification from Smarandache in Appendix 4, the inequality property has been improved where indeterminacy-membership and falsity-membership are considered as negative quality, while truth-membership is considered as a positive quality.

Therefore, let $B_1 = \{\langle x_1, 0.10, 0.80, 0.90, -0.10, -0.80, -0.90 \rangle\}$ and $B_2 = \{\langle 0.35, 0.60, 0.70, -0.35, -0.60, -0.70 \rangle\}$ are two bipolar neutrosophic numbers. Then, the inequality property is defined as $B_1 \subseteq B_2$ if and only if $T_1^+ \leq T_2^+ = 0.10 \leq 0.35$, $I_1^+ \geq I_2^+ = 0.80 \geq 0.60$, $F_1^+ \geq F_2^+ = 0.90 \geq 0.70$, $T_1^- \geq T_2^- = -0.10 \geq -0.35$, $I_1^- \leq I_2^- = -0.80 \leq -0.60$ and $F_1^- \leq F_2^- = -0.90 \leq -0.70$. The linguistic variable of bipolar neutrosophic is verified.

Second, the linguistic variable of bipolar neutrosophic is verified using complement property in *Definition 11*. Let B be a bipolar neutrosophic set in X. Therefore, we have a complement of B denoted by B^C verified as:

$$B^C = \begin{Bmatrix} \langle x_1, 0.90, 0.20, 0.10, -0.90, -0.20, -0.10 \rangle \\ \langle x_2, 0.65, 0.40, 0.30, -0.65, -0.40, -0.30 \rangle \\ \langle x_3, 0.50, 0.60, 0.55, -0.50, -0.60, -0.55 \rangle \\ \langle x_4 0.20, 0.80, 0.85, -0.20, -0.80, -0.85 \rangle \\ \langle x_5, 0.10, 0.90, 0.90, -0.10, -0.90, -0.90 \rangle \end{Bmatrix}$$

for all $x \in X$. The linguistic variable of bipolar neutrosophic is verified.

The proposed linguistic variable will be used in eliciting the decision makers' opinions. For example, a group of decision makers, $D = \{d_1, d_2, \ldots, d_q\}$ are required to give their preferences regarding a set of criteria, $C = \{c_1, c_2, \ldots, c_n\}$ and a set of alternatives, $A = \{a_1, a_2, \ldots, a_m\}$ under linguistic variable. Their preferences reflect the influence of the criteria against another criteria and alternatives with respect to the criteria. Therefore, the preferences of decision makers are based on the linguistic variable as shown in Table 4.2.

4.3 Aggregation and Deneutrosophication of Bipolar Neutrosophic

In this section, the aggregation and deneutrosophication of bipolar neutrosophic information is presented to find the initial decision matrix.

4.3.1 Aggregation of Bipolar Neutrosophic

To aggregate the bipolar neutrosophic information, the bipolar neutrosophic weighted average operator is used in this step. Let $\tilde{a} = \langle T_j^+, I_j^+, F_j^+, T_j^-, I_j^-, F_j^- \rangle$, $(j = 1, 2, \ldots, n)$ be a family of bipolar information numbers. Bipolar neutrosophic average operator is defined as:

$$\tilde{A}g_w = \sum_{j=1}^{n} \tilde{w}_j \tilde{a}_j$$
$$= \left\langle \begin{array}{l} (1 - \prod_{j=1}^{n}(1 - T_j^+)^{w_j}), \prod_{j=1}^{n}(I_j^+)^{w_j}, \prod_{j=1}^{n}(F_j^+)^{w_j}, -\prod_{j=1}^{n}(T_j^-)^{w_j}, \\ -(1 - \prod_{j=1}^{n}(1 - (-I_j^-))^{w_j}), -(1 - \prod_{j=1}^{n}(1 - (-F_j^-))^{w_j}) \end{array} \right\rangle \tag{4.1}$$

4.3.2 Deneutrosophication of Bipolar Neutrosophic

Deneutrosophication is the process of obtaining crisp number from neutrosophic number. Therefore, deneutrosophication of bipolar neutrosophic set is defined as below:

$$\tilde{A}_B(x) = \begin{cases} 1 - \left[\frac{1}{2} \sqrt{ \left(\frac{(1 - T^+(x))^2 + (I^+(x))^2 + (F^+(x))^2}{3} \right) + \left(\frac{(1 - (-T^-(x)))^2 + (-I^=(x))^2 + (-F^-(x))^2}{3} \right) } \right] \\ 0 \end{cases} \tag{4.2}$$

4.4 Bipolar Neutrosophic DEMATEL-MABAC Method

In this section, the bipolar neutrosophic DEMATEL-MABAC method is proposed where bipolar neutrosophic DEMATEL obtains the weight of criteria and bipolar neutrosophic MABAC determine the rank of alternatives. The algorithm of the proposed method consist of ten steps as follows:

Step 1. Normalize the direct-relation matrix

From the deneutrosophication of bipolar neutrosophic, bipolar neutrosophic DEMATEL method was obtained by following steps (Dalalah *et al.*, 2011). The direct relation matrix $(\tilde{A})$ is constructed in the form $n \times n$ matrix as follows:

$$\tilde{A} = \begin{bmatrix} 0 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 0 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & 0 \end{bmatrix} \tag{4.3}$$

where $\tilde{a}_{ij}$ is the individual elements which i-th criterion influences j-th and n is the total number of criteria. Then, the normalized direct-relation matrix $(\tilde{D})$ can be obtained as below:

$$\tilde{D} = \tilde{A} \times \tilde{S} \tag{4.4}$$

where

$$\tilde{S} = \frac{1}{\max\limits_{1 \le i \le n} \left(\sum_{j=1}^{n} \tilde{a}_{ij} \right)} \tag{4.5}$$

Step 2. Compute the total relation matrix

The total relation matrix $(\tilde{T})$ can be computed as follows:

$$\tilde{T} = \tilde{D}(I - \tilde{D})^{-1} \tag{4.6}$$

where I represents the identity matrix.

Step 3. Calculate the sums of rows and columns

The sum of rows $\left(\tilde{R}\right)$ and the sum of columns $\left(\tilde{C}\right)$ can be obtained by summing the element of rows and columns of total relation matrix $(\tilde{T})$.

$$\tilde{R} = \left[\sum_{i=1}^{n} \tilde{t}_{ij}\right]$$
$$\tilde{C} = \left[\sum_{j=1}^{n} \tilde{t}_{ij}\right] \tag{4.7}$$

The $\tilde{R}+\tilde{C}$ are calculated by adding $\tilde{R}$ and $\tilde{C}$ where $\tilde{R}-\tilde{C}$ calculated by subtracting $\tilde{R}$ and $\tilde{C}$.

Step 4. Determine weight of criteria

Baykasoğlu *et al*. (2013) and Dalalah *et al*. (2011) were used to determine the weight of criteria $\left(\tilde{w}_j\right)$ as follows:

$$\tilde{w}_j = \left[(\tilde{R}+\tilde{C})^2 + (\tilde{R}-\tilde{C})^2\right]^{\frac{1}{2}} \tag{4.8}$$

Step 5. Normalize the weight of criteria

Then, the weight of criteria can be normalized as below:

$$\tilde{W}_j = \frac{\tilde{w}_j}{\sum_{i=1}^{n} \tilde{w}_j} \tag{4.9}$$

where $\tilde{W}_j$ represents the final criteria weights.

After obtaining the weight of criteria, the bipolar neutrosophic MABAC method is determined to rank the alternatives that can be implemented in the next step as below:

Step 6. Normalize the elements from the decision matrix

The first step of the MABAC method by Pamučar and Ćirović (2015) is evaluated alternatives with respect to criteria. . The alternative in the form of vectors

$A_i = (x_{i1}, x_{i2}, \ldots, x_{in})$ where x_{ij} is the value of the i-th alternative according to the j-th criterion $(i = 1,2,\ldots,m; j = 1,2,\ldots,n)$.

The elements of the decision matrix are normalized depending on two types of criteria namely are benefit type of criteria and cost type of criteria. The benefit type of criteria is considered as a positive framework while cost type of criteria is a negative framework of the criteria.

$$\tilde{N} = \begin{bmatrix} \tilde{n}_{11} & \tilde{n}_{12} & \cdots & \tilde{n}_{1n} \\ \tilde{n}_{21} & \tilde{n}_{22} & \cdots & \tilde{n}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{n}_{m1} & \tilde{n}_{m2} & \cdots & \tilde{n}_{mn} \end{bmatrix} \tag{4.10}$$

For the benefit type of criteria (maximization) the high value will correspond to the high normalized value. The computation is as follows:

$$\tilde{n}_{ij} = \frac{\tilde{x}_{ij} - \tilde{x}_i^-}{\tilde{x}_i^+ - \tilde{x}_i^-} \tag{4.11}$$

For the cost type of criteria (minimization) the high value will correspond to the low normalized value. The computation as follows:

$$\tilde{n}_{ij} = \frac{\tilde{x}_{ij} - \tilde{x}_i^+}{\tilde{x}_i^- - \tilde{x}_i^+} \tag{4.12}$$

where $\tilde{x}_{ij}$, $\tilde{x}_i^+$ and $\tilde{x}_i^-$ are the elements from the initial decision matrix for which $\tilde{x}_i^+$ and $\tilde{x}_i^-$ are defined as: $\tilde{x}_i^+ = \max(\tilde{x}_1, \tilde{x}_2, \ldots \tilde{x}_m)$ is the maximum value of the observed criterion according to the alternatives and $\tilde{x}_i^- = \min(\tilde{x}_1, \tilde{x}_2, \ldots, \tilde{x}_m)$ is the minimum value of the observed criterion with respect to alternatives.

Step 7. Calculate the elements from the weighted matrix

$$\tilde{V} = \begin{bmatrix} \tilde{v}_{11} & \tilde{v}_{12} & \cdots & \tilde{v}_{1n} \\ \tilde{v}_{21} & \tilde{v}_{22} & \cdots & \tilde{v}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{v}_{m1} & \tilde{v}_{m2} & \cdots & \tilde{v}_{mn} \end{bmatrix} \tag{4.13}$$

The elements from the weighted matrix $(\tilde{V})$ are calculated as below:

$$\tilde{v}_{ij} = \tilde{W}_j.(\tilde{n}_{ij} + 1) \tag{4.14}$$

where $\tilde{n}_{ij}$ are the elements of the normalized matrix, $\tilde{W}_j$ is the weight coefficients of the criteria.

Step 8. Determine the border approximation area of the matrix

The border approximation area for each criterion is determined as below:

$$\tilde{g}_i = \left(\prod_{j=1}^{m} \tilde{v}_{ij} \right)^{\frac{1}{m}} \tag{4.15}$$

where $\tilde{v}_{ij}$ are the elements of the weighted matrix. Then, a border approximation area matrix is given in matrix $n \times 1$(n columns and one row):

$$\tilde{G} = [\tilde{g}_1 \quad \tilde{g}_2 \quad \cdots \quad \tilde{g}_n] \tag{4.16}$$

Step 9. Calculate the distance of the alternative

$$\tilde{Q} = \begin{bmatrix} \tilde{q}_{11} & \tilde{q}_{12} & \cdots & \tilde{q}_{1n} \\ \tilde{q}_{21} & \tilde{q}_{22} & \cdots & \tilde{q}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{q}_{m1} & \tilde{q}_{m2} & \cdots & \tilde{q}_{mn} \end{bmatrix} \tag{4.17}$$

The distance of the alternatives from the approximation border area $(\tilde{q}_{ij})$ are determined as the difference of weighted matrix elements $(\tilde{V})$ and the values of border approximation area $(\tilde{G})$ as follows:

$$\tilde{Q} = \tilde{V} - \tilde{G} \tag{4.18}$$

which can be written as:

$$\tilde{Q} = \begin{bmatrix} \tilde{v}_{11} & \tilde{v}_{12} & \cdots & \tilde{v}_{1n} \\ \tilde{v}_{21} & \tilde{v}_{22} & \cdots & \tilde{v}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{v}_{m1} & \tilde{v}_{m2} & \cdots & \tilde{v}_{mn} \end{bmatrix} - \begin{bmatrix} \tilde{g}_{1} & \tilde{g}_{2} & \cdots & \tilde{g}_{n} \\ \tilde{g}_{1} & \tilde{g}_{2} & \cdots & \tilde{g}_{n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{g}_{1} & \tilde{g}_{2} & \cdots & \tilde{g}_{n} \end{bmatrix} \tag{4.19}$$

where $\tilde{g}_{ij}$ is the border approximation area for criterion.

Step 10. Rank the alternative

The values of the criterion functions for the alternative is obtained as the sum of the distance of the alternative from the border approximation. The final values of the criterion functions for the alternative can be determined by calculating the sum of element of matrix by rows:

$$\tilde{S}_i = \sum_{j=1}^{n} \tilde{q}_{ij} \tag{4.20}$$

where $(i = 1,2,\ldots,m)$ and $(j = 1,2,\ldots,n)$

4.5 Illustrative Example

In this section, an illustrative example is presented to verify the developed proposed method. For a clear explanation, consider an example of a group of decision makers, $D = \{d_1, d_2, d_3\}$ making a decision to buy a car. There are three types of cars (alternatives), $A = \{a_1, a_2, a_3\}$ are available. The customers takes the decision to evaluate the cars with three criteria, $C = \{c_1, c_2, c_3\}$ representing the Comfort (c_1), Safety (c_3) and Price (c_3). A group of decision makers provide the evaluation of criteria and alternatives based on linguistic variable from “No Influence (NI)” to “Very High Influence (VHI)” and shown in Table 4.3 until Table 4.5.

For the bipolar neutrosophic DEMATEL method, the evaluation of decision makers is as below:

Table 4.3: Decision maker 1 (d_1) evaluation for DEMATEL method

Criteria	**C1**	**C2**	**C3**
C_1	0	MI	HI
C_2	HI	0	HI
C_3	HI	HI	0

Table 4.4: Decision maker 2 (d_2) evaluation for DEMATEL method

Criteria	**C1**	**C2**	**C3**
C_1	0	LI	HI
C_2	LI	0	HI
C_3	MI	HI	0

Table 4.5: Decision maker 3 (d_3) evaluation for DEMATEL method

Criteria	**C1**	**C2**	**C3**
C_1	0	LI	LI
C_2	LI	0	MI
C_3	LI	HI	0

Then, decision makers' evaluations as in Table 4.3 until Table 4.5 are converted into a new linguistic variable of bipolar neutrosophic as provided in Table 4.2.

Table 4.6: Decision maker 1 (d_1) in linguistic variable of bipolar neutrosophic for DEMATEL method

Criteria	**C1**	**C2**	**C3**
C_1	0	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
C_2	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	0	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
C_3	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	0

Table 4.7: Decision maker 2 (d_2) in linguistic variable of bipolar neutrosophic for DEMATEL method

Criteria	**C₁**	**C₂**	**C₃**
C_1	0	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
C_2	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	0	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
C_3	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	0

Table 4.8: Decision maker 3 (d_3) in linguistic variable of bipolar neutrosophic for DEMATEL method

Criteria	**C_1**	**C_2**	**C_3**
C_1	0	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>
C_2	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	0	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>
C_3	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	0

For the bipolar neutrosophic MABAC method, the evaluations of decision makers as are follows:

Table 4.9: Decision maker 1 (d_3) evaluation for MABAC method

Criteria	**C_1**	**C_2**	**C_3**
A_1	MI	MI	MI
A_2	HI	LI	HI
A_3	VHI	HI	HI

Table 4.10: Decision maker 2 (d_2) evaluation for MABAC method

Criteria	C_1	C_2	C_3
A_1	MI	MI	MI
A_2	MI	MI	HI
A_3	HI	VHI	HI

Table 4.11: Decision maker 3 (d_3)evaluation for MABAC method

Criteria	C_1	C_2	C_3
A_1	LI	MI	HI
A_2	MI	MI	MI
A_3	HI	HI	HI

The decision maker's evaluation is converted into a new linguistic variable of bipolar neutrosophic based on Table 4.2 and shown in Table 4.12 until Table 4.14.

Table 4.12: Decision maker 1 $(d\ )$ in linguistic variable of bipolar neutrosophic for MABAC method

Criteria	C_1	C_2	C_3
A_1	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>
A_2	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
A_3	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>

Table 4.13: Decision maker 2 (d_2) in linguistic variable of bipolar neutrosophic for MABAC method

Criteria	C_1	C_2	C_3
A_1	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>

A_2	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
A_3	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>

Table 4.14: Decision maker 3 (d_3) in linguistic variable of bipolar neutrosophic for MABAC method

Criteria	**C_1**	**C_2**	**C_3**
A_1	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
A_2	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>
A_3	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>

For the application example of the DEMATEL method, the information based on bipolar neutrosophic linguistic variable in Table 4.6, Table 4.7 and Table 4.8 can be aggregated using Equation (1) as follows:

$$T_{12}^{+} = 1-((1-0.50)^{0.3188}\times(1-0.35)^{0.3444}\times(1-0.35)^{0.3368})$$
$$= 0.4022$$

$$I_{12}^{+} = (0.40)^{0.3188}\times(0.60)^{0.3444}\times(0.60)^{0.3368}$$
$$= 0.5272$$

$$F_{12}^{+} = (0.45)^{0.3188}\times(0.70)^{0.3444}\times(0.70)^{0.3368}$$
$$= 0.6080$$

$$T_{12}^{-} = \text{-}(\text{-}0.5)^{0.3188}\times(\text{-}0.35)^{0.3444}\times(\text{-}0.35)^{0.3368})$$
$$= -0.3922$$
$$I_{12}^{-} = 1-((1-(\text{-}0.40))^{0.3188}\times(1-(\text{-}0.60))^{0.3444}\times(1-(\text{-}0.60))^{0.3368})$$
$$= -0.5448$$

$$F_{12}^{+} = 1-((1-(\text{-}0.45))^{0.3188}\times(1-(\text{-}0.70))^{0.3444}\times(1-(\text{-}0.70))^{0.3368})$$
$$= -0.6360$$

Also, the computation is followed using Equation (1) for the aggregation of the bipolar neutrosophic information of MABAC method. It can be calculated as follows:

$$T_{11}^{+} = 1-((1-0.50)^{0.3188} \times (1-0.50)^{0.3444} \times (1-0.35)^{0.3368})$$
$$= 0.4538$$

$$I_{11}^{+} = (0.40)^{0.3188} \times (0.40)^{0.3444} \times (0.60)^{0.3368}$$
$$= 0.4585$$

$$F_{11}^{+} = (0.45)^{0.3188} \times (0.45)^{0.3444} \times (0.70)^{0.3368}$$
$$= 0.5222$$

$$T_{11}^{-} = \text{-}(\text{-}0.5)^{0.3188} \times (\text{-}0.50)^{0.3444} \times (\text{-}0.35)^{0.3368})$$
$$= \text{-}0.4434$$

$$I_{11}^{-} = 1-((1-(\text{-}0.40))^{0.3188} \times (1-(\text{-}0.40))^{0.3444} \times (1-(\text{-}0.60))^{0.3368})$$
$$= \text{-}0.4766$$

$$F_{11}^{+} = 1-((1-(\text{-}0.45))^{0.3188} \times (1-(\text{-}0.45))^{0.3444} \times (1-(\text{-}0.70))^{0.3368})$$
$$= \text{-}0.5516$$

where weight of decision maker are assumed as. $w_{dm} = (0.3188, 0.3444, 0.3368)$. The result of aggregation of bipolar neutrosophic information for the DEMATEL method is presented in Table 4.15 and Table 4.16 shows the aggregation of bipolar neutrosophic information for the MABAC method.

Table 4.15: Aggregation of bipolar neutrosophic information for the DEMATEL method

Criteria	**C_1**	**C_2**	**C_3**
C_1	0	<0.4022, 0.5272, 0.6080, -0.3922, -0.5448, -0.6360>	<0.7025, 0.2896, 0.2520, -0.6056, -0.3666, -0.4015>

C_2	<0.5536, 0.4227, 0.4284, -0.4555, -0.5011, -0.5819>	0	<0.7277, 0.2526, 0.2172, -0.6829, -0.2739, -0.2659>
C_3	<0.5922, 0.3676, 0.3679, -0.5151, -0.4263, -0.4848>	<0.8000, 0.2000, 0.1500, -0.8000, -0.2000, -0.1500>	0

Table 4.16: Aggregation of bipolar neutrosophic information for the MABAC method

Criteria	**C_1**	**C_2**	**C_3**
A_1	<0.4538, 0.4585, 0.5222, -0.4434, -0.4766, -0.5516>	<0.5000, 0.4000, 0.4500, -0.5000, -0.4000, -0.4500>	<0.6328, 0.3167, 0.3108, -0.5858, -0.3390, -0.3631>
A_2	<0.6267, 0.3207, 0.3170, -0.5808, -0.3424, -0.3681>	<0.4564, 0.4552, 0.5181, -0.4463, -0.4728, -0.5466>	<0.7277, 0.2526, 0.2172, -0.6829, -0.2739, -0.2659>
A_3	<0.8397, 0.1603, 0.1318, -0.8306, -0.1694, -0.1344>	<0.8425, 0.1575, 0.1305, -0.8331, -0.1669, -0.1331>	<0.8000, 0.2000, 0.1500, -0.8000, -0.2000, -0.1500>

Based on Table 4.15, the deneutrosophication of bipolar neutrosophic can be computed using Equation (2) as follows:

$$\langle T_{12}^{+}, I_{12}^{+}, F_{12}^{+}, T_{12}^{-}, I_{12}^{-}, F_{12}^{-} \rangle = \langle 0.4022, 0.5272, 0.6080, -0.3922, -0.5448, -0.6360 \rangle$$

$$= 1 - \left[\frac{1}{2} \sqrt{ \left(\frac{(1-0.4022)^2 + (0.5272)^2 + (0.6080)^2}{3} \right) + \left(\frac{(1-(-0.3922))^2 + (-0.5448)^2 + (-0.6360)^2}{3} \right) } \right]$$

$$= 0.4489$$

Then, the deneutrosophication of MABAC method is calculated using the Equation (2) after aggregate the bipolar neutrosophic information as below:

$$\langle T_{11}^{+}, I_{11}^{+}, F_{11}^{+}, T_{11}^{-}, I_{11}^{-}, F_{11}^{-} \rangle = \langle 0.4538, 0.4585, 0.5222, -0.4434, -0.4766, -0.5516 \rangle,$$

then,

$$= 1 - \left[\frac{1}{2} \sqrt{ \left(\frac{(1-0.4538)^2 + (0.4585)^2 + (0.5222)^2}{3} \right) + \left(\frac{(1-(-0.4434)^2) + (-0.4766)^2 + (-0.5516)^2}{3} \right) } \right]$$
$$= 0.4680$$

Table 4.17 shows the deneutrosophication of bipolar neutrosphic information for the DEMATEL method and Table 4.18 presents the deneutrosophication of bipolar neutrosophic information for the MABAC method.

Table 4.17: Deneutrosophication of bipolar neutrosophic information for the DEMATEL method

Criteria	**C_1**	**C_2**	**C_3**
C_1	0	0.4489	0.4910
C_2	0.4780	0	0.4866
C_3	0.4877	0.4673	0

Table 4.18: Deneutrosophication of bipolar neutrosophic information for the MABAC method

Criteria	**C_1**	**C_2**	**C_3**
A_1	0.4680	0.4816	0.4923
A_2	0.4922	0.4689	0.4866
A_3	0.4625	0.4621	0.4673

Next, the calculation is continued with the steps of DEMATEL method to obtain the weight of criteria as follows:

Step 1. Normalize the direct-relation matrix

Based on Table 4.17, the normalization of the direct-relation matrix can be calculated using Equation (4) and Equation (5). The normalization of direct-relation matrix is shown in Table 4.19.

Table 4.19: Normalized direct-relation matrix

Criteria	**C_1**	**C_2**	**C_3**
C_1	0.0000	0.4654	0.5090
C_2	0.4955	0.0000	0.5045
C_3	0.5056	0.4845	0.0000

Step 2. Compute the total relation matrix

The total relation matrix is computed follow by Equation (6) where I is the identity matrix. The total relation matrix is shown in Table 4.20.

Table 4.20: Total relation matrix

Criteria	**C_1**	**C_2**	**C_3**
C_1	27.2418	26.6100	27.7982
C_2	28.0548	26.7572	28.2818
C_3	27.8711	26.9018	27.7568

Step 3. Calculate the sums of rows and columns

The sum of rows and columns are calculated using Equation (7) as follows:

$$\begin{aligned}\tilde{R}_{C_1} &= 27.2418 + 26.6100 + 27.7982 \\ &= 81.6500\end{aligned}$$

$$\begin{aligned}\tilde{C}_{C_1} &= 27.2418 + 28.0548 + 27.8711 \\ &= 83.1677\end{aligned}$$

$$\begin{aligned}\tilde{R}_{C_1} + \tilde{C}_{C_1} &= 81.6500 + 83.1677 \\ &= 164.8177\end{aligned}$$

$$\tilde{R}_{C_1} - \tilde{C}_{C_1} = 81.6500 - 83.1677$$
$$= -1.5177$$

Table 4.21 presents the sums of rows and columns.

Table 4.21: Sums of rows and columns

Criteria	$\tilde{R}$	$\tilde{C}$	$\tilde{R}+\tilde{C}$	$\tilde{R}-\tilde{C}$
C_1	81.6500	83.1677	164.8177	-1.5177
C_2	83.0937	80.2690	163.3627	2.8248
C_3	82.5297	83.8367	166.3664	-1.3070

Step 4. Determine weight of criteria

The weight of criteria are calculated based on Equation (8) as below:

$$\tilde{w}_{C_1} = \left[(164.8177)^2 + (-1.5177)^2\right]^{\frac{1}{2}}$$
$$= 13583.5859$$

After calculation, the weight of criteria are shown in Table 4.22.

Table 4.22: Weight of criteria

Criteria	$\tilde{w}$
C_1	13583.5859
C_2	13347.6778
C_3	13839.7486

Step 5. Normalize the weight of criteria

The weight of criteria are normalized using Equation (9) as follows:

$$\sum_{i=1}^{3} \tilde{w} = 13583.5859 + 13347.6778 + 13839.7486$$
$$= 40771.0122$$

Then,

$$\tilde{W}_{C_1} = \frac{13583.5859}{40771.0122}$$
$$= 0.3332$$

The final weight of criteria after normalization is presented in Table 4.23.

Table 4.23: Normalize weight of criteria

Criteria	$\tilde{W}$
C_1	0.3332
C_2	0.3274
C_3	0.3395

After obtaining the weight of criteria, the MABAC method can be implemented in the next step to determine the rank of the alternatives.

Step 6. Normalize the elements from the decision matrix

The initial direct-relation matrix is obtained based on deneutrosophication of bipolar neutrosophic information in Table 4.18. In this case, comfort criteria and safety criteria are benefit criteria where high value are desirable and price criterion is a cost criterion where low value is better.

For the benefit type criteria, the elements from the initial decision matrix of comfort criteria and safety criteria are computed using Equation (11). The computation as below:

$$\tilde{n}_{11} = \frac{0.4680 - 0.4625}{0.4922 - 0.4625}$$
$$= 0.1855$$

where the elements from initial decision matrix of comfort criteria are $\tilde{x} = 0.4680$, $\tilde{x}_i^+ = 0.4922$ and $\tilde{x}_i^- = 0.4625$.

For the cost type criteria, the elements from the initial decision matrix of price criteria is computed in Equation (12) as below:

$$\tilde{n}_{13} = \frac{0.4923 - 0.4923}{0.4673 - 0.4923}$$
$$= 0.0000$$

where $\tilde{x} = 0.4923$, $\tilde{x}_i^{+} = 0.4923$ and $\tilde{x}_i^{-} = 0.4673$. Table 4.24 presents maximum value and minimum value.

Table 4.24: Maximum and minimum values

	C$_1$	**C$_2$**	**C$_3$**
x^{+}	0.4922	0.4816	0.4923
x^{-}	0.4625	0.4621	0.4673

Then, the normalize elements from the decision matrix is presented in Table 4.25.

Table 4.25: Normalize elements from the decision matrix

Criteria	**C$_1$**	**C$_2$**	**C$_3$**
A$_1$	0.1855	1.0000	0.0000
A$_2$	1.0000	0.3490	0.2278
A$_3$	0.0000	0.0000	1.0000

Step 7. Calculate the elements from the weighted matrix

Based on the Table 4.23, the weight of criteria after normalized are $\tilde{W} = (0.3332, 0.3274, 0.3395)$. Then, the weighted matrix is calculated based on Equation (14) as below:

$$\tilde{v}_{11} = 0.3332.(0.1855 + 1)$$
$$= 0.3950$$

The weighted matrix is shown in Table 4.26.

Table 4.26: Weighted matrix

Criteria	**C_1**	**C_2**	**C_3**
A_1	0.3950	0.6548	0.3395
A_2	0.6664	0.4416	0.4168
A_3	0.3332	0.3274	0.6790

Step 8. Determine the border approximation area of matrix

The border approximation area matrix is computed based on Equation (15) as follows:

$$\prod_{j=1}^{3} \tilde{v}_{ij} = (0.3950 \times 0.6664 \times 0.3332)$$
$$= 0.0877$$

Then,

$$\tilde{g}_i = (0.0877)^{\frac{1}{3}}$$
$$= 0.4443$$

Table 4.27 presents the border approximation area of matrix.

Table 4.27: Border approximation area of matrix

Criteria	**C_1**	**C_2**	**C_3**
$\tilde{G}$	0.4443	0.4558	0.4580

Step 9. Calculate the distance of the alternative

The distance of the alternative from the border approximation area is calculated using Equation (18) as below:

$$\tilde{Q} = 0.3950 - 0.443$$
$$= -0.0493$$

Table 4.28 presents the distance of the alternative.

Table 4.28: Distance of the alternative

Criteria	**C_1**	**C_2**	**C_3**
A_1	-0.0493	0.1990	-0.1185
A_2	0.2221	-0.0141	-0.0412
A_3	-0.1111	-0.1284	0.2210

Step 10. Rank the alternative

The sum of the distance is calculated follow by Equation (20) as below:

$$\tilde{S}_1 = (-0.0493) + 0.1990 + (-0.1185)$$
$$= 0.0312$$

The final rank of the alternative is presented in Table 4.29.

Table 4.29: Rank the alternative

Alternative	$\tilde{S}$	**Rank**
A_1	0.0312	2
A_2	0.1668	1
A_3	-0.0185	3

Based on the given example, the result reveals that car A_2 (0.1668) is the best alternative to select followed by A_1 (0.0312) and A_3 (-0.0815). The alternatives can be ranked as $A_2 \succ A_1 \succ A_3$. The bar chart of the ranking is illustrated as in Figure 4.2 for the intuitive and simple understanding.

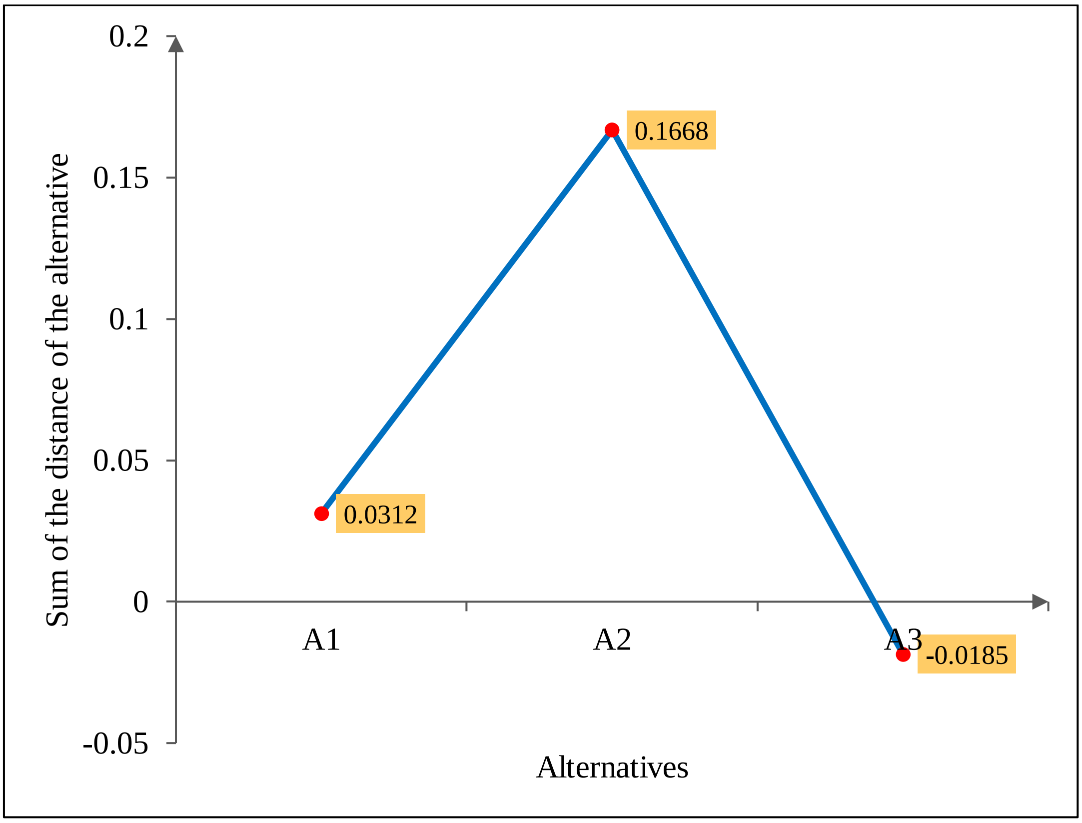

Figure 4.2: Rank of the alternatives for illustrative example

As explained in the previous section, there are four phases involved in this proposed method. The modification of the proposed method is done by introducing the new linguistic variable based on bipolar neutrosophic set in the first phase and phase two determined the weight of the decision maker. Then, the aggregation and deneutrosophication of bipolar neutrosophic information is determined in phase three and the implementation of DEMATEL and MABAC methods in phase four.

CHAPTER 5

APPLICATION TO THE SUSTAINABLE ENERGY SELECTION

This chapter presents the implementation of the proposed method to a case study which is the selection of sustainable energy. The aim of this chapter is to validate the applicability and reliability of the proposed method in solving the real life problem. This chapter is divided into four sections. Section 5.1 provides the introduction of this case study. Next, Section 5.2 present the detailed of the data collection process. Section 5.3 describes the aggregation and deneutrosophication of bipolar neutrosophic information. The implementation of DEMATEL-MABAC method is demonstrated in Section 5.4. The results and discussion are provided in Section 5.5.

5.1 Introduction

MCDM methods are often combined as an integrated method to get a more accurate result or to solve a particular class of problems and cases. The systematic solution will sort out and ultimately produce the best solution that can be an important reference for an authority and stakeholders. In this chapter, the development of the combination of DEMATEL method and MABAC method under a bipolar neutrosophic set is proposed. In order to validate the proposed method in solving real-life MCDM problems, the implementation on the case study of sustainable energy is applied. To highlight the structure of the proposed DEMATEL-MABAC method under a bipolar neutrosophic set for the selection of sustainable energy, the four-phase is visualized as in Figure 5.1.

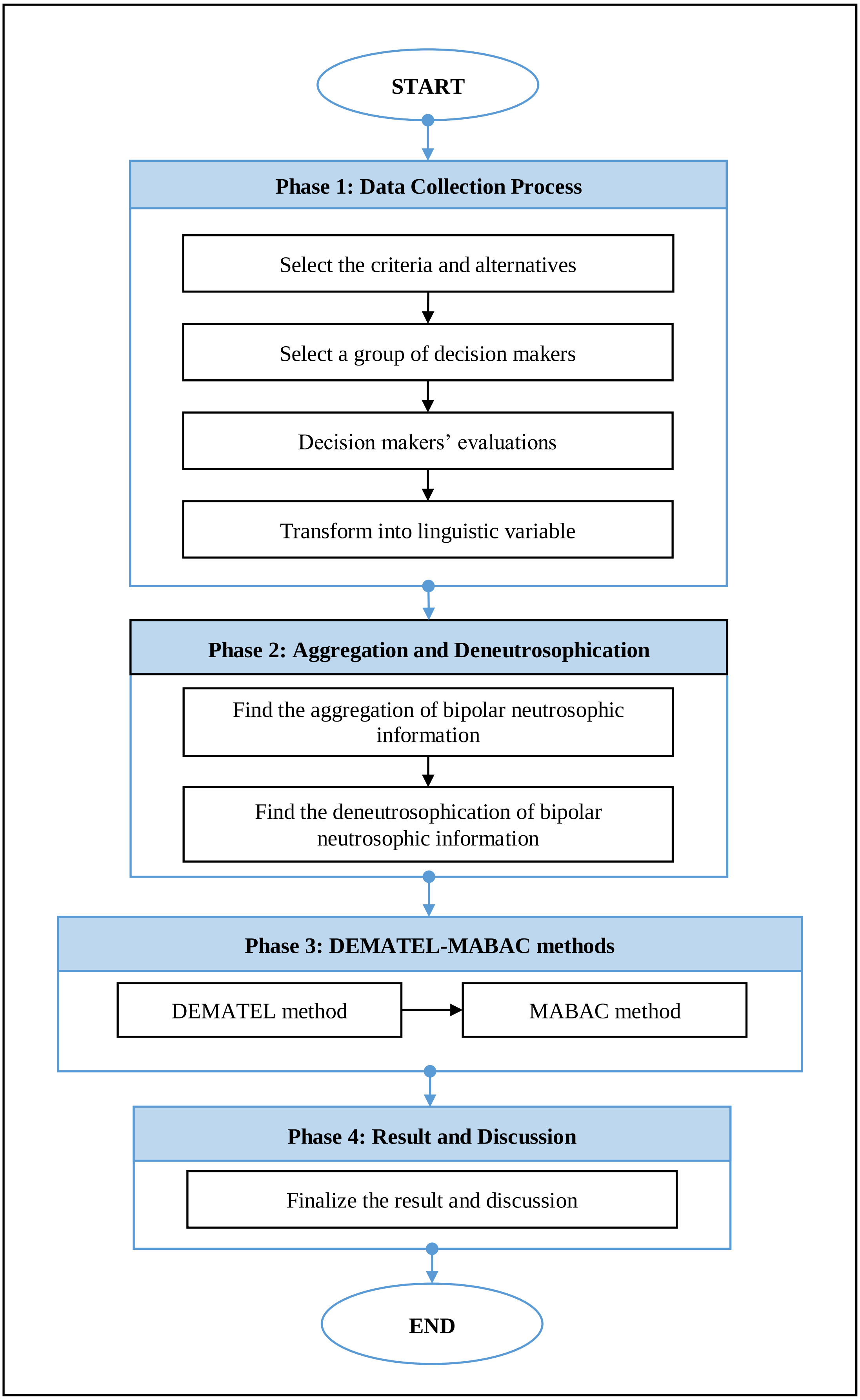

Figure 5.1: The overall framework of the proposed method

5.2 Data Collection Process

Before the data collection process, the selection of criteria and the feasible alternatives are involved to determine and finalize based on the literature review and decision makers' agreement. Then, a group of decision makers in the sustainable energy field is selected and their preferences are elicited by a questionnaire. Their evaluations are transformed into the linguistic variable to identify weight of criteria and to rate the alternatives with respect to each criterion. For a simple understanding, Figure 5.2 illustrates the process of collecting data and the detailed explanation is described in the next sub-section.

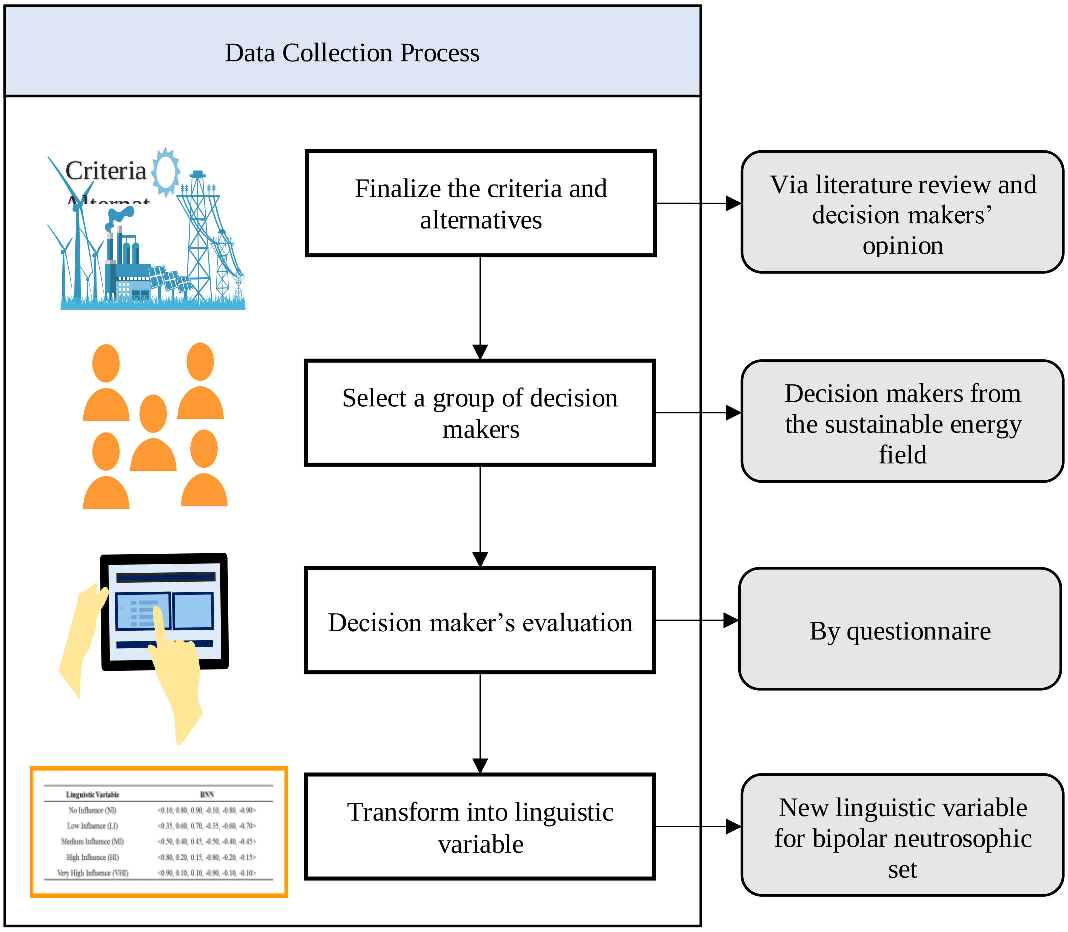

Figure 5.2: Data collection process

5.2.1 Select the Criteria and Alternatives

Sustainable energy is the provision of energy such that it meets the needs of the present without compromising the ability of future generations to meet their needs (Lemaire, 2004). This means that sustainable energy is able to be replenished within a human lifetime and causes no long-term damage, especially to the environment. The evaluation criteria are selected to rank the alternatives and decision makers provide preferences towards criteria and alternatives for sustainable energy. The selection of criteria or alternatives require the parameters that related to reliability, appropriateness, practically and limitation of measurement.

In this research, the criteria in sustainable energy were selected based on research conducted by Wang *et al*. (2009). Fourteen criteria, $C = \{c_1, c_2, c_3, \ldots, c_{14}\}$ are considered and they are shown in Table 5.1.

Table 5.1: List of criteria in sustainable energy

Notation	Criteria	Description
C_1	Efficiency	Efficiency refers to how much useful energy can get from energy resources. The efficiency coefficient is the ratio of output energy to the input energy which is used to evaluate the energy system.
C_2	Exergy efficiency	Exergy efficiency is a second-law efficiency or rational efficiency computes efficiency of a process taking the second law of thermodynamic into account. Exergy accounts for the irreversibility of a process due to an increase in entropy.
C_3	Safety	Safety is one of the groups of related disciplines to the quality, reliability, availability, maintainability, and safety.
C_4	NO_X emission	NO_X emission is a generic term for mono-nitrogen oxides (NO and NO_X emission) which comprises a group of molecules that can contribute to local air pollution, acid deposition and global climate change. NOX is produced during the combustion of fossil fuel and biomass especially combustion at high temperature.
C_5	CO_2 emission	CO_2 emission is colourless, odourless and tasteless gas that is about one and half times as

		dense as air under ordinary conditions of temperature and pressure. CO_2 is mainly released through the combustion of coal or lignite, oil and natural gas in energy systems.
C_6	CO emission	CO emission is produced from the partial combustion of carbon-containing compounds, notably in internal-combustion engines.
C_7	Land use	Land use is energy systems occupies the environment and landscape are affected directly by the land occupied by energy systems. Land use can also be a social criterion to evaluate energy systems.
C_8	Noise	Noise pollution from energy systems is displeasing machine-created sound that disrupts the activity or balances human and animal life.
C_9	Social acceptability	Social acceptability expresses the overview of opinions related to the energy systems by the local population regarding the hypnotized realization of the projects under review from the consumer point of view.
C_{10}	Job creation	Energy supply systems employ many people during their life cycle, from construction and operation till decommissioning.
C_{11}	Investment cost	Investments costs comprise of all costs relating to the purchases of mechanical equipment, technological installations, construction of roads or connections to the national grid, engineering services, drilling and other incidental construction work.
C_{12}	Operation and maintenance cost	Operation costs include employees' wages and funds spent on the energy, the products and services for the energy system operation. Maintenance costs aims to its operation suspension.
C_{13}	Fuel cost	Fuel costs are the fund spent on the provision of raw material necessary for energy supply system operation include extraction or mining, transportation and possible fuel processing that use in the power plants.
C_{14}	Electric cost	Electric costs are the product cost of the power plants to evaluate economic performance from the viewpoint of customers.

Besides that, sustainable energy includes renewable energy sources such as biomass, solar, geothermal, hydroelectricity, wind, wave and tidal. In this study, sustainable energy sources explore to be alternative energy where seven alternatives,

$A = \{a_1, a_2, a_3, \ldots, a_7\}$ were selected and defined in Table 5.2. The decision makers gave their preferences based on the fourteen criteria and seven alternatives.

Table 5.2: List of alternative in sustainable energy

Notation	Alternative	Description
A_1	Biomass energy	Biomass energy generates organic matter converted to energy that comes from plants, animals, bio wastes or process wastes includes crops, waste, wood and trees When biomass is burned, the chemical energy is released as heat and can generate electricity with a steam turbine.
A_2	Biogas energy	Biogas energy produces by the decomposition of organic matter such as food scraps or animal waste. When organic matter breaks down by microorganisms in the absence of oxygen in a process called anaerobic digestion. Anaerobic digestion is a natural form of waste to energy that uses the process of fermentation to break down organic matter.
A_3	Geothermal energy	Geothermal energy is the internal heat from the Earth that uses for electric power production, heating and cooling the buildings. Resources of geothermal energy range from the shallow ground to hot water and hot rock found a few miles beneath the Earth's surface and down even deeper to the extremely high temperatures of molten rock.
A_4	Hydro energy	Hydro energy relies on water that fast-moving water in the large river or rapidly descending water from the high point and converts the force of water into electricity by spinning a generator's turbine blade. This energy also captures water vapour that turns into rain or snow and flows downhill into rivers or streams. Small hydropower defines as the generation of electricity by exploiting the power of flowing water from lakes, rivers and streams. It also uses moving water down the stream to turn turbine.
A_5	Solar energy	Solar energy utilizes the radiant light emitted from the sun and converted into electrical energy through a device called a photovoltaic cell. This energy classified into two types which is passive solar energy that makes direct and indirect use of thermal energies from the sun and active solar energy uses the sun's electromagnetic radiation in generating electrical energy.

A_6	Tidal energy	Tidal energy generates due to the natural rise and fall of the ocean surface caused by the gravitational forces of the sun and moon. The movement of the water at the coastal front in kinetic energy can be converted into electrical energy. The energy of the ocean's waves.
A_7	Wind energy	Wind energy produces by the atmospheric air when the sun heats the atmosphere and also works on cloudy days and rainy seasons. Wind energy turns a turbine's blades which produce electricity using the kinetic energy created by air in motion.

5.2.2 Select a Group of Decision Makers

A group decision making (GDM) can be defined as two or more individuals which characterized by the perceptions, attitudes, motivations and personalities who recognize the existence of a common problem and attempt to reach a collective decision (Bui and Jarke, 1986). In the classical GDM situation, there is a problem to solve where a group of two or more decision makers need to express their opinions about the set of criteria or alternatives and attempt to reach a collective decision with the possible solution. For common example question for decision maker, what is/are the best solution alternative(s) for this problem?

In this study, a group of five decision-makers, $D = \{d_1, d_2, d_3, d_4, d_5\}$ in the field of sustainable energy are invited to evaluate the criteria and alternatives. Table 5.3 shows the background information of all the five decision makers and the details of personal profile decision makers are provided in Appendix 2.

Table 5.3: Background information of decision-makers

Decision Maker	Name of Company/ Institute	Position in Company/Institute	Expertise	Year of Experience

d_1	Universiti Malaya	Senior Lecturer	Power and Energy	5
d_2	Epic Solar Sdn Bhd	Electrical Executive	Operation and Maintenance Solar Power Plant	3
d_3	University College TATI	Lecturer	Electrical power	6
d_4	Universiti Teknologi Malaysia	Senior Lecturer	Power System	7
d_5	Universiti Malaysia Pahang	Lecturer	Recycling Technology, Separation, Wastewater Treatment, Renewable Energy	10

5.2.3 Decision Maker's Evaluation

Based on the preferences, opinions and experience in the sustainable energy field, the decision makers evaluate the data according to the linguistic terms influence from "no influence" to "very high influence" through the questionnaire in the google form. This questionnaire is constructed to assist the assessment of the influence between criteria or alternatives in sustainable energy. This evaluation process took approximately 15 to 20 minutes for each decision maker to finish their preferences on the fourteen criteria and seven alternatives of sustainable energy.

In first part, this questionnaire was evaluated to find out the important criteria of sustainable energy in general. Second, this questionnaire aims to determine the weight of criteria based on the bipolar neutrosophic DEMATEL method. This questionnaire asks whether one criterion will influence by other criteria in sustainable energy. For example: Does efficiency (C_1) influence the other criteria below in sustainable energy? Third part, this questionnaire aims to select the optimal alternatives to rank the alternatives based on the bipolar neutrosophic MABAC method. This questionnaire asks whether each alternative influences the criteria in sustainable energy. For example: To what extent, the following criteria influence Biomass energy (A_1)?

The data collection through this questionnaire could be used to find the weight of criteria using the DEMATEL method and rank the alternatives using the MABAC method under bipolar neutrosophic set. The full questionnaire shows in Appendix 3.

After that, the weight of decision maker is determined based on the 5-scale linguistic variable: “Very Unimportance” to “Very Importance” in Table 5.4.

Table 5.4: Evaluation scores

Scores	**Linguistic Variable**	**Expertise**	**Experience (year)**
0	Very Unimportance (VU)	Unrelated expertise in sustainable energy field	0
1	Unimportance (UM)	Minimum expertise in sustainable energy field	(0-3]
2	Medium Importance (MIM)	Medium expertise in sustainable energy field	(3,5]
3	Importance (IM)	Relate expertise in sustainable energy field	(5,7]
4	Very Importance (VIM)	Very relate in sustainable energy field	More than 7

The expertise (E_1) and experience (E_2) in sustainable energy fields of decision makers are transformed into number of scores based on Table 5.4. Table 5.5 presents the evaluation matrix of decision makers.

Table 5.5: Evaluation matrix of decision makers

Criteria of DM	**d_1**	**d_2**	**d_3**	**d_4**	**d_5**
E_1	3	3	2	2	4
E_2	2	1	3	3	4

From the Table 5.5, the weight of decision maker is determined and shown in Table 5.6.

Table 5.6: Weight of decision makers

Decision makers	$\tilde{w}_d$
d_1	0.1852
d_2	0.1481
d_3	0.1852
d_4	0.1852
d_5	0.2963

5.2.4 Transform into New Linguistic Variable of Bipolar Neutrosophic

After a group of decision makers evaluated the criteria and alternatives according to linguistic terms from “no influence” to “very high influence”, their evaluation transformed based on the new bipolar neutrosophic linguistic variable in Table 4.2. Table 5.7 until Table 5.11 show the evaluation of five decision makers on criteria with respect to criteria of sustainable energy for the DEMATEL method.

Table 5.7: Decision maker 1 (d_1) evaluation for DEMATEL method

Criteria	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**
C_1	0	HI	MI	MI	MI	MI	LI	LI	HI	MI	MI	HI	HI	HI
C_2	HI	0	LI	LI	LI	LI	LI	LI	MI	LI	MI	MI	MI	MI
C_3	LI	LI	0	MI	LI	LI	LI	LI	VHI	MI	HI	HI	MI	MI
C_4	HI	MI	LI	0	MI	MI	LI	LI	HI	MI	MI	MI	HI	MI
C_5	HI	MI	LI	MI	0	MI	LI	LI	HI	MI	MI	MI	HI	MI
C_6	HI	MI	LI	MI	MI	0	LI	LI	HI	MI	MI	MI	HI	MI
C_7	LI	LI	LI	LI	LI	LI	0	NI	MI	LI	MI	LI	LI	LI
C_8	NI	NI	NI	NI	NI	NI	NI	0	HI	LI	LI	MI	LI	LI
C_9	HI	MI	VHI	HI	HI	HI	MI	HI	0	HI	MI	MI	MI	MI
C_{10}	LI	LI	HI	LI	LI	LI	NI	LI	HI	0	LI	MI	LI	MI
C_{11}	MI	LI	HI	LI	MI	MI	HI	LI	MI	LI	0	LI	LI	LI
C_{12}	MI	LI	HI	LI	MI	MI	MI	LI	MI	LI	LI	0	LI	LI
C_{13}	MI	LI	HI	LI	MI	MI	MI	LI	MI	LI	LI	LI	0	LI
C_{14}	MI	LI	MI	LI	MI	MI	MI	LI	MI	LI	LI	LI	LI	0

Table 5.8: Decision maker 2 (d_2) evaluation for DEMATEL method

Criteria	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**
C_1	0	MI	HI	HI	HI	HI	MI	MI	MI	HI	VHI	VHI	MI	MI
C_2	HI	0	HI	HI	HI	HI	MI	MI	MI	HI	HI	HI	MI	MI
C_3	HI	HI	0	HI	VHI	HI	HI	HI	HI	HI	HI	HI	MI	MI
C_4	HI	HI	HI	0	HI	HI	MI	MI	MI	HI	HI	HI	MI	MI
C_5	HI	HI	HI	HI	0	HI	MI	MI	MI	HI	HI	HI	MI	MI
C_6	HI	HI	HI	HI	HI	0	MI	MI	MI	HI	HI	HI	MI	MI
C_7	MI	MI	HI	HI	HI	HI	0	MI	MI	MI	VHI	HI	MI	MI
C_8	HI	HI	HI	HI	HI	HI	MI	0	HI	HI	HI	HI	MI	MI
C_9	HI	HI	HI	HI	HI	HI	MI	HI	0	HI	HI	HI	MI	MI
C_{10}	HI	HI	HI	HI	HI	HI	MI	HI	HI	0	HI	VHI	MI	MI
C_{11}	HI	HI	HI	HI	HI	HI	MI	MI	HI	HI	0	VHI	MI	MI
C_{12}	VHI	VHI	VHI	VHI	VHI	VHI	VHI	HI	HI	VHI	VHI	0	MI	MI

C_{13}	HI	HI	HI	HI	HI	HI	HI	MI	MI	HI	HI	HI	0	MI
C_{14}	HI	HI	HI	HI	HI	HI	HI	MI	MI	HI	HI	HI	MI	0

Table 5.9: Decision maker 3 (d_3) evaluation for DEMATEL method

Criteria	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**
C_1	0	HI	HI	HI	HI	HI	HI	HI	HI	VHI	HI	MI	VHI	HI
C_2	HI	0	HI	HI	MI	MI	HI	HI	HI	VHI	HI	HI	HI	VHI
C_3	HI	MI	0	HI	MI	MI	HI	HI	VHI	VHI	HI	MI	HI	HI
C_4	HI	HI	MI	0	MI	HI	MI	MI	HI	VHI	VHI	HI	HI	HI
C_5	HI	MI	MI	HI	0	HI	MI	MI	HI	HI	HI	VHI	VHI	HI
C_6	HI	MI	HI	MI	MI	0	MI	MI	VHI	MI	MI	HI	VHI	HI
C_7	HI	HI	MI	MI	MI	HI	0	MI	HI	MI	HI	HI	VHI	HI
C_8	MI	HI	HI	HI	MI	MI	HI	0	HI	HI	HI	HI	VHI	HI
C_9	MI	HI	MI	HI	MI	MI	MI	MI	0	VHI	HI	MI	HI	VHI
C_{10}	HI	MI	MI	MI	MI	HI	HI	HI	HI	0	MI	HI	HI	VHI
C_{11}	HI	MI	HI	HI	HI	HI	HI	HI	VHI	HI	0	HI	HI	VHI
C_{12}	MI	MI	MI	MI	HI	HI	HI	HI	VHI	HI	MI	0	HI	VHI
C_{13}	HI	MI	MI	MI	MI	HI	HI	VHI	VHI	HI	MI	HI	0	VHI
C_{14}	HI	MI	MI	HI	MI	HI	HI	VHI	VHI	HI	MI	HI	HI	0

Table 5.10: Decision maker 4 (d_4) evaluation for DEMATEL method

Criteria	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**
C_1	0	HI	LI	VHI	HI	HI	HI	LI	HI	LI	HI	HI	HI	HI
C_2	HI	0	LI	VHI	HI	HI	HI	LI	HI	LI	HI	HI	HI	HI
C_3	LI	LI	0	MI	MI	LI	MI	LI	MI	LI	HI	VHI	MI	MI
C_4	HI	HI	MI	0	HI	MI	HI	LI	HI	LI	HI	MI	HI	MI
C_5	HI	HI	MI	HI	0	MI	HI	LI	LI	LI	HI	MI	HI	MI
C_6	HI	HI	MI	HI	HI	0	HI	LI	LI	LI	HI	MI	HI	MI
C_7	MI	HI	HI	MI	VHI	LI	0	LI	MI	MI	VHI	LI	MI	HI
C_8	LI	LI	HI	MI	LI	LI	LI	0	LI	LI	LI	LI	LI	HI
C_9	LI	MI	VHI	MI	HI	HI	MI	LI	0	HI	HI	MI	MI	MI
C_{10}	NI	HI	HI	LI	MI	MI	LI	LI	LI	0	HI	HI	HI	HI

C_{11}	HI	VHI	VHI	HI	HI	HI	HI	HI	HI	HI	0	HI	HI	HI
C_{12}	MI	HI	HI	HI	HI	HI	HI	MI	HI	HI	HI	0	HI	MI
C_{13}	VHI	HI	HI	MI	HI	VHI	VHI	HI	HI	VHI	HI	VHI	0	HI
C_{14}	HI	VHI	HI	HI	MI	HI	HI	HI	HI	HI	HI	HI	HI	0

Table 5.11: Decision maker 5 (d_5) evaluation for DEMATEL method

Criteria	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**
C_1	0	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI
C_2	VHI	0	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI
C_3	VHI	VHI	0	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI
C_4	VHI	VHI	VHI	0	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI
C_5	VHI	VHI	VHI	VHI	0	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI
C_6	VHI	VHI	VHI	VHI	VHI	0	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI
C_7	VHI	VHI	VHI	VHI	VHI	VHI	0	VHI	VHI	VHI	VHI	VHI	VHI	VHI
C_8	VHI	VHI	VHI	VHI	VHI	VHI	VHI	0	VHI	VHI	VHI	VHI	VHI	VHI
C_9	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	0	VHI	VHI	VHI	VHI	VHI
C_{10}	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	0	VHI	VHI	VHI	VHI
C_{11}	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	0	VHI	VHI	VHI
C_{12}	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	0	VHI	VHI
C_{13}	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	0	VHI
C_{14}	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	0

Decision maker's evaluation for DEMATEL method in Table 5.7 until Table 5.11 transformed into new linguistic variable of bipolar neutrosophic based on Table 4.2. The completed of the decision maker evaluation in linguistic variable of bipolar neutrosophic for DEMATEL method are shown on Appendix 5.

For the MABAC method, the evaluation of decision makers are shown in Table 5.12 until Table 5.16.

Table 5.12: Decision maker 1 (d_1) evaluation for MABAC method

Criteria	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**
A_1	HI	MI	HI	HI	HI	HI	MI	MI	VHI	MI	HI	HI	HI	HI
A_2	HI	MI	HI	HI	HI	HI	LI	LI	VHI	MI	HI	HI	HI	HI
A_3	HI	MI	HI	HI	HI	HI	LI	LI	VHI	MI	HI	HI	HI	HI
A_4	HI	MI	HI	HI	HI	HI	LI	LI	VHI	MI	HI	HI	HI	HI
A_5	HI	MI	HI	HI	HI	HI	VHI	LI	VHI	MI	HI	HI	HI	HI
A_6	HI	MI	HI	HI	HI	HI	LI	LI	VHI	MI	HI	HI	HI	HI
A_7	HI	MI	HI	HI	HI	HI	MI	LI	VHI	MI	HI	HI	HI	HI

Table 5.13: Decision maker 2 (d_2) evaluation for MABAC method

Criteria	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**
A_1	HI	MI	MI	HI	HI	HI	MI	MI	HI	MI	HI	HI	HI	HI
A_2	HI	HI	HI	HI	HI	HI	HI	HI	MI	HI	HI	HI	HI	HI
A_3	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI
A_4	HI	MI	HI	HI	HI	HI	HI	MI	MI	HI	VHI	VHI	VHI	VHI
A_5	VHI	HI	HI	HI	HI	HI	VHI	MI	MI	HI	HI	VHI	MI	MI
A_6	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI
A_7	VHI	HI	MI	MI	MI	MI	MI	MI	MI	MI	VHI	VHI	MI	MI

Table 5.14: Decision maker 3 (d_3) evaluation for MABAC method

Criteria	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**
A_1	HI	HI	HI	VHI	VHI	VHI	VHI	HI	HI	HI	VHI	VHI	VHI	VHI
A_2	HI	HI	VHI	VHI	VHI	VHI	HI	HI	HI	VHI	VHI	VHI	HI	HI

A_3	HI	HI	MI	HI	HI	HI	VHI	VHI	VHI	HI	VHI	VHI	VHI	HI
A_4	VHI	HI	VHI	MI	MI	MI	VHI	HI	VHI	VHI	VHI	VHI	MI	VHI
A_5	VHI	VHI	MI	MI	MI	MI	VHI	MI	MI	MI	VHI	HI	VHI	VHI
A_6	VHI	HI	HI	HI	HI	MI	MI	MI	HI	HI	HI	HI	VHI	VHI
A_7	VHI	HI	HI	HI	VHI	VHI	HI	HI	HI	HI	HI	HI	VHI	VHI

Table 5.15: Decision maker 4 (d_4) evaluation for MABAC method

Criteria	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**
A_1	HI	HI	MI	HI	HI	HI	VHI	MI	HI	HI	HI	HI	HI	HI
A_2	HI	HI	MI	HI	HI	HI	HI	MI	HI	HI	HI	HI	HI	HI
A_3	HI	HI	MI	HI	HI	HI	HI	MI	HI	HI	HI	HI	HI	HI
A_4	HI	HI	MI	HI	HI	HI	HI	MI	HI	HI	HI	HI	HI	HI
A_5	HI	HI	MI	HI	HI	HI	HI	NI	HI	HI	HI	HI	HI	HI
A_6	HI	HI	MI	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI
A_7	HI	HI	MI	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI

Table 5.16: Decision maker 5 (d_5) evaluation for MABAC method

Criteria	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**
A_1	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI
A_2	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI
A_3	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI
A_4	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI
A_5	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI
A_6	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI	VHI
A_7	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI

Also, decision makers' evaluation for the MABAC method in Table 5.12 until Table 5.16 transformed into new linguistic variable of bipolar neutrosophic based on Table 4.2. Appendix 6 showed the completed of the decision maker evaluation in linguistic variable of bipolar neutrosophic for MABAC method.

5.3 Aggregation and Deneutrosophication of Bipolar Neutrosophic Information

According to five individual of decision makers information, the aggregation have been obtained using bipolar neutrosophic weighted average operator based on the weight of decision makers from the Table 5.6.

5.3.1 Aggregation of Bipolar Neutrosophic Information

For the DEMATEL method, the aggregation of bipolar neutrosophic information can be calculated using Equation (4) as follows:

$$T_{12}^{+} = 1-((1-0.80)^{0.1852}\times(1-0.50)^{0.1481}\times(1-0.80)^{0.1852}\times(1-0.80)^{0.1852}\times(1-0.90)^{0.2963})$$
$$= 0.8135$$

$$I_{12}^{+} = (0.20)^{0.1852}\times(0.40)^{0.1481}\times(0.20)^{0.1852}\times(0.20)^{0.1852}\times(0.10)^{0.2963}$$
$$= 0.1805$$

$$F_{12}^{+} = (0.15)^{0.1852}\times(0.45)^{0.1481}\times(0.15)^{0.1852}\times(0.15)^{0.1852}\times(0.10)^{0.2963}$$
$$= 0.1565$$

$$T_{12}^{-} = \text{-}(\text{-}0.80)^{0.1852}\times(\text{-}0.50)^{0.1481}\times(\text{-}0.80)^{0.1852}\times(\text{-}0.80)^{0.1852}\times(\text{-}0.90)^{0.2963})$$
$$= -0.7727$$

$$I_{12}^{-} = 1-((1-(\text{-}0.20))^{0.1852} \times (1-(\text{-}0.40))^{0.1481} \times (1-(\text{-}0.20))^{0.1852} \times (1-(\text{-}0.20))^{0.1852} \times (1-(\text{-}0.10))^{0.2963}) = \text{-}0.2062$$

$$F_{12}^{-} = 1-((1-(\text{-}0.15))^{0.1852} \times (1-(\text{-}0.45))^{0.1481} \times (1-(\text{-}0.15))^{0.1852} \times (1-(\text{-}0.15))^{0.1852} \times (1-(\text{-}0.10))^{0.2963}) = \text{-}0.1895$$

For the MABAC method, the bipolar neutrosophic information also can be aggregated using the Equation (4). The calculation is presented as follows:

$$T_{11}^{+} = 1-((1-0.80)^{0.1852} \times (1-0.80)^{0.1481} \times (1-0.80)^{0.1852} \times (1-0.80)^{0.1852} \times (1-0.90)^{0.2963}) = 0.8371$$

$$I_{11}^{+} = (0.20)^{0.1852} \times (0.20)^{0.1481} \times (0.20)^{0.1852} \times (0.20)^{0.1852} \times (0.10)^{0.2963} = 0.1629$$

$$F_{11}^{+} = (0.15)^{0.1852} \times (0.15)^{0.1481} \times (0.15)^{0.1852} \times (0.15)^{0.1852} \times (0.10)^{0.2963} = 0.1330$$

$$T_{11}^{-} = \text{-}(\text{-}0.80)^{0.1852} \times (\text{-}0.80)^{0.1481} \times (\text{-}0.80)^{0.1852} \times (\text{-}0.80)^{0.1852} \times (\text{-}0.90)^{0.2963}) = \text{-}0.8284$$

$$I_{11}^{-} = 1-((1-(\text{-}0.20))^{0.1852} \times (1-(\text{-}0.20))^{0..1481} \times (1-(\text{-}0.20))^{0.1852} \times (1-(\text{-}0.20))^{0.1852} \times (1-(\text{-}0.10))^{0.2963}) = \text{-}0.1716$$

$$F_{11}^{-} = 1-((1-(\text{-}0.15))^{0.1852} \times (1-(\text{-}0.15))^{0.1481} \times (1-(\text{-}0.15))^{0.1852} \times (1-(\text{-}0.15))^{0.1852} \times (1-(\text{-}0.10))^{0.2963}) = \text{-}0.1355$$

where $w_d = (0.1852, 0.1481, 0.1852, 0.1852, 0.2963)$. Therefore, the overall aggregation of bipolar neutrosophic information for DEMATEL method and aggregation of bipolar neutrosophic MABAC method shown in Appendix 7.

5.3.2 Deneutrosophication of Bipolar Neutrosophic Information

The deneutrosophication of bipolar neutrosophic information for the DEMATEL method can be computed using the Equation (5) as follows:

$$= 1 - \left[\frac{1}{2} \sqrt{ \left(\frac{(1-0.8135)^2 + (0.1805)^2 + (0.1565)^2}{3} \right) + \left(\frac{(1-(-0.7727))^2 + (-0.2062)^2 + (-0.1895)^2}{3} \right) } \right]$$
$$= 0.4746$$

Also, deneutrosophication for the MABAC method can be calculated using the Equation (5) below:

$$= 1 - \left[\frac{1}{2} \sqrt{ \left(\frac{(1-0.8371)^2 + (0.1629)^2 + (0.1330)^2}{3} \right) + \left(\frac{(1-(-0.8284))^2 + (-0.1716)^2 + (-0.1355)^2}{3} \right) } \right]$$
$$= 0.4629$$

The deneutrosophication of bipolar neutrosophic for the DEMATEL method and MABAC method are presented in Appendix 8.

5.4 Bipolar Neutrosophic DEMATEL-MABAC Method

The bipolar neutrosophic DEMATEL-MABAC method is proposed as discussed in Chapter 4 and applied the uses of proposed methods in this section. The DEMATEL method is applied to obtain the weight of criteria and used to calculate the elements from the weighted matrix in the MABAC method. Then, the MABAC method is used to rank the alternatives. The detailed computation is implemented for select sustainable energy according to the following steps:

Step 1. Normalize the direct-relation matrix

After the deneutrosophication of bipolar neutrosophic information for DEMATEL method, the direct-relation matrix is normalized using Equation (4) and Equation (5). Table 5.17 presents the normalized direct-relation matrix.

Table 5.17: Normalized direct-relation matrix

Criteria	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**
C_1	0.0000	0.0729	0.0756	0.0733	0.0733	0.0733	0.0762	0.0761	0.0762	0.0789	0.0731	0.0749	0.0726	0.0729
C_2	0.0711	0.0000	0.0763	0.0744	0.0756	0.0756	0.0754	0.0763	0.0759	0.0756	0.0748	0.0750	0.0759	0.0759
C_3	0.0760	0.0760	0.0000	0.0760	0.0765	0.0756	0.0756	0.0744	0.0726	0.0750	0.0706	0.0733	0.0759	0.0759
C_4	0.0706	0.0730	0.0756	0.0000	0.0733	0.0750	0.0764	0.0762	0.0747	0.0763	0.0733	0.0750	0.0759	0.0747
C_5	0.0711	0.0750	0.0763	0.0750	0.0000	0.0750	0.0764	0.0761	0.0747	0.0760	0.0733	0.0733	0.0747	0.0765
C_6	0.0711	0.0750	0.0763	0.0750	0.0750	0.0000	0.0763	0.0761	0.0747	0.0750	0.0733	0.0733	0.0726	0.0747
C_7	0.0754	0.0754	0.0756	0.0756	0.0756	0.0756	0.0000	0.0784	0.0765	0.0763	0.0731	0.0744	0.0753	0.0754
C_8	0.0786	0.0786	0.0786	0.0783	0.0783	0.0783	0.0776	0.0000	0.0756	0.0760	0.0744	0.0750	0.0753	0.0753
C_9	0.0711	0.0733	0.0726	0.0711	0.0744	0.0742	0.0759	0.0744	0.0000	0.0744	0.0730	0.0730	0.0745	0.0745
C_{10}	0.0761	0.0761	0.0742	0.0761	0.0760	0.0763	0.0783	0.0760	0.0706	0.0000	0.0744	0.0731	0.0753	0.0747
C_{11}	0.0733	0.0744	0.0711	0.0742	0.0733	0.0750	0.0726	0.0763	0.0733	0.0756	0.0000	0.0756	0.0762	0.0762
C_{12}	0.0749	0.0742	0.0726	0.0756	0.0746	0.0749	0.0756	0.0760	0.0760	0.0742	0.0742	0.0000	0.0753	0.0754
C_{13}	0.0730	0.0744	0.0733	0.0744	0.0730	0.0730	0.0748	0.0766	0.0759	0.0744	0.0744	0.0744	0.0000	0.0754

C_{14}	0.0733	0.0742	0.0750	0.0756	0.0750	0.0750	0.0733	0.0754	0.0759	0.0742	0.0742	0.0756	0.0753	0.0000

Step 2. Compute the total relation matrix

The total relation matrix are computed using Equation (6) where I an identity matrix. Table 5.18 shows the total relation matrix.

Table 5.18: Total relation matrix

Criteria	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**
C_1	2.5010	2.6095	2.6137	2.6151	2.6134	2.6201	2.6413	2.6501	2.6123	2.6370	2.5696	2.5946	2.6148	2.6216
C_2	2.5875	2.5619	2.6347	2.6364	2.6358	2.6425	2.6612	2.6710	2.6324	2.6547	2.5912	2.6150	2.6381	2.6447
C_3	2.5809	2.6215	2.5528	2.6269	2.6256	2.6315	2.6503	2.6582	2.6186	2.6431	2.5767	2.6027	2.6271	2.6337
C_4	2.5684	2.6110	2.6152	2.5483	2.6149	2.6230	2.6430	2.6517	2.6125	2.6363	2.5713	2.5962	2.6192	2.6247
C_5	2.5770	2.6210	2.6240	2.6262	2.5548	2.6312	2.6513	2.6600	2.6207	2.6443	2.5794	2.6030	2.6264	2.6344
C_6	2.5648	2.6086	2.6117	2.6139	2.6122	2.5491	2.6387	2.6475	2.6084	2.6310	2.5672	2.5907	2.6122	2.6205
C_7	2.6029	2.6439	2.6460	2.6494	2.6477	2.6545	2.6032	2.6849	2.6448	2.6673	2.6014	2.6264	2.6496	2.6562
C_8	2.6471	2.6889	2.6908	2.6940	2.6922	2.6991	2.7178	2.6550	2.6862	2.7096	2.6440	2.6687	2.6918	2.6985
C_9	2.5360	2.5779	2.5791	2.5812	2.5823	2.5887	2.6087	2.6162	2.5095	2.6009	2.5381	2.5613	2.5844	2.5909
C_{10}	2.5900	2.6308	2.6311	2.6361	2.6343	2.6413	2.6620	2.6689	2.6261	2.5827	2.5890	2.6116	2.6359	2.6419
C_{11}	2.5638	2.6052	2.6042	2.6102	2.6078	2.6159	2.6325	2.6446	2.6042	2.6285	2.4960	2.5898	2.6124	2.6189
C_{12}	2.5805	2.6207	2.6212	2.6272	2.6246	2.6315	2.6510	2.6603	2.6223	2.6431	2.5805	2.5351	2.6273	2.6339
C_{13}	2.5629	2.6045	2.6055	2.6098	2.6069	2.6135	2.6338	2.6442	2.6058	2.6269	2.5646	2.5881	2.5409	2.6176
C_{14}	2.5752	2.6165	2.6191	2.6230	2.6208	2.6275	2.6449	2.6556	2.6180	2.6389	2.5764	2.6012	2.6232	2.5597

Step 3. Calculate the sums of rows and columns

The sum of rows and columns is calculated according to Equation (7). Table 5.19 presents the sum of rows and columns.

Table 5.19: Sums of rows and columns

Criteria	$\tilde{R}$	$\tilde{C}$	$\tilde{R}+\tilde{C}$	$\tilde{R}-\tilde{C}$
C_1	36.5140	36.0379	72.5519	0.4761
C_2	36.8071	36.6219	73.4289	0.1852
C_3	36.6498	36.6490	73.2988	0.0008
C_4	36.5355	36.6977	73.2332	-0.1622
C_5	36.6537	36.6735	73.3272	-0.0199
C_6	36.4766	36.7693	73.2459	-0.2927
C_7	36.9783	37.0396	74.0179	-0.0614
C_8	37.5838	37.1683	74.7521	0.4155
C_9	36.0551	36.6217	72.6768	-0.5666
C_{10}	36.7815	36.9444	73.7259	-0.1628
C_{11}	36.4341	36.0453	72.4793	0.3888
C_{12}	36.6592	36.3846	73.0437	0.2746
C_{13}	36.4251	36.7032	73.1284	-0.2781
C_{14}	36.5999	36.7972	73.3971	-0.1973

Step 4. Determine weight of criteria

The weight of criteria are determined by following the Equation (8). The weight of criteria show in Table 5.20.

Table 5.20: Weight of criteria

Criteria	$\tilde{w}$
C_1	2631.9993
C_2	2695.9208
C_3	2686.3554
C_4	2681.5666
C_5	2688.4419
C_6	2682.5207
C_7	2739.3273
C_8	2794.0225
C_9	2641.1176

C_{10}	2717.7650
C_{11}	2626.7007
C_{12}	2667.7307
C_{13}	2673.9179
C_{14}	2693.5848

Step 5. Normalize the weight of criteria

Next, the weight of criteria is normalized using the Equation (9). The final weight of criteria after normalized presents in Table 5.21.

Table 5.21: Normalize weight of criteria

Criteria	$\widetilde{W}$
C_1	0.0700
C_2	0.0717
C_3	0.0714
C_4	0.0713
C_5	0.0715
C_6	0.0713
C_7	0.0728
C_8	0.0743
C_9	0.0702
C_{10}	0.0722
C_{11}	0.0698
C_{12}	0.0709
C_{13}	0.0711
C_{14}	0.0716

After the normalization the weights in the DEMATEL method, the MABAC method then is implemented in the next step to obtain the rank of alternatives.

Step 6. Normalize the elements from the decision matrix

The initial decision matrix is structured according to deneutrosophication of bipolar neutrosophic information for MABAC method in Table 5.22. Then, the elements of the decision matrix are normalized using the Equation (11) or Equation (12) depending on two types of criteria.

Based on this study, C_1, C_2, C_3, C_9 and C_{10} are benefit criteria and C_4, C_5, C_6, C_7, C_8, C_{11}, C_{12}, C_{13} and C_{14} are cost criteria. The initial decision matrix is divided to maximum value and minimum value as shown in Table 5.28.

Table 5.22: Maximum and minimum values

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}
x^+	0.4774	0.4865	0.4915	0.4774	0.4860	0.4860	0.4958	0.5048	0.4847	0.4878	0.4758	0.4758	0.4758	0.4774
x^-	0.4564	0.4749	0.4749	0.4595	0.4595	0.4595	0.4523	0.4898	0.4595	0.4749	0.4564	0.4564	0.4595	0.4564

For the benefit criteria, the elements from the initial decision matrix are determined using Equation (11) and, the elements from the initial decision matrix for the cost criteria are determined using Equation (12). The normalized elements from the decision matrix are presented in Table 5.23.

Table 5.23: Normalized initial matrix

Alternative	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**
A_1	0.3094	0.9562	0.6678	1.0000	1.0000	1.0000	0.3000	0.7403	0.0000	0.8579	0.8425	0.8425	1.0000	0.8541
A_2	0.3094	0.1972	0.0000	1.0000	1.0000	1.0000	0.2720	0.8499	0.4995	0.0000	0.8425	0.8425	0.7904	0.6906
A_3	1.0000	1.0000	1.0000	0.0000	0.3243	0.3243	0.1202	0.6656	0.5622	0.8972	0.0000	0.0000	0.0000	0.0000
A_4	0.1459	0.9562	0.0000	0.0126	0.3328	0.3328	0.3061	0.5953	0.3795	0.0000	1.0000	1.0000	0.0286	1.0000
A_5	0.0000	0.0000	0.7785	0.0126	0.0000	0.3328	1.0000	0.0000	1.0000	1.0000	0.8425	0.8053	0.2305	0.2536
A_6	0.7464	0.9562	0.6678	0.1558	0.4296	0.0000	0.0000	0.5953	0.4995	0.8579	0.0640	0.0640	0.2305	0.2536
A_7	0.2785	0.4003	0.6984	0.0000	0.3826	0.3826	0.2150	1.0000	0.6491	0.8972	0.5430	0.5430	0.0000	0.0738

Step 7. Calculate the elements from the weighted matrix

Based on the calculation in Step 5, the weight of criteria after the normalization is used in this step to calculate the elements from the weighted matrix. The weighted of matrix is calculated according to Equation (14) where the weight on criteria in Table 5.21. Table 5.24 shows the weighted of normalized decision matrix.

Table 5.24: Weighted of normalized decision matrix

Alternative	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**
A_1	0.0916	0.1402	0.1191	0.1426	0.1429	0.1426	0.0947	0.1292	0.0702	0.1342	0.1286	0.1307	0.1422	0.1328
A_2	0.0916	0.0858	0.0714	0.1426	0.1429	0.1426	0.0926	0.1374	0.1053	0.0722	0.1286	0.1307	0.1273	0.1210
A_3	0.1399	0.1433	0.1428	0.0713	0.0946	0.0944	0.0816	0.1237	0.1097	0.1371	0.0698	0.0709	0.0711	0.0716
A_4	0.0802	0.1402	0.0714	0.0722	0.0952	0.0950	0.0951	0.1185	0.0968	0.0722	0.1396	0.1418	0.0731	0.1432
A_5	0.0700	0.0717	0.1270	0.0722	0.0715	0.0950	0.1456	0.0743	0.1404	0.1445	0.1286	0.1280	0.0875	0.0898
A_6	0.1222	0.1402	0.1191	0.0824	0.1022	0.0713	0.0728	0.1185	0.1053	0.1342	0.0743	0.0755	0.0875	0.0898
A_7	0.0894	0.1003	0.1213	0.0713	0.0988	0.0986	0.0885	0.1485	0.1158	0.1371	0.1077	0.1094	0.0711	0.0769

Step 8. Determine the border approximation area matrix

The border approximation area for each criterion is determined using Equation (15). Table 5.25 shows the border approximation area matrix.

Table 5.25: Border approximation area matrix

Criteria	$\tilde{G}$
C_1	0.0954
C_2	0.1136
C_3	0.1069
C_4	0.0890
C_5	0.1041

C_6	0.1029
C_7	0.0938
C_8	0.1191
C_9	0.1043
C_{10}	0.1143
C_{11}	0.1075
C_{12}	0.1089
C_{13}	0.0909
C_{14}	0.1003

Step 9. Calculate the distance of the alternative

The distance of the alternatives from the approximation border area is computed using Equation (18). The distance of the alternative is presented in Table 5.26.

Table 5.26: Distance of the alternative

Alternative	**C₁**	**C₂**	**C₃**	**C₄**	**C₅**	**C₆**	**C₇**	**C₈**	**C₉**	**C₁₀**	**C₁₁**	**C₁₂**	**C₁₃**	**C₁₄**
A_1	-0.0038	0.0266	0.0122	0.0535	0.0388	0.0397	0.0009	0.0101	-0.0341	0.0199	0.0211	0.0218	0.0513	0.0325
A_2	-0.0038	-0.0278	-0.0354	0.0535	0.0388	0.0397	-0.0012	0.0183	0.0010	-0.0421	0.0211	0.0218	0.0364	0.0208
A_3	0.0445	0.0298	0.0360	-0.0177	-0.0095	-0.0084	-0.0122	0.0046	0.0054	0.0227	-0.0377	-0.0380	-0.0198	-0.0287
A_4	-0.0152	0.0266	-0.0354	-0.0168	-0.0089	-0.0078	0.0013	-0.0006	-0.0075	-0.0421	0.0321	0.0329	-0.0177	0.0429
A_5	-0.0254	-0.0419	0.0201	-0.0168	-0.0327	-0.0078	0.0518	-0.0448	0.0361	0.0302	0.0211	0.0191	-0.0034	-0.0105
A_6	0.0268	0.0266	0.0122	-0.0066	-0.0020	-0.0316	-0.0210	-0.0006	0.0010	0.0199	-0.0332	-0.0334	-0.0034	-0.0105
A_7	-0.0060	-0.0132	0.0144	-0.0177	-0.0053	-0.0043	-0.0053	0.0294	0.0115	0.0227	0.0002	0.0005	-0.0198	-0.0234

Step 10. Rank the alternatives

The values of the criteria for the alternatives are obtained by calculating the sum of elements of matrix by rows using Equation (20). The final ranking of the alternatives is shown in Table 5.27.

Table 5.27: Sum of the distance of alternatives and ranking of alternatives

Alternative	$\tilde{S}$	**Rank**
A_1	0.2906	1
A_2	0.1411	2
A_3	-0.0291	6
A_4	-0.0163	5
A_5	-0.0050	3
A_6	-0.0559	7
A_7	-0.0162	4

5.5 Results and Discussions

Based on the sum of distance of alternatives in Table 5.27, the ranking of the alternatives are accomplished as $A_1 \succ A_2 \succ A_5 \succ A_7 \succ A_4 \succ A_3 \succ A_6$. For the simple understanding, the chart of rank the alternatives is illustrated as Figure 5.3.

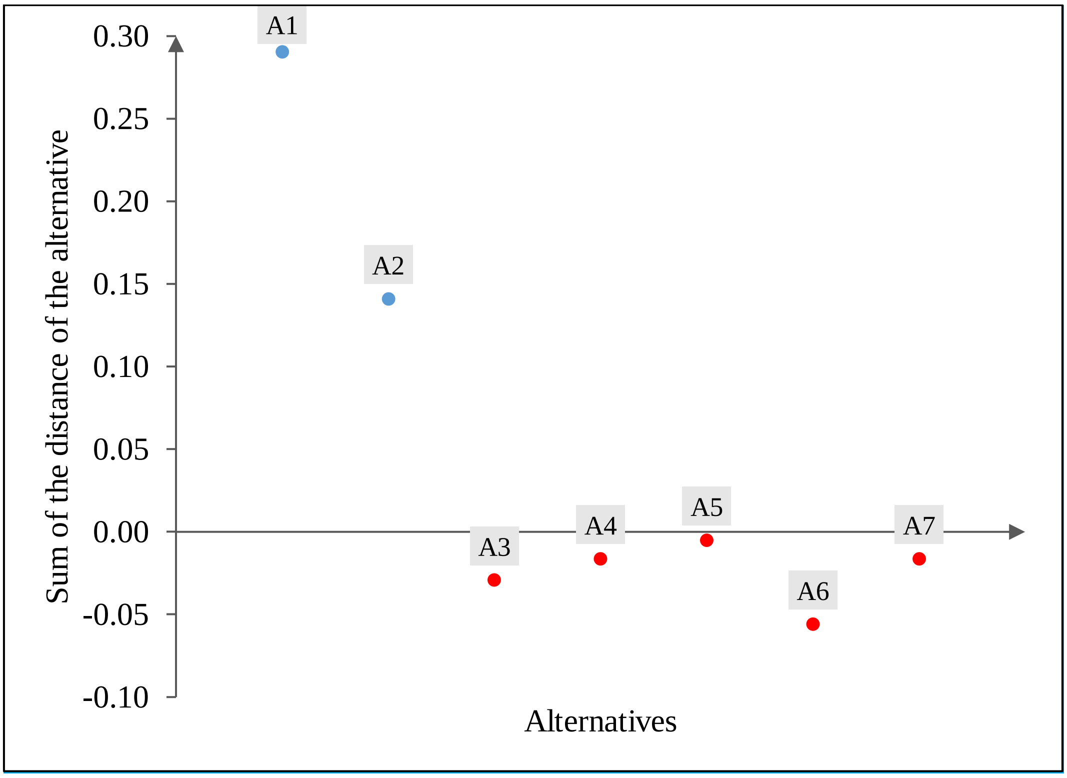

Figure 5.3: Rank the alternatives

Based on Figure 5.3, the two alternatives which are A_1 and A_2 have belonging to the upper approximation area and other alternatives which are A_3, A_4, A_5, A_6 and A_7 have belonging to the lower approximation area. According to *Definition 3.14* by Pamučar and Ćirović (2015), the upper approximation is the area which contains the ideal alternatives and lower approximation area is the area which contains the anti-ideal alternatives. The result reveals that A_1(0.2906) is the optimal alternative to be selected for sustainable energy. The output results obtained by applying the DEMATEL-MABAC under bipolar neutrosophic set show that the proposed method is useful and reliable for the decision making on sustainable energy. Furthermore, this proposed method has the unique characteristics by depicting bipolar information and computing the distance between each alternative and the border approximation area. Therefore, the result can be derive stable computing results and more reliable in the application of MCDM problems. To sum up, this chapter have shown the application of the proposed method under bipolar neutrosophic set in the process of decision making on selection of sustainable energy.

CHAPTER 6

COMPARATIVE ANALYSIS

This chapter is divided into two sections. Section 6.1 describes the comparative analysis between the DEMATEL-MABAC under bipolar neutrosophic set and other well-known sets. Then, the comparative analysis between the proposed methods with another multi-criteria decision-making methods is presented in section 6.2.

6.1 Comparative Analysis with Different Sets

The comparative analysis is demonstrated to examine the effectiveness and feasibility of the proposed method, bipolar neutrosophic set. For this purpose, the same data from the case study in sustainable energy is applied to analyse the result between the proposed bipolar neutrosophic DEMATEL-MABAC method and different sets which are DEMATEL-MABAC method, fuzzy DEMATEL-MABAC method and single-valued neutrosophic DEMATEL-MABAC method.

6.1.1 DEMATEL-MABAC Method

In this method, the crisp set of data from decision-makers in sustainable energy is based on integer scale (score) ranging between 0 and 4 as presented in Table 6.1. The step-by-step procedure is explained as the following below:

Table 6.1: Integer scale

Linguistic Variable	**Score**
No Influence	0
Low Influence	1
Medium Influence	2
High Influence	3
Very High Influence	4

First, the classical DEMATEL method is used to obtain the weight of criteria where the initial decision matrix is computed based on average of the decision-makers' scores. Table 6.2 shows the initial decision matrix of the DEMATEL method.

Table 6.2: Initial decision matrix for DEMATEL method

Criteria	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**
C_1	0.0	3.0	2.6	3.2	3.0	3.0	2.6	2.2	3.0	2.8	3.2	3.2	3.2	3.0
C_2	3.2	0.0	2.4	3.0	2.6	2.6	2.6	2.2	2.8	2.6	3.0	3.0	2.8	3.0
C_3	2.4	2.2	0.0	2.8	2.6	2.2	2.6	2.4	3.4	2.8	3.2	3.2	2.6	2.6
C_4	3.2	3.0	2.4	0.0	2.8	2.8	2.4	2.0	3.0	2.8	3.2	2.8	3.0	2.6
C_5	3.2	2.8	2.4	3.0	0.0	2.8	2.4	2.0	2.6	2.6	3.0	3.0	3.2	2.6
C_6	3.2	2.8	2.6	2.8	2.8	0.0	2.4	2.0	2.8	2.4	2.8	2.8	3.2	2.6
C_7	2.4	2.6	2.6	2.4	2.8	2.4	0.0	1.8	2.6	2.2	3.4	2.4	2.6	2.6
C_8	2.0	2.2	2.6	2.4	2.0	2.0	2.0	0.0	2.8	2.4	2.4	2.6	2.4	2.6
C_9	2.6	2.8	3.4	3.0	3.0	3.0	2.4	2.6	0.0	3.4	3.0	2.6	2.6	2.8
C_{10}	2.2	2.6	3.0	2.2	2.4	2.6	2.0	2.4	2.8	0.0	2.6	3.2	2.6	3.0
C_{11}	3.0	2.8	3.4	2.8	3.0	3.0	3.0	2.6	3.2	2.8	0.0	3.0	2.6	2.8
C_{12}	2.8	2.8	3.2	2.8	3.2	3.2	3.2	2.6	3.2	3.0	2.8	0.0	2.6	2.6
C_{13}	3.2	2.6	3.0	2.4	2.8	3.2	3.2	2.8	3.0	3.0	2.6	3.0	0.0	2.8
C_{14}	3.0	2.8	2.8	2.8	2.6	3.0	3.0	2.8	3.0	2.8	2.6	2.8	2.6	0.0

From this initial decision matrix, the calculation processes are followed by Step (1) until Step (5) in Chapter 4. The result for the weight of criteria after the normalization is presented in Table 6.3

Table 6.3: Normalized weight of criteria for DEMATEL method

Criteria	$\tilde{w}$
C_1	0.0774
C_2	0.0705
C_3	0.0716
C_4	0.0720
C_5	0.0714
C_6	0.0711
C_7	0.0629
C_8	0.0528
C_9	0.0789
C_{10}	0.0675
C_{11}	0.0797
C_{12}	0.0761
C_{13}	0.0753
C_{14}	0.0727

Then, the ranking of alternatives is obtained using the classical MABAC method where the data are based on the crisp numerical scale as presented Table 6.1. The initial decision matrix is computed and the result is shown in Table 6.4.

Table 6.4: Initial decision matrix for MABAC method

Alternative	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}
A_1	3.2	2.8	2.8	3.4	3.4	3.4	3.2	2.6	3.4	2.8	3.4	3.4	3.4	3.4
A_2	3.2	3.0	3.2	3.4	3.4	3.4	2.8	2.6	3.2	3.2	3.4	3.4	3.2	3.2
A_3	2.8	2.6	2.4	2.8	2.8	2.8	2.6	2.4	3.2	2.6	3.0	3.0	3.0	2.8
A_4	3.4	2.8	3.2	3.0	3.0	3.0	3.0	2.4	3.4	3.2	3.6	3.6	3.2	3.6
A_5	3.6	3.2	2.8	3.0	3.0	3.0	3.8	1.8	3.0	2.8	3.4	3.4	3.2	3.2
A_6	3.2	2.8	2.8	3.0	3.0	2.8	2.4	2.4	3.2	2.8	3.0	3.0	3.2	3.2
A_7	3.4	2.8	2.6	2.8	3.0	3.0	2.6	2.4	3.0	2.6	3.2	3.2	3.0	3.0

Following the same procedure, specifically Step (6) until Step (10) in Chapter 4, the ranking of alternatives can be generated as shown in Table 6.5.

Table 6.5: Ranking of the alternatives

Alternative	$\tilde{S}$	**Rank**
A_1	-0.1794	7
A_2	-0.0407	6
A_3	0.1491	2
A_4	0.0535	4
A_5	0.0521	5
A_6	0.1567	1
A_7	0.0915	3

6.1.2 Fuzzy DEMATEL-MABAC Method

Due to the limitation of the classical method, the fuzzy method has been proposed recently to take into consideration the uncertainty problem. In this section, the linguistic variable for fuzzy set proposed by Camparo (2013) and Li (2013) and applied to the case study data for comparison purpose. This method use the linguistic variable as the input data as follows as Table 6.6.

Table 6.6: Linguistic variable of fuzzy set

Linguistic Variable	**FS number**
No Influence	<0.10, 0.80, 0.90>
Low Influence	<0.35, 0.60, 0.70>
Medium Influence	<0.50, 0.40, 0.45>
High Influence	<0.80, 0.20, 0.15>
Very High Influence	<0.90, 0.10, 0.10>

Source: Camparo (2013) and Li (2013)

Based on this input data, the initial decision matrix of the DEMATEL method is formed after aggregation of the decision-makers' opinions and defuzzification process is conducted to obtain a single number from the output of the aggregated fuzzy set. The step-by-step procedure for the aggregation and defuzzification are based on by Pamučar and Ćirović (2015). Initial decision matrix for the fuzzy DEMATEL method is shown in Table 6.7.

Table 6.7: Initial decision matrix for fuzzy DEMATEL method

Criteria	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}
C_1	0.0000	3.4261	3.9190	1.3277	2.8109	4.0777	2.4623	3.5993	4.2123	2.4190	3.4261	4.1690	2.4190	3.4261
C_2	0.8333	0.0000	0.0000	0.4464	2.6189	3.7797	1.4012	3.1050	3.9012	1.3277	2.8109	3.8277	1.3277	2.8109
C_3	1.2507	2.5027	0.0000	0.8333	0.0000	0.2500	1.5476	3.2736	3.8809	1.3297	2.8189	3.8297	1.2507	2.5027
C_4	2.4190	3.4261	3.9190	0.0000	2.6822	3.7956	0.8333	0.0000	0.2500	1.5476	3.2736	4.1309	2.3809	3.2736
C_5	2.3809	3.2736	3.8809	1.2956	0.0000	4.0456	2.4190	3.4261	3.9190	0.8333	0.0000	0.2500	1.5476	3.2736
C_6	2.3809	3.2736	3.8809	1.3277	2.8109	0.0000	2.3809	3.2736	4.1309	2.3809	3.2736	3.8809	0.8333	0.0000
C_7	1.3277	2.8109	3.8277	1.3277	2.8109	3.8277	0.0000	2.6822	3.7956	1.3643	2.9571	3.8643	1.2797	2.6189
C_8	0.8333	0.8333	3.3333	0.8333	0.8333	3.3333	0.8333	0.0000	3.3333	0.8333	0.8333	3.3333	0.8333	0.8333
C_9	2.3809	3.2736	4.1309	2.5088	3.7854	4.2588	2.4190	3.4261	0.0000	2.4190	3.4261	4.1690	2.4190	3.4261
C_{10}	1.3277	2.8109	4.0777	2.4190	3.4261	3.9190	1.2507	2.5027	3.7507	0.0000	2.6822	3.7956	1.3277	2.8109
C_{11}	1.3643	2.9571	4.2810	3.1728	3.9411	4.0061	1.3621	2.9486	4.1121	2.4190	0.0000	4.1690	2.4190	3.4261
C_{12}	1.3643	2.9571	4.1143	2.4623	3.5993	3.9623	1.3277	2.8109	4.0777	2.4623	3.5993	0.0000	2.4623	3.5993
C_{13}	1.3277	2.8109	4.0777	2.4190	3.4261	3.9190	1.2956	2.6822	4.0456	2.3809	3.2736	4.1309	0.0000	3.5993
C_{14}	1.3643	2.9571	4.1143	2.3809	3.2736	3.8809	1.3621	2.9486	4.1121	2.3453	3.1311	4.0953	2.4190	0.0000

Similarly, the weight of criteria is determined using Step (1) until Step (5) in Chapter 4. The normalized weight of criteria is presented in Table 6.8.

Table 6.8: Normalized weight of criteria for fuzzy DEMATEL method

Criteria	$\tilde{w}$
C_1	0.0778

C_2	0.0708
C_3	0.0724
C_4	0.0737
C_5	0.0751
C_6	0.0695
C_7	0.0603
C_8	0.0378
C_9	0.0846
C_{10}	0.0623
C_{11}	0.0817
C_{12}	0.0806
C_{13}	0.0775
C_{14}	0.0760

For the fuzzy MABAC method, the data is evaluated based on the linguistic variable in Table 6.6. Then, the initial decision matrix can be generated as Table 6.9 after determine the aggregation and defuzzification based on Pamučar and Ćirović (2015).

Table 6.9: Initial decision matrix for fuzzy MABAC method

Alternative	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**
A_1	3.7559	4.2098	2.3809	3.2736	4.1309	2.3809	3.2736	4.2976	3.1728	3.9411	4.4228	3.1728	3.9411	4.4228
A_2	3.7559	4.2098	2.4190	3.4261	4.1690	2.4623	3.5993	4.3790	3.1728	3.9411	4.4228	3.1728	3.9411	4.4228
A_3	3.1815	3.7954	2.2599	3.0395	3.7599	2.2267	2.9068	3.7267	2.2954	3.1815	3.7954	2.2954	3.1815	3.7954
A_4	3.9411	4.2561	2.3809	3.2736	4.1309	2.4623	3.5993	4.2123	2.4190	3.4261	4.1690	2.4190	3.4261	4.1690
A_5	4.1401	4.3059	2.4623	3.5993	4.2123	2.3809	3.2736	4.1309	2.4190	3.4261	4.1690	2.3809	3.2736	4.1309
A_6	3.5993	4.2123	2.3809	3.2736	4.1309	2.3809	3.2736	4.1309	2.4190	3.4261	4.1690	2.4190	3.4261	4.1690
A_7	3.9411	4.2561	2.3787	3.1815	3.7954	2.2599	3.0395	3.7599	2.2954	3.1815	3.7954	2.3357	3.4261	4.1690

Table 6.10 presents the ranking of the alternatives after following Step (6) until Step (10) in Chapter 4.

Table 6.10: Sum of the distance of alternatives and ranking of alternatives

Alternative	$\tilde{S}$	Rank
A_1	-0.1655	6
A_2	-0.0604	3
A_3	0.1469	5
A_4	0.0581	7
A_5	0.0764	4
A_6	0.1640	2
A_7	0.0643	1

6.1.3 Single-Valued Neutrosophic DEMATEL-MABAC Method

Since neutrosophic sets is difficult to apply in real problems, the single-valued neutrosophic set is defined and Biswas *et al*. (2016) introduced a linguistic variable for the single-valued neutrosophic set. In this section, a single-valued neutrosophic is applied to be compared with the proposed method. Table 6.11 presents the linguistic variable for single-valued neutrosophic and applied in the case study data of sustainable energy

Table 6.11: Linguistic variable of single-valued neutrosophic (Biswas *et al*., 2015)

Linguistic Variable	SVN number
No Influence	<0.10, 0.80, 0.90>
Low Influence	<0.35, 0.60, 0.70>
Medium Influence	<0.50, 0.40, 0.45>
High Influence	<0.80, 0.20, 0.15>
Very High Influence	<0.90, 0.10, 0.10>

Step-by-step procedure in this section is based on the single-valued neutrosophic method as proposed by Awang *et al*. (2018a). Table 6.12 shows the initial decision matrix for the single-valued neutrosophic DEMATEL method.

Table 6.12: Initial decision matrix for single-valued neutrosophic DEMATEL method

Criteria	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**
C_1	0.0000	0.9125	0.8859	0.9096	0.9096	0.9096	0.8696	0.8349	0.8696	0.8796	0.9174	0.9025	0.9219	0.9125
C_2	0.9232	0.0000	0.8557	0.9033	0.8859	0.8859	0.8896	0.8605	0.8781	0.8859	0.9046	0.8933	0.8781	0.8909
C_3	0.8780	0.8780	0.0000	0.8739	0.8766	0.8859	0.8859	0.9033	0.9278	0.8933	0.9315	0.9096	0.8781	0.8781
C_4	0.9315	0.9193	0.8859	0.0000	0.9096	0.8933	0.8457	0.8696	0.8968	0.8652	0.9096	0.8933	0.8781	0.8968
C_5	0.9232	0.8933	0.8652	0.8933	0.0000	0.8933	0.8833	0.8349	0.8968	0.8739	0.9096	0.9096	0.8968	0.8557
C_6	0.9232	0.8933	0.8557	0.8933	0.8933	0.0000	0.8605	0.8349	0.8968	0.8933	0.9096	0.9096	0.9219	0.8968
C_7	0.8896	0.8896	0.8859	0.8859	0.8859	0.8859	0.0000	0.8528	0.8557	0.8605	0.9174	0.9033	0.9013	0.8896
C_8	0.8712	0.8712	0.8712	0.8478	0.8478	0.8478	0.8258	0.0000	0.8859	0.8780	0.9033	0.8933	0.9013	0.9013
C_9	0.9232	0.9096	0.9278	0.9232	0.9033	0.9136	0.8781	0.9033	0.0000	0.9033	0.9193	0.9193	0.9078	0.9078
C_{10}	0.8908	0.8908	0.9136	0.8908	0.8780	0.8557	0.8372	0.8780	0.9315	0.0000	0.9033	0.9174	0.9013	0.8968
C_{11}	0.9096	0.9033	0.9232	0.9136	0.9096	0.8933	0.9219	0.8605	0.9096	0.8859	0.0000	0.8957	0.8696	0.8696
C_{12}	0.9025	0.9117	0.9262	0.8859	0.9128	0.9025	0.8957	0.8780	0.8739	0.9117	0.9117	0.0000	0.9013	0.8896
C_{13}	0.9193	0.9033	0.9096	0.9033	0.9193	0.9193	0.9046	0.8751	0.8781	0.9033	0.9033	0.9033	0.0000	0.8896
C_{14}	0.9096	0.9136	0.8933	0.8859	0.8933	0.8933	0.9096	0.8896	0.8909	0.9136	0.9136	0.8980	0.9013	0.0000

From the initial decision matrix, the weight of criteria based on bipolar neutrosophic DEMATEL method is computed using Step (1) until Step (5) in Chapter 4. Table 6.13 presents the normalized weight of criteria.

Table 6.13: Normalized weight of criteria

Criteria	$\tilde{w}$
C_1	0.0726
C_2	0.0714
C_3	0.0713
C_4	0.0713
C_5	0.0710
C_6	0.0711
C_7	0.0697
C_8	0.0680
C_9	0.0726
C_{10}	0.0709
C_{11}	0.0731
C_{12}	0.0727
C_{13}	0.0724
C_{14}	0.0717

Also, the data case study is defined linguistic variable based on Table 6.11 for the MABAC method. Then, aggregation and deneutrosophication are determined based on Awang *et al*. (2018a) to find initial decision matrix of MABAC method in Table 6.14.

Table 6.14: Initial decision matrix for single-valued neutrosophic MABAC method

Alternative	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}
A_1	0.9232	0.8968	0.8968	0.9315	0.9315	0.9315	0.9175	0.8781	0.9315	0.8968	0.9315	0.9315	0.9315	0.9315
A_2	0.9232	0.9096	0.9193	0.9315	0.9315	0.9315	0.9033	0.8859	0.9219	0.9193	0.9315	0.9315	0.9232	0.9232
A_3	0.8948	0.8762	0.8540	0.8948	0.8948	0.8948	0.8819	0.8606	0.9164	0.8762	0.9063	0.9063	0.9063	0.8948

A_4	0.9315	0.8968	0.9193	0.9096	0.9096	0.9096	0.9136	0.8696	0.9302	0.9193	0.9375	0.9375	0.9174	0.9375
A_5	0.9375	0.9193	0.8933	0.9096	0.8968	0.9096	0.9441	0.8258	0.9078	0.8933	0.9315	0.9299	0.9219	0.9219
A_6	0.9219	0.8968	0.8968	0.9125	0.9125	0.8968	0.8696	0.8696	0.9219	0.8968	0.9125	0.9125	0.9219	0.9219
A_7	0.9250	0.8913	0.8762	0.8948	0.9063	0.9063	0.8762	0.8677	0.9063	0.8762	0.9158	0.9158	0.9063	0.9063

Then, the values of sum distance alternative is obtained following the Step (6) until Step (10) in Chapter 4. Table 6.15 shows the ranking of alternatives.

Table 6.15: Ranking of the alternatives

Alternative	$\tilde{S}$	**Rank**
A_1	-0.1612	7
A_2	-0.0640	6
A_3	0.1507	1
A_4	0.0541	5
A_5	0.0566	4
A_6	0.1370	2
A_7	0.1116	3

6.1.4 Summary

Table 6.16 shows the comparative analysis of each set and Figure 6.1 illustrates the evaluation ranking under different sets.

Table 6.16: Comparative analysis with the existing methods of different sets

Type of Data	**Method**	**Weights**	**Ranking order**
Real numbers	DEMATEL-MABAC	C_1 = 0.0774, C_2 = 0.0705, C_3 = 0.0716, C_4 = 0.0720, C_5 = 0.0714, C_6 = 0.0711, C_7 = 0.0629, C_8 = 0.0528, C_9 = 0.0789, C_{10} = 0.0675, C_{11} = 0.0797, C_{12} = 0.0761, C_{13} = 0.0753, C_{14} = 0.0727	$A_6 \succ A_3 \succ A_7 \succ A_4 \succ A_5 \succ A_2 \succ A_1$
Fuzzy numbers	Fuzzy DEMATEL-MABAC	C_1 = 0.0778, C_2 = 0.0708, C_3 = 0.0724, C_4 = 0.0737, C_5 = 0.0751, C_6 = 0.0695, C_7 = 0.0603, C_8 = 0.0378, C_9 = 0.0846, C_{10} = 0.0623, C_{11} = 0.0817, C_{12} = 0.0806, C_{13} = 0.0775, C_{14} = 0.0760	$A_6 \succ A_3 \succ A_5 \succ A_7 \succ A_4 \succ A_2 \succ A_1$
Single-valued neutrosophic numbers	Single-valued neutrosophic DEMATEL-MABAC	C_1 = 0.0726, C_2 = 0.0714, C_3 = 0.0713, C_4 = 0.0713, C_5 = 0.0710, C_6 = 0.0711, C_7 = 0.0697, C_8 = 0.0680, C_9 = 0.0726, C_{10} = 0.0709, C_{11} = 0.0731, C_{12} = 0.0727, C_{13} = 0.0724, C_{14} = 0.0717	$A_3 \succ A_6 \succ A_7 \succ A_5 \succ A_4 \succ A_2 \succ A_1$
Bipolar neutrosophic numbers	Bipolar neutrosophic DEMATEL-MABAC (proposed method)	C_1 = 0.0700, C_2 = 0.0717, C_3 = 0.0714, C_4 = 0.0713, C_5 = 0.0715, C_6 = 0.0713, C_7 = 0.0728, C_8 = 0.0743, C_9 = 0.0702, C_{10} = 0.0722, C_{11} =	$A_1 \succ A_2 \succ A_5 \succ A_7 \succ A_4 \succ A_3 \succ A_6$

	0.0698, $C_{12} = 0.0709$, $C_{13} = 0.0711$, $C_{14} = 0.0716$	

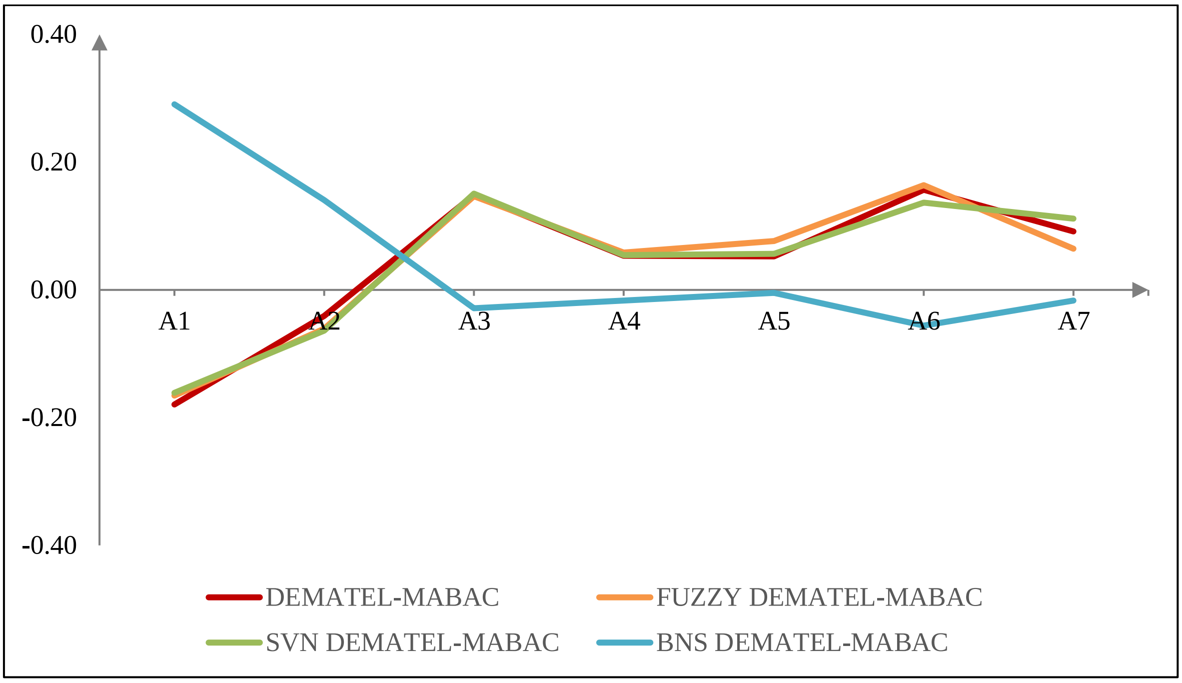

Figure 6.1: Comparative analysis of evaluation ranking under different sets

Based on Table 6.16, it can be observed that the rankings of DEMATEL-MABAC method, fuzzy DEMATEL-MABAC method and single-valued DEMATEL-MABAC method and are slightly different while the ranking of the proposed method is totally different which is almost reversed order. The result obtained A_6 is the optimal alternative for DEMATEL-MABAC method and fuzzy DEMATEL-MABAC method. For single-valued DEMATEL-MABAC method, the optimal alternative is A_3 while A_1 is the optimal alternative in bipolar neutrosophic DEMATEL-MABAC method.

In order to explain a different ranking of alternative, some observations for existing sets are described as follows:

i. DEMATEL and MABAC is the fundamental method which assume all criteria and alternatives in crisp numbers with no fuzzy and no neutrosophic involved. It is not appropriate to utilize DEMATEL and MABAC to solve MCDM problems since there exists uncertain situation in decision making.

ii. Fuzzy set only accommodate the uncertainty with membership degree. Thus, it is not faithful in judgement process since do not consider the non-membership degree and disregard the existing of the positive and negative information.

iii. Single valued neutrosophic is developed to represent the membership degree, non-membership degree. However, neutrosophic set can express incomplete, indeterminate and inconsistent information. But, single valued neutrosophic is less pragmatic in analysis.

iv. Bipolar neutrosophic set defined as double-sided judgement where crisp set, fuzzy set and single-valued neutrosophic set only defined single-sided judgement. Therefore, bipolar neutrosophic DEMATEL-MABAC carries more information specially in handling positive and negative membership degree. Then, the ranking may provide a more pragmatic results in solving MCDM problems compared to the other sets.

6.2 Comparative Analysis between Different Methods

In this section, the comparative analysis is conducted between the proposed methods with other MCDM methods namely bipolar neutrosophic AHP-MABAC and bipolar neutrosophic DEMATEL-TOPSIS.

6.2.1 Bipolar Neutrosophic AHP-MABAC Method

First, the same case study data from decision-makers in sustainable energy is evaluated the criteria and alternatives using the proposed linguistic variable based on Table 4.2 in Chapter 4. After defining the data for bipolar neutrosophic number, the aggregation of bipolar neutrosophic determined using Equation (5) and deneutrosophication of bipolar neutrosophic information computed using Equation (6) in Chapter 4. However, the DEMATEL method exchange with the AHP method to find the weight of criteria. The calculation of the AHP method retrieved by Saaty (1980). Therefore, the initial decision matrix for AHP method is structured in Table 6.17.

Table 6.17: Initial decision matrix for AHP method

Criteria	**C_{1}**	**C_{2}**	**C_{3}**	**C_{4}**	**C_{5}**	**C_{6}**	**C_{7}**	**C_{8}**	**C_{9}**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**
C_{1}	1.0000	0.4746	0.4920	0.4771	0.4771	0.4771	0.4958	0.4952	0.4958	0.5133	0.4754	0.4870	0.4721	0.4746
C_{2}	0.4629	1.0000	0.4964	0.4840	0.4920	0.4920	0.4907	0.4962	0.4937	0.4920	0.4868	0.4878	0.4937	0.4938
C_{3}	0.4942	0.4942	1.0000	0.4947	0.4975	0.4920	0.4920	0.4840	0.4721	0.4878	0.4595	0.4771	0.4937	0.4937
C_{4}	0.4595	0.4749	0.4920	1.0000	0.4771	0.4878	0.4971	0.4958	0.4860	0.4964	0.4771	0.4878	0.4937	0.4860
C_{5}	0.4629	0.4878	0.4964	0.4878	1.0000	0.4878	0.4968	0.4952	0.4860	0.4947	0.4771	0.4771	0.4860	0.4974
C_{6}	0.4629	0.4878	0.4964	0.4878	0.4878	1.0000	0.4962	0.4952	0.4860	0.4878	0.4771	0.4771	0.4721	0.4860
C_{7}	0.4907	0.4907	0.4920	0.4920	0.4920	0.4920	1.0000	0.5101	0.4974	0.4962	0.4754	0.4840	0.4902	0.4907
C_{8}	0.5117	0.5117	0.5117	0.5094	0.5094	0.5094	0.5048	1.0000	0.4920	0.4942	0.4840	0.4878	0.4902	0.4902
C_{9}	0.4629	0.4771	0.4721	0.4629	0.4840	0.4825	0.4937	0.4840	1.0000	0.4840	0.4749	0.4749	0.4847	0.4847
C_{10}	0.4948	0.4948	0.4825	0.4948	0.4942	0.4964	0.5097	0.4942	0.4595	1.0000	0.4840	0.4754	0.4902	0.4860
C_{11}	0.4771	0.4840	0.4629	0.4825	0.4771	0.4878	0.4721	0.4962	0.4771	0.4920	1.0000	0.4919	0.4958	0.4958
C_{12}	0.4870	0.4828	0.4727	0.4920	0.4855	0.4870	0.4919	0.4942	0.4947	0.4828	0.4828	1.0000	0.4902	0.4907
C_{13}	0.4749	0.4840	0.4771	0.4840	0.4749	0.4749	0.4868	0.4981	0.4937	0.4840	0.4840	0.4840	1.0000	0.4907
C_{14}	0.4771	0.4825	0.4878	0.4920	0.4878	0.4878	0.4771	0.4907	0.4938	0.4825	0.4825	0.4918	0.4902	1.0000

The weight of criteria using AHP method is presented in Table 6.18.

Table 6.18: Weight of criteria

Criteria	$\tilde{w}$
C_1	0.0713
C_2	0.0717
C_3	0.0714
C_4	0.0712
C_5	0.0714
C_6	0.0711
C_7	0.0720
C_8	0.0731
C_9	0.0703
C_{10}	0.0716
C_{11}	0.0711
C_{12}	0.0715
C_{13}	0.0710
C_{14}	0.0713

After obtained the weight of criteria, the MABAC method implemented where the data case study also defined with the linguistic variable of bipolar neutrosophic set in Table 4.2. Also, the aggregation and deneutrosophication of bipolar neutrosophic information also calculated based on Equation (1) and Equation (2) in Chapter 4 and formed the initial decision matrix in Table 6.19.

Table 6.19: Initial decision matrix for MABAC

Alternative	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**
A_1	0.4629	0.4860	0.4860	0.4595	0.4595	0.4595	0.4828	0.4937	0.4595	0.4860	0.4595	0.4595	0.4595	0.4595
A_2	0.4629	0.4771	0.4749	0.4595	0.4595	0.4595	0.4840	0.4920	0.4721	0.4749	0.4595	0.4595	0.4629	0.4629

A_3	0.4774	0.4865	0.4915	0.4774	0.4774	0.4774	0.4906	0.4948	0.4736	0.4865	0.4758	0.4758	0.4758	0.4774
A_4	0.4595	0.4860	0.4749	0.4771	0.4771	0.4771	0.4825	0.4958	0.4690	0.4749	0.4564	0.4564	0.4754	0.4564
A_5	0.4564	0.4749	0.4878	0.4771	0.4860	0.4771	0.4523	0.5048	0.4847	0.4878	0.4595	0.4602	0.4721	0.4721
A_6	0.4721	0.4860	0.4860	0.4746	0.4746	0.4860	0.4958	0.4958	0.4721	0.4860	0.4746	0.4746	0.4721	0.4721
A_7	0.4623	0.4795	0.4865	0.4774	0.4758	0.4758	0.4865	0.4898	0.4758	0.4865	0.4653	0.4653	0.4758	0.4758

The alternatives ranked in Table 6.20 follow by Step (6) until Step (10) in Chapter 4.

Table 6.20: Sum of the distance of alternatives and ranking of alternatives

Alternative	$\tilde{S}$	**Rank**
A_1	0.2903	1
A_2	0.1413	2
A_3	-0.0292	6
A_4	-0.0154	4
A_5	-0.0049	3
A_6	-0.0560	7
A_7	-0.0168	5

The both of DEMATEL and AHP method determined the weights of criteria. The AHP and DEMATEL method reflect the relationships between the analysed elements based on the accurate initial matrix. However, the starting point of AHP method is the pairwise comparison of all elements from each individual level of the structure. Therefore, the initial pairwise comparison matrix for AHP method does not contain zeros. By contrast, the initial direct influence matrix for DEMATEL method does contain zeros (Kobryń, 2017). Based on this comparative analysis, the weights of criteria using the DEMATEL method exhibit high compatibility than weights determined using the AHP method.

6.2.2 Bipolar Neutrosophic DEMATEL-TOPSIS Method

In this sub-section, the DEMATEL method applied to determine the weight of the criteria. But, the rank of the alternatives obtained using the TOPSIS method. The weight of criteria after normalized that have been done using DEMATEL method in Table 5.37.

Using the same data defined by the linguistic variable of a bipolar neutrosophic set, the initial decision matrix is determined by calculating the aggregation and deneutrosophication of bipolar neutrosophic based on Equation (1) and Equation (2) in Chapter 4. Then, the TOPSIS method retrieved by Hwang and Yoon (1981b) is applied to find the alternatives. Table 6.21 shows the initial decision matrix for TOPSIS method.

Table 6.21: Initial decision matrix for TOPSIS method

Alternative	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**
A_1	0.4629	0.4860	0.4860	0.4595	0.4595	0.4595	0.4828	0.4937	0.4595	0.4860	0.4595	0.4595	0.4595	0.4595
A_2	0.4629	0.4771	0.4749	0.4595	0.4595	0.4595	0.4840	0.4920	0.4721	0.4749	0.4595	0.4595	0.4629	0.4629
A_3	0.4774	0.4865	0.4915	0.4774	0.4774	0.4774	0.4906	0.4948	0.4736	0.4865	0.4758	0.4758	0.4758	0.4774
A_4	0.4595	0.4860	0.4749	0.4771	0.4771	0.4771	0.4825	0.4958	0.4690	0.4749	0.4564	0.4564	0.4754	0.4564
A_5	0.4564	0.4749	0.4878	0.4771	0.4860	0.4771	0.4523	0.5048	0.4847	0.4878	0.4595	0.4602	0.4721	0.4721

A_6	0.4721	0.4860	0.4860	0.4746	0.4746	0.4860	0.4958	0.4958	0.4721	0.4860	0.4746	0.4746	0.4721	0.4721
A_7	0.4623	0.4795	0.4865	0.4774	0.4758	0.4758	0.4865	0.4898	0.4758	0.4865	0.4653	0.4653	0.4758	0.4758

Following the equation from the TOPSIS method, the each alternative was ranked in Table 6.22.

Table 6.22: Ranking of the alternatives

Alternative	$\tilde{S}$	**Rank**
A_1	0.5821	1
A_2	0.5588	2
A_3	0.3728	6
A_4	0.4341	4
A_5	0.5380	3
A_6	0.3252	7
A_7	0.3904	5

The MABAC method applied for the selection process to rank and determine the best of alternative. The TOPSIS method utilizes the concept of similarity to the ideal solution define in ideal positive and negative solutions based on the shortest distance to an ideal solution. The TOPSIS method do not give consistent solutions where it do not meet between one or more of the conditions set while MABAC method showed the stability and consistency in its solutions. It also has a simple computation process, systematic procedure and logic to the rational of human decision making.

6.2.3 Summary

Table 6.23 summarizes the comparative analysis between different methods and Figure 6.2 illustrates the comparative analysis of evaluation ranking under different methods.

Table 6.23: Summary of comparative analysis between different methods

Method	Weights		Ranking order	
Bipolar neutrosophic AHP-MABAC	Bipolar neutrosophic AHP	C_1 = 0.0713, C_2 = 0.0717, C_3 = 0.0714, C_4 = 0.0712, C_5 = 0.0714, C_6 = 0.0711, C_7 = 0.0720, C_8 = 0.0731, C_9 = 0.0703, C_{10} = 0.0716, C_{11} = 0.0711, C_{12} = 0.0715, C_{13} = 0.0710, C_{14} = 0.0713	Bipolar neutrosophic MABAC	$A_1 \succ A_2 \succ A_5 \succ A_4 \succ A_7 \succ A_3 \succ A_6$
Bipolar neutrosophic DEMATEL-TOPSIS	Bipolar neutrosophic DEMATEL (see Table 5.37)	C1 = 0.0700, C2 = 0.0717, C3 = 0.0714, C4 = 0.0713, C5 = 0.0715, C6 = 0.0713, C7 = 0.0728, C8 = 0.0743, C9 = 0.0702, C10 = 0.0722, C11 = 0.0698, C12 = 0.0709,	Bipolar neutrosophic TOPSIS	$A_1 \succ A_2 \succ A_5 \succ A_4 \succ A_7 \succ A_3 \succ A_6$

		C13 = 0.0711, C14 = 0.0716		
Bipolar neutrosophic DEMATEL-MABAC (proposed method)	Bipolar neutrosophic DEMATEL (see Table 5.37)	C1 = 0.0700, C2 = 0.0717, C3 = 0.0714, C4 = 0.0713, C5 = 0.0715, C6 = 0.0713, C7 = 0.0728, C8 = 0.0743, C9 = 0.0702, C10 = 0.0722, C11 = 0.0698, C12 = 0.0709, C13 = 0.0711, C14 = 0.0716	Bipolar neutrosophic MABAC (see Table 5.43)	$A_1 \succ A_2 \succ A_5 \succ A_7 \succ A_4 \succ A_3 \succ A_6$

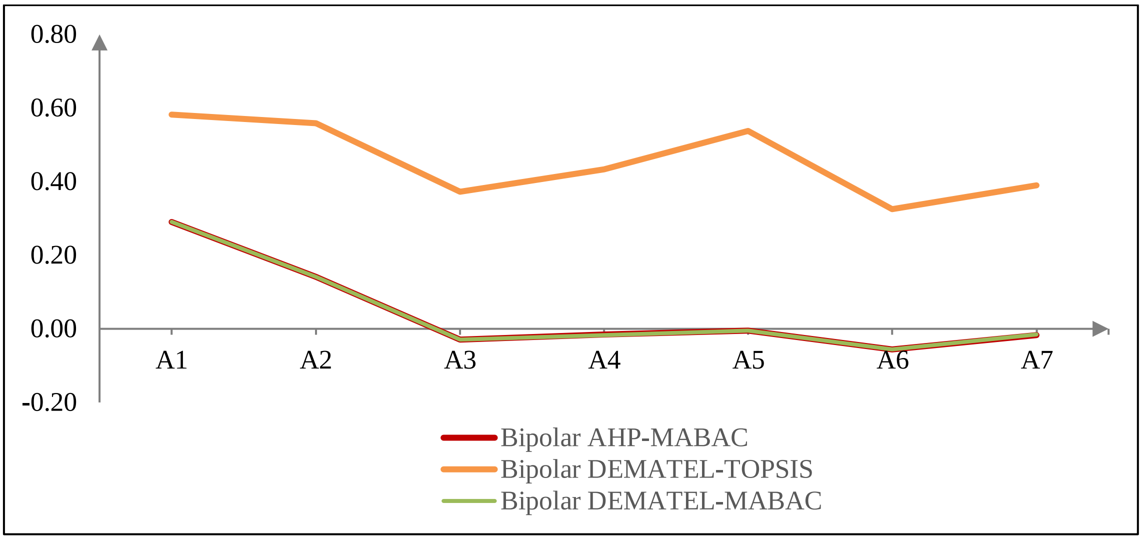

Figure 6.2: Comparative analysis of evaluation ranking under different methods

Surprisingly, the obtained results based on Table 6.23 show that A_1 is the optimal alternative than other alternatives. It can be seen that the proposed bipolar neutrosophic DEMATEL-MABAC produces consistent results. In order to explain a significant differences, some observations are describes as follows:

i. DEMATEL and AHP method provides to determine the weights of criteria. The initial direct influence matrix for DEMATEL method does contain zeros (Kobryń, 2017) but initial pairwise comparison matrix for AHP method does not contain zeros. DEMATEL and AHP method reflect the relationships between the analysed elements based on the accurate initial matrix. Therefore, the weights of criteria determined by DEMATEL method exhibit high compatibility than weights of criteria of AHP method.

ii. MABAC method determines the rank of alternative based on the sum of distance alternative from the border approximation area. Moreover, TOPSIS method determines the alternative based on the shortest distance to an ideal solution that define in ideal positive and negative solutions. But, MABAC method showed the stability and consistency in its solutions while TOPSIS method do not meet between one or more of the condition. Therefore, TOPSIS method do not give consistent solutions.

CHAPTER 7

CONCLUSIONS

This final chapter is devoted to summarize the study in four main sections. Section 7.1 recaps research objectives and outcomes. Next, section 7.2 highlights the contributions of the research. The limitations of this research and the recommendations for the future research are presented in section 7.3. Last but not least, section 7.4 given the final words regarding this research.

7.1 Research Objectives and Outcomes

This section explains how this thesis has satisfied the objectives answered the research questions of this research as outlined at the beginning of the introduction chapter. The ultimate aim of this research was to propose the MCDM methods involving neutrosophic environment to solve decision-making problems. The research has proposed a novel method that employed DEMATEL and MABAC methods under bipolar neutrosophic set. To solve the complicated MCDM problems, the combination of DEMATEL and MABAC method is used where DEMATEL method obtained the weight of criteria and determined the rank of alternatives offered by MABAC method

The aim was achieved through developing proposed method based on literature reviews. The review of the literature reveals the extensions of DEMATEL-MABAC methods based on fuzzy sets that used only one membership degree and only deal with uncertainty information. None of them clearly addresses the indeterminacy information in the form of human doubt and bipolar judgemental thinking that contains the positive side and negative side when assigning membership degrees during the assessments. Indeed, the combination of DEMATEL-MABAC is widely known to be efficient and provides simple computation in solving MCDM problems.

In addition, this section has restated the research questions stated in Section 1.3 and Chapter 4 until Chapter 6 to respond to each question.

The first research question was *'How to model and define linguistic variables based on bipolar neutrosophic sets?'*

At first, this study has addressed the issues by proposing a bipolar neutrosophic set (BNS) to capture the indeterminacy information and bipolar judgemental information in Chapter 1. Some basic properties of BNS presented in Chapter 3 such as the operational laws, union, intersection and complement are studied and its related algebraic properties. The BNS has been proposed based on the bipolar fuzzy set and neutrosophic set. The new bipolar neutrosophic linguistic variable defined and proved based on the idea of single-valued neutrosophic number in Chapter 4. The decision-makers evaluate the assessment towards criteria and alternatives and converted their preference into the new bipolar neutrosophic linguistic variable. The first objective of this research meet where to propose a new linguistic variable for bipolar neutrosophic sets.

These findings answered the second research question; '*How to integrate the bipolar neutrosophic DEMATEL and MABAC methods based on the newly defined linguistic variable?'*

The designation of the proposed method was explained and presented in Chapter 4 of this thesis. The integration of bipolar neutrosophic DEMATEL and MABAC method based on the newly defined linguistic variables are developed where BNS of DEMATEL determined the weight of criteria and the weights are applied in the weighted matrix in MABAC method. Then, the rank of alternatives are obtained using MABAC method to solve the complicated MCDM problems in MABAC method. This study meets the second objective of research to integrate the bipolar neutrosophic DEMATEL and MABAC method based on the newly defined linguistic variable.

The third research question in this research was *'How can these proposed methods be used to solve MCDM problems?'*

The developed DEMATEL-MABAC method under BNS is implemented in a case study of the sustainable energy selection in Chapter 5. The five decision-makers in sustainable energy were selected to evaluate the fourteen criteria and seven alternatives. The outcomes of the sustainable energy selection with the proposed bipolar neutrosophic DEMATEL-MABAC method conducted in this study was solely decided by five decision-maker of sustainable energy. The result revealed that "Biomass energy" is the most important alternative, followed by "Biogas energy", "Solar energy" and "Wind energy". The researcher, energy consultant or contractors should pay extra attention to these four alternatives to select the best of sustainable energy. In this regard, the results of rank the alternative outline a critical role for finding the importance of each criteria and alternatives and provides important insights on how to improve sustainable energy problems. This research question meets objective three where to apply the proposed method for sustainable energy selection.

The four research questions was "*How efficient and useful are this proposed method in solving MCDM problems?*

To respond to these research questions, the applicability of the proposed method was demonstrated using actual data from the case study to determine the consistency and feasibility of the proposed methods mentioned in Chapter 6. The findings were discussed and analysed. The comparative results between the proposed method and existing methods were studied and meet the last research objective to analysis the comparative results between the proposed method and the existing methods.

7.2 Contributions of the Research

This research make several contributions to the current literature. The contribution of this study are written in four-fold based on the main research objectives; the proposed set of new linguistic variable of bipolar neutrosophic set, the proposed method of DEMATEL-MABAC and the application to the sustainable energy selection.

i. Firstly, there are several significant features of the proposed BNS. By adopting the characteristics of bipolar fuzzy sets and neutrosophic sets, the proposed set provides the indeterminacy information and bipolar judgemental thinking. Therefore, the decision evaluation will be more rational by considering indeterminacy information and bipolar judgemental thinking. This proposed BNS has made a huge contribution by providing a schematic and practical bipolar neutrosophic decision making approach. Since, there is no extension set that combined the bipolar fuzzy set and neutrosophic set concept, this proposed set has contributed to the set development domain.
ii. The proposed bipolar neutrosophic DEMATEL-MABAC method generalizes the existing MCDM methods of DEMATEL and MABAC methods. The proposed method contributes to existing knowledge of integrated DEMATEL-MABAC method by providing a schematic procedure of decision-making approach with multiple criteria and alternatives.
iii. Then, this study applied the developed bipolar neutrosophic DEMATEL-MABAC method to evaluate the criteria and alternatives of sustainable energy. The findings of this study which is ranking order of the sustainable energy will be of interest to researcher, energy consultant and contractors. The study contributes to our understanding of the weight of criteria and find the optimal alternatives in sustainable energy.
iv. Prior to this study, it was hard to make decision on how to choose the optimal alternatives of sustainable energy this study established a realistic alternatives sustainable energy that are easy to assist. Then, this study also applicable in various application decision making such as hybrid renewable energy system and nanotechnology application.

7.3 Limitations and Future Recommendation of the Research

Beyond the contribution, this study suffers from limitations that are investigated in potential studies. The results in this research are subjected to two main limitations. First, this study is challenging and take time-consuming where needs to consider fourteen criteria and seven alternatives. Prior to the analysis, the evaluation process for the higher number of criteria and alternatives was acknowledged to be confusing. Each decision makers need to evaluate 294 judgments for fourteen criteria and seven alternatives. Therefore, the decision-makers take a long time to complete the analysis and become high making mistakes during computation.

In addition, this study is also limited by the absence of decision-makers. There are five decision makers involved in this study for sustainable energy selection. Although no clear ideal number of decision-makers has been found in the literature. Based on our observation, the number of decision-makers generally should not be more than 5 to collect the response or opinion in decision-making problems. The higher number of decision-makers would lead to high degree of inconsistency, length of computation and time consuming. Hence, it make results unreliable and trouble analysis.

In this regard, this study suggested some recommendations for further researchers. Based on the proposed BNS, there is a broad opportunity for future research direction. Future work may develop various approaches to MCDM using BNS. For example, the BNS AHP method, BNS VIKOR method, BNS TOPSIS and much more. Then, it is worth to investigate the practically and suitability of integration of the existing proposed method with other MCDM methods. New possible modifications of the proposed method by fusing other aggregation operators such as Choquet integral or another aggregation method. The proposed BN-DEMATEL approach would be of great benefit for future work in applying it to actual science and engineering decision-making problems.

7.4 Final Words

In summary, this study contributes to the knowledge of the multiple-criteria decision making in the linguistic variable of sets and modified MCDM methods with a convenient computation procedure and provides the best solution that considers the rank of the alternatives. The proposed DEMATEL-MABAC method under bipolar neutrosophic set featured positive membership degree and negative membership degree. Research in this area of decision-making is important and very useful for various applications in science and engineering.

REFERENCES

Abdel-Basset, M., Mohamed, M., Elhoseny, M., Son, L. H., Chiclana, F. and Zaied, A. E.-N. H. (2019). Cosine similarity measures of bipolar neutrosophic set for diagnosis of bipolar disorder diseases. *Artificial Intelligence in Medicine*. 101, 101735.

Abdullah, L. and Najib, L. (2014). A new preference scale of intuitionistic fuzzy analytic hierarchy process in multi-criteria decision making problems. *Journal of Intelligent and Fuzzy Systems*. 26(2), 1039–1049.

Abdullah, L., Ong, Z. and Mahali, S. M. (2021). Single-valued neutrosophic DEMATEL for segregating types of criteria: A case of subcontractors' selection. *Journal of Mathematics*. 2021, 6636029.

Abdullah, L. and Rahim, N. (2020a). The use of fuzzy DEMATEL for urban sustainable development. *Advances in Intelligent Systems and Computing*. 1029, 722–729.

Abdullah, L. and Rahim, S. N. (2020b). Bipolar neutrosophic DEMATEL for urban sustainable development. *Journal of Intelligent and Fuzzy Systems*. 39(5), 6109–6119.

Agarwal, S., Chakraborty, S. and Chakraborty, S. (2020). A DEMATEL-MABAC-based approach for grading and evaluation of jute fibers. *Research Journal of Textile and Apparel*. 24(4), 341–355.

Akram, M. and Sarwar, M. (2017). Novel multiple criteria decision making methods based on bipolar neutrosophic sets and bipolar neutrosophic graphs. *Italian Journal of Pure and Applied Mathematics*. 38, 368–389.

Akram, M., Shumaiza, and Smarandache, F. (2018). Decision-making with bipolar neutrosophic TOPSIS and bipolar neutrosophic ELECTRE-I. *Axioms*. 7(2), 33.

Al-Obaidi, A. S. M. and NguyenHuynh, T. (2018). Renewable vs. conventional energy: Which wins the race to sustainable development? *IOP Conference Series: Materials Science and Engineering*. 434, 012310.

Al-Quran, A., Hashim, H. and Abdullah, L. (2020). A hybrid approach of interval neutrosophic vague sets and DEMATEL with new linguistic variable. *Symmetry*. 12(2), 275.

Ali, M., Deli, I. and Smarandache, F. (2016). The theory of neutrosophic cubic sets and their applications in pattern recognition. *Journal of Intelligent and Fuzzy Systems*. 30(4), 1957–1963.

Ali, M. and Smarandache, F. (2017). Complex neutrosophic set. *Neural Computing and Applications*. 28(7), 1817–1834.

Ali, M., Son, L. H., Deli, I. and Tien, N. D. (2017). Bipolar neutrosophic soft sets and applications in decision making. *Journal of Intelligent and Fuzzy Systems*. 33(6), 4077–4087.

Alrikabi, N. K. M. A. (2014). Renewable Energy Types. *Journal of Clean Energy Technologies*. 2(1), 61–64.

Arulpandy, P. and Trinita Pricilla, M. (2019). Reduction of indeterminacy of gray-scale image in bipolar neutrosophic domain. *Neutrosophic Sets and Systems*. 28, 1–12.

Ataei, M. and Norouzi Masir, R. (2020). A fuzzy DEMATEL based sustainable development index (FDSDI) in open pit mining – a case study. *Rudarsko Geolosko Naftni Zbornik*. 35(1), 1–11.

Atanassov, K. T. (1986). Intuitionistic fuzzy sets. *Fuzzy Sets and Systems*. 20(1), 87–96.

Awang, A., Ali, M. and Abdullah, L. (2019). Hesitant bipolar-valued neutrosophic set: formulation, theory and application. *IEEE Access*. 7, 176099–176114.

Awang, A., Ghani, A. T. A., Abdullah, L. and Ahmad, M. F. (2018a). A DEMATEL method with single valued neutrosophic set (SVNS) in identifying the key contribution factors of Setiu Wetland's coastal erosion. *AIP Conference Proceedings*. 1974.

Awang, A., Ghani, A. T. A., Abdullah, L. and Ahmad, M. F. (2018b). The shapley weighting vector-based neutrosophic aggregation operator in DEMATEL method. *Journal of Physics: Conference Series*. 1132(1).

Aydin, S., Kahraman, C. and Kabak, M. (2018). Evaluation of investment alternatives using present value analysis with simplified neutrosophic sets. *Engineering Economics*. 29(3), 254–263.

Barry, M. L., Steyn, H. and Brent, A. C. (2009a). Determining the most important factors for sustainable energy technology selection in Africa. *South African Journal of Industrial Engineering*. 20(2), 33–51.

Barry, M. L., Steyn, H. and Brent, A. C. (2009b). Selection of renewable energy technologies in Africa: The case of efficient stoves in Malawi. *WIT Transactions on Ecology and the Environment*. 121, 117–128.

Baykasoğlu, A., Kaplanoglu, V., Durmuşoglu, Z. D. U. and Şahin, C. (2013). Integrating fuzzy DEMATEL and fuzzy hierarchical TOPSIS methods for truck selection. *Expert Systems with Applications*. 40(3), 899–907.

Benayoun, B. R. and Sussman, N. (1966). Manual de reference du programme ELECTRE. Note De Synthese et Formaton 25. Paris: Direction Scientifique SEMA. *Paris: Direction Scientifiques SEMA.*

Bhowmik, C., Baruah, A., Bhowmik, S. and Ray, A. (2018). Green energy sources selection for sustainable energy planning using multi-criteria decision-making approach. *IOP Conference Series: Materials Science and Engineering*. 377(1).

Bhowmik, C., Gangwar, S., Bhowmik, S. and Ray, A. (2018). Selection of energy-efficient material: An entropy–TOPSIS approach. *Advances in Intelligent Systems and Computing*. 584, 31–39.

Birgün, S. and Ulu, M. (2021). Site selection for a training centre focused on industry 4.0 by using DEMATEL and COPRAS. *Lecture Notes in Mechanical Engineering*. 37–50.

Biswas, P., Pramanik, S. and Giri, B. C. (2016). TOPSIS method for multi-attribute group decision-making under single-valued neutrosophic environment. *Neural Computing and Applications*. 27(3), 727–737.

Biswas, T. K. and Das, M. C. (2019). Selection of commercially available electric vehicle using fuzzy AHP-MABAC. *Journal of The Institution of Engineers (India): Series C*. 100(3), 531–537.

Bobar, Z., Božanić, D., Djurić, K. and Pamučar, D. (2020). Ranking and assessment of the efficiency of social media using the fuzzy AHP-Z number model-fuzzy MABAC. *Acta Polytechnica Hungarica*. 17(3), 43–70.

Bokaei Hosseini, M. and Tarokh, M. J. (2011). Interval type-2 fuzzy set extension of DEMATEL method. *Communications in Computer and Information Science*. 250 CCIS, 157–165.

Bordogna, G., Fedrizzi, M. and Pasi, G. (1997). A linguistic modeling of consensus in group decision making based on OWA operators. *IEEE Transactions on Systems, Man, and Cybernetics Part A:Systems and Humans.* 27(1), 126–132.

Bosc, P. and Pivert, O. (2013). On a fuzzy bipolar relational algebra. *Information Sciences*. 219, 1–16.

Bose, S., Mandal, N. and Nandi, T. (2020). Selection and experimentation of the best hybrid green composite using advanced MCDM methods for clean sustainable energy recovery: A novel approach. *International Journal of Mathematical, Engineering and Management Sciences*. 5(3), 556–566.

Božanić, D. I., Pamučar, D. S. and Karović, S. M. (2016). Application the MABAC method in support of decision-making on the use of force in a defensive operation. *Tehnika*. 71(1), 129–136.

Broumi, S., Bakali, A., Talea, M., Smarandache, F., Singh, P. K., Uluçay, V. and Khan, M. (2019). Bipolar complex neutrosophic sets and its application in decision making problem. *Studies in Fuzziness and Soft Computing*. 369, 677–710.

Bui, T. X. and Jarke, M. (1986). Communications design for Co-oP: a group decision support system. *ACM Transactions on Information Systems (TOIS)*. 4(2), 81–103.

Büyüközkan, G. and Güleryüz, S. (2016). An integrated DEMATEL-ANP approach for renewable energy resources selection in Turkey. *International Journal of Production Economics*. 182, 435–448.

Büyüközkan, G., Havle, C. A., Feyziolu, O. and Uztürk, D. (2020). Integrated fuzzy multi criteria decision making approach for sustainable energy technology selection. *ACM International Conference Proceeding Series*. 93–98.

Büyüközkan, G., Mukul, E. and Kongar, E. (2021). Health tourism strategy selection via SWOT analysis and integrated hesitant fuzzy linguistic AHP-MABAC approach. *Socio-Economic Planning Sciences*. 74.

Camparo, J. (2013). A geometrical approach to the ordinal data of Likert scaling and attitude measurements: The density matrix in psychology. *Journal of Mathematical Psychology*. 57(1–2), 29–42.

Candan, G., Kir, S. and Yazgan, H. R. (2017). Solution of material selection problem using fuzzy axiomatic design and DEMATEL methods. *Acta Physica Polonica A*. 131(1), 24–27.

Chatterjee, K., Zavadskas, E. K., Roy, J. and Kar, S. (2018). Performance evaluation of green supply chain management using the grey DEMATEL–ARAS model. *Springer Proceedings in Mathematics and Statistics*. 225, 347–363.

Chatterjee, P., Mondal, S., Boral, S., Banerjee, A. and Chakraborty, S. (2017). A novel hybrid method for non-traditional machining process selection using factor relationship and multi-attribute border approximation method. *Facta Universitatis, Series: Mechanical Engineering*. 15(3), 439–456.

Chen, W. C., Chang, H. P., Lin, K. M. and Kan, N. H. (2015). An efficient model for NPD performance evaluation using DEMATEL and fuzzy ANP-applied to the TFT-LCD touch panel industry in Taiwan. *Energies*. 8(10), 11973–12003.

Chen, Y., Ran, Y., Huang, G., Xiao, L. and Zhang, G. (2021). A new integrated MCDM approach for improving QFD based on DEMATEL and extended MULTIMOORA under uncertainty environment. *Applied Soft Computing*. 105.

Chien, K. F., Wu, Z. H. and Huang, S. C. (2014). Identifying and assessing critical risk factors for BIM projects: Empirical study. *Automation in Construction*. 45, 1–15.

Chou, Y. C., Yang, C. H., Lu, C. H., Dang, V. T. and Yang, P. A. (2017). Building criteria for evaluating green project management: An integrated approach of DEMATEL and ANP. *Sustainability (Switzerland)*. 9(5).

Chuang, H. M., Lin, C. K., Chen, D. R. and Chen, Y. S. (2013). Evolving MCDM applications using hybrid expert-based ISM and DEMATEL models: An example of sustainable ecotourism. *The Scientific World Journal*. 2013.

Dalalah, D. (2009). A hybrid DEMATEL-TOPSIS multi-criteria decision making model. *IEEE International Conference on Information Reuse and Integration, 2009*. 428–430.

Dalalah, D., Hayajneh, M. and Batieha, F. (2011). A fuzzy multi-criteria decision making model for supplier selection. *Expert Systems with Applications*. 38(7), 8384–8391.

Das, H. and Saha, T. (2020). An algorithmic procedure for finding nash equilibrium. *GANIT: Journal of Bangladesh Mathematical Society*. 40(1), 71–85.

Debnath, A., Roy, J., Kar, S., Zavadskas, E. K. and Antucheviciene, J. (2017). A hybrid MCDM approach for strategic project portfolio selection of Agro by-products. *Sustainability (Switzerland)*. 9(8).

Deli, I., Ali, M. and Smarandache, F. (2015). Bipolar neutrosophic sets and their application based on multi-criteria decision making problems. *International Conference on Advanced Mechatronic System.* 2015, 249–254.

Deli, I., Şubaş, Y., Smarandache, F. and Ali, M. (2016). Interval valued bipolar fuzzy weighted neutrosophic sets and their application. *2016 IEEE International Conference on Fuzzy Systems.* 2460–2467.

Dey, S., Kumar, A., Ray, A. and Pradhan, B. B. (2012). Supplier selection: Integrated theory using dematel and quality functions deployment methodology. *Procedia Engineering*. 38, 3560–3565.

Díaz, D. R. B., López, L. R. R. and Castro, L. P. A. (2020). Neutrosophic DEMATEL to prioritize risk factors in teenage pregnancy. *Neutrosophic Sets and Systems*. 37, 24–31.

Dinçer, H., Yüksel, S., Korsakiene, R., Raišiene, A. G. and Bilan, Y. (2019). IT2 hybrid decision-making approach to performance measurement of internationalized firms in the Baltic States. *Sustainability (Switzerland)*. 11(2).

Dung, V., Thuy, L. T., Mai, P. Q., Dan, N. Van, and Lan, N. T. M. (2018). TOPSIS approach using interval neutrosophic sets for personnel selection. *Asian Journal of Scientific Research*. 11(3), 434–440.

El Mariouli, O. and Abouabdellah, A. (2020). Development of supplier selection model using fuzzy DEMATEL approach in a sustainable development context. *Smart Innovation, Systems and Technologies*. 146, 59–71.

Estiri, M., Dahooie, J. H., Vanaki, A. S., Banaitis, A. and Binkytė-Vėlienė, A. (2021). A multi-attribute framework for the selection of high-performance work systems: the hybrid DEMATEL-MABAC model. *Economic Research-Ekonomska Istrazivanja*. 34(1), 970–997.

Fan, C. X., Fan, E. and Hu, K. (2018). New form of single valued neutrosophic uncertain linguistic variables aggregation operators for decision-making. *Cognitive Systems Research*. 52, 1045–1055.

Fan, J., Guan, R. and Wu, M. (2020). Z-MABAC method for the selection of third-party logistics suppliers in fuzzy environment. *IEEE Access*. 8, 199111–199119.

Feng, J., Li, M. and Li, Y. (2018). Study of decision framework of shopping mall photovoltaic plan selection based on DEMATEL and ELECTRE III with symmetry under neutrosophic set environment. *Symmetry*. 10(5).

Fontela, E. and Gabus, A. (1972). World problems an invitation to further thought within the framework of DEMATEL. *Battelle Geneva Research Centre*. 1–8.

Gabus, A. and Fontela, E. (1973) Perceptions of the world problem atique: communication procedure, communicating with those bearing collective responsibility. DEMATEL Report No.1, *Battelle Geneva Research Centre, Geneva*.

Ghadami, L., Masoudi Asl, I., Hessam, S. and Modiri, M. (2021). Developing hospital accreditation standards: applying fuzzy DEMATEL. *International Journal of Healthcare Management*. 14(3), 847–855.

Gigović, L., Pamučar, D., Božanić, D. and Ljubojević, S. (2017). Application of the GIS-DANP-MABAC multi-criteria model for selecting the location of wind farms: A case study of Vojvodina, Serbia. *Renewable Energy*. 103(2017), 501–521.

Gigović, L., Pamučar, D., Lukić, D. and Marković, S. (2016). GIS-Fuzzy DEMATEL MCDA model for the evaluation of the sites for ecotourism development: A case study of "Dunavski ključ" region, Serbia. *Land Use Policy*. 58, 348–365.

Gopal, J., Sangaiah, A. K., Basu, A. and Gao, X. Z. (2018). Integration of fuzzy DEMATEL and FMCDM approach for evaluating knowledge transfer effectiveness with reference to GSD project outcome. *International Journal of Machine Learning and Cybernetics*. 9(2), 225–241.

Govindan, K. and Chaudhuri, A. (2016). Interrelationships of risks faced by third party logistics service providers: A DEMATEL based approach. *Transportation Research Part E: Logistics and Transportation Review*. 90, 177–195.

Gulfam, M., Mahmood, M. K., Smarandache, F. and Ali, S. (2021). New Dombi aggregation operators on bipolar neutrosophic set with application in multi-Attribute decision-making problems. *Journal of Intelligent and Fuzzy Systems*. 40(3), 5043–5060.

Guo, Z. and Sun, F. (2019). Multi-attribute decision making method based on single-valued neutrosophic linguistic variables and prospect theory. *Journal of Intelligent and Fuzzy Systems*. 37(4), 5351–5362.

Hashemizadeh, A., Ju, Y., Bamakan, S. M. H. and Le, H. P. (2021). Renewable energy investment risk assessment in belt and road initiative countries under uncertainty conditions. *Energy*. 214.

Hashim, R. M., Gulistan, M., Rehman, I., Hassan, N. and Nasruddin, A. M. (2020). Neutrosophic bipolar fuzzy set and its application in medicines preparations. *Neutrosophic Sets and Systems*. 31, 86–100.

Hashim, R. M., Gulistan, M. and Smarandache, F. (2018). Applications of neutrosophic bipolar fuzzy sets in HOPE foundation for planning to build a children hospital with different types of similarity measures. *Symmetry*. 10(8).

Hassan, I. U. and Asghar, S. (2021). A framework of software project scope definition elements: An ism-dematel approach. *IEEE Access*. 9, 26839–26870.

Hatefi, S. M. and Tamošaitienė, J. (2018). An integrated fuzzy DEMATEL-fuzzy ANP model for evaluating construction projects by considering interrelationships among risk factors. *Journal of Civil Engineering and Management*. 25(2), 114–131.

Herrera, F. and Herrera-Viedma, E. (2000). Linguistic decision analysis: Steps for solving decision problems under linguistic information. *Fuzzy Sets and Systems*. 115(1), 67–82.

Herrera, F., Herrera-Viedma, E. and Martínez, L. (2000). A fusion approach for managing multi-granularity linguistic term sets in decision making. *Fuzzy Sets and Systems*. 114(1), 43–58.

Hosseini, M. B. and Tarokh, M. J. (2011). Interval type-2 fuzzy set extension of DEMATEL method. *Communications in Computer and Information Science*. 250 CCIS, 157–165.

Hosseini, M. B. and Tarokh, M. J. (2013). Type-2 fuzzy set extension of DEMATEL method combined with perceptual computing for decision making. *Journal of Industrial Engineering International*. 9(1).

Hristov, N., Pamucar, D. and Amine, M. S. M. E. (2021). Application of a D number based LBWA model and an interval MABAC model in selection of an automatic cannon for integration into combat vehicles. *Defence Science Journal*. 71(1), 34–45.

Hsu, C. W., Kuo, T. C., Chen, S. H. and Hu, A. H. (2013). Using DEMATEL to develop a carbon management model of supplier selection in green supply chain management. *Journal of Cleaner Production*. 56, 164–172.

Hsueh, S. L. and Yan, M. R. (2011). Enhancing sustainable community developments: A multi-criteria evaluation model for energy efficient project selection. *Energy Procedia*. 5, 135–144.

Hu, J., Chen, P. and Yang, Y. (2019). An interval type-2 fuzzy similarity-based MABAC approach for patient-centered care. *Mathematics*. 7(2).

Huang, C. Y., Chang, Y. N., Lu, H. H. and Wu, M. J. (2016). Evaluating the electronic service quality of group buying websites by using the DEMATEL based network process. *2016 International Conference on Applied System Innovation*.

Hussain, S. S., Hussain, R. J., Jun, Y. B. and Smarandache, F. (2019). Neutrosophic bipolar vague set and its application to neutrosophic bipolar vague graphs. *Neutrosophic Sets and Systems*. 28(2019), 69–86.

Hwang, C.-L. and Yoon, K. (1981a). *Methods for Multiple Attribute Decision Making*. Springer, Berlin, Heidelberg.

Hwang, C.-L. and Yoon, K. (1981b). Multiple attributes decision making methods and applications. *Springer New York*.

Hwang, W., Hsiao, B., Chen, H. G. and Chern, C. C. (2016). Multiphase assessment of project risk interdependencies: Evidence from a university ISD project in Taiwan. *Project Management Journal*. 47(1), 59–75.

Irvanizam, I., Zi, N. N., Zuhra, R., Amrusi, A. and Sofyan, H. (2020). An extended MABAC method based on triangular fuzzy neutrosophic numbers for multiple-criteria group decision making problems. *Axioms*. 9(3).

Jayant, A. and Sharma, J. (2018). A Comprehensive literature review of MCDM techniques ELECTRE, PROMETHEE, VIKOR, and TOPSIS applications in business competitive environment. *International Journal of Current Research*. 10(2).

Jeong, J. S., García-Moruno, L., Hernández-Blanco, J. and Sánchez-Ríos, A. (2016). Planning of rural housings in reservoir areas under (mass) tourism based on a fuzzy DEMATEL-GIS/MCD. A hybrid and participatory method for Alange, Spain. *Habitat International*. 57.

Jeong, J. S. and Ramírez-Gómez, Á. (2018). Optimizing the location of a biomass plant with a fuzzy-Decision-Making Trial and Evaluation Laboratory (F-DEMATEL) and multi-criteria spatial decision assessment for renewable energy management and long-term sustainability. *Journal of Cleaner Production*. 182.

Jha, S., Kumar, R., Son, L. H., Chatterjee, J. M., Khari, M., Yadav, N. and Smarandache, F. (2019). Neutrosophic soft set decision making for stock trending analysis. *Evolving Systems*. 10(4).

Ji, P., Zhang, H. Yu, and Wang, J. Qiang. (2018a). A projection-based TODIM method under multi-valued neutrosophic environments and its application in personnel selection. *Neural Computing and Applications*. 29(1).

Ji, P., Zhang, H. Yu, and Wang, J. Qiang. (2018b). Selecting an outsourcing provider based on the combined MABAC–ELECTRE method using single-valued neutrosophic linguistic sets. *Computers and Industrial Engineering*. 120.

Kazemi, S., Mavi, R. K., Soltanmohammad, N., Latifi, I. and Fallahian-Najafabadi, A. (2013). Selection and ranking sustainable strategies and assessing their impact on reducing carbon dioxide (CO2), using DEMATEL method. *Advances in Environmental Biology*. 7(11).

Keshavarz-Ghorabaee, M., Amiri, M., Hashemi-Tabatabaei, M. and Ghahremanloo, M. (2021). Sustainable public transportation evaluation using a novel hybrid method based on fuzzy BWM and MABAC. *The Open Transportation Journal*. 15(1).

Keskin, G. A. (2015). Using integrated fuzzy DEMATEL and fuzzy C: Means algorithm for supplier evaluation and selection. *International Journal of Production Research*. 53(12).

Kilic, H. S., Demirci, A. E. and Delen, D. (2020). An integrated decision analysis methodology based on IF-DEMATEL and IF-ELECTRE for personnel selection. *Decision Support Systems*. 137.

Kilic, H. S. and Yalcin, A. S. (2021). Comparison of municipalities considering environmental sustainability via neutrosophic DEMATEL based TOPSIS. *Socio-Economic Planning Sciences*. 75.

Kilic, H. S., Yurdaer, P. and Aglan, C. (2021). A leanness assessment methodology based on neutrosophic DEMATEL. *Journal of Manufacturing Systems*. 59.

Kobryń, A. (2017). DEMATEL as a weighting method in multi-criteria decision analysis. *Multiple Criteria Decision Making*. 12, 153–167.

Köseoğlu, A., Şahin, R. and Merdan, M. (2020). A simplified neutrosophic multiplicative set-based TODIM using water-filling algorithm for the determination of weights. *Expert Systems*. 37(4).

Kumar Maji, P. (2013). Neutrosophic soft set. *Annals of Fuzzy Mathematics and Informatics*. 5(1), 157–168.

Lemaire, X. (2004). Glossary of terms in sustainable energy regulation. *Renewable Energy and Energy Efficiency Partnership*.

Levrat, E., Voisin, A., Bombardier, S. and Brémont, J. (1997). Subjective evaluation of car seat comfort with fuzzy set techniques. *International Journal of Intelligent Systems*. 12(1112).

Li, Q. (2013). A novel Likert scale based on fuzzy sets theory. *Expert Systems with Applications*. 40(5).

Li, Y. (2021). IF-MABAC method for evaluating the intelligent transportation system with intuitionistic fuzzy information. *Journal of Mathematics*. 2021.

Lin, L. and Lee, H. M. (2008). Fuzzy assessment for sampling survey defuzzification by signed distance method. *Proceedings - 8th International Conference on Intelligent Systems Design and Applications, ISDA 2008*. 1.

Lin, X. H., Feng, Y. X., Tan, J. R. and An, X. H. (2011). A hybrid fuzzy DEMATEL-VIKOR method for product concept evaluation. *Advanced Materials Research*. 186.

Liu, F., Aiwu, G., Lukovac, V. and Vukic, M. (2018). A multicriteria model for the selection ofthe transport service provider: A single valued neutrosophic dematel multicriteria model. *Decision Making: Applications in Management and Engineering*. 1(2).

Liu, P. and Cheng, S. (2020). An improved MABAC group decision-making method using regret theory and likelihood in probability multi-valued neutrosophic sets. *International Journal of Information Technology and Decision Making*. 19(5).

Liu, P. and Tang, G. (2016). multi-criteria group decision-making based on interval neutrosophic uncertain linguistic variables and choquet integral. *Cognitive Computation*. 8(6).

Liu, R., Hou, L. X., Liu, H. C. and Lin, W. (2020). Occupational health and safety risk assessment using an integrated SWARA-MABAC model under bipolar fuzzy environment. *Computational and Applied Mathematics*. 39(4).

Long, X., Liu, L., Xiao, C., Cheng, P. and Fu, C. (2020). Restoration Methods selection for wood components of chinese ancient architectures based on TODIM with single-valued neutrosophic sets. *Mathematical Problems in Engineering*. 2020.

Lu, L. and Luo, X. (2020). Emergency transportation problem based on single-valued neutrosophic set. *Discrete Dynamics in Nature and Society*. 2020.

Luo, S. Zhi, and Xing, L. Ning. (2019). A hybrid decision making framework for personnel selection using BWM, MABAC and PROMETHEE. *International Journal of Fuzzy Systems*. 21(8).

Mahmud, M., Md Nor, N., Jauhari, N. E., Nordin, N. I. and Abdul Rahman, N. (2020). Student engagement and attitude in mathematics achievement using single valued neutrosophic set. *Journal of Physics: Conference Series*. 1496(1).

Martínez, L., Ruan, D., Herrera, F., Herrera-Viedma, E. and Wang, P. P. (2009). Linguistic decision making: tools and applications. *Information Sciences*. 179 (14).

Mukherjee, A. and Das, R. (2020). Neutrosophic bipolar vague soft set and its application to decision making problems. *Neutrosophic Sets and Systems*. 32.

Nafei, A. H., Yuan, W. and Nasseri, H. (2019). Group multi-attribute decision making based on interval neutrosophic sets. *Studies in Informatics and Control*. 28(3).

Narayanamoorthy, S., Ramya, L., Kalaiselvan, S., Kureethara, J. V. and Kang, D. (2021). Use of DEMATEL and COPRAS method to select best alternative fuel for control of impact of greenhouse gas emissions. *Socio-Economic Planning Sciences*. 76.

Neumann, J. Von, and Morgenstern, O. (1945). Theory of games and economic behaviour. *The Mathematical Gazette*. 29(285).

Oğuz, E. and Şentürk, A. E. (2019). Selection of the most sustainable renewable energy system for Bozcaada Island: wind vs. photovoltaic. *Sustainability (Switzerland)*. 11(15).

Okokpujie, I. P., Okonkwo, U. C., Bolu, C. A., Ohunakin, O. S., Agboola, M. G. and Atayero, A. A. (2020). Implementation of multi-criteria decision method for selection of suitable material for development of horizontal wind turbine blade for sustainable energy generation. *Heliyon*. 6(1).

Opricovic, S. (1998). Multicriteria optimization of civil engineering systems. *Faculty of Civil Engineering, Belgrade*.

Pamučar, D. and Božanić, D. (2019). Selection of a location for the development of multimodal logistics center: Application of single-valued neutrosophic MABAC model. *Operational Research in Engineering Sciences: Theory and Applications*. 2(2).

Pamučar, D. and Ćirović, G. (2015). The selection of transport and handling resources in logistics centers using multi-attributive border approximation area comparison (MABAC). *Expert Systems with Applications*. 42(6), 3016–3028.

Pamučar, D., Stević, Ž. and Zavadskas, E. K. (2018). Integration of interval rough AHP and interval rough MABAC methods for evaluating university web pages. *Applied Soft Computing Journal*. 67.

Pamucar, D. S., Tarle, S. P. and Parezanovic, T. (2018). New hybrid multi-criteria decision-making DEMATEL-MAIRCA model: sustainable selection of a location for the development of multimodal logistics centre. *Economic Research-Ekonomska Istrazivanja*. 31(1).

Pantoja, R. M. M., Ortiz, K. A. N., Salas, S. G. and Pico, O. A. (2020). Prioritization internal factors in the emergency service of the "Luis Gabriel Davila" hospital that cause the reentry of patients within 48 hours, based on neutrosophic DEMATEL. *Neutrosophic Sets and Systems*. 34.

Peng, J. J. and Tian, C. (2018). Multi-valued neutrosophic distance-based QUALIFLEX method for treatment selection. *Information (Switzerland)*. 9(12).

Peng, J. J., Wang, J. Q., Wang, J., Zhang, H. Y. and Chen, X. H. (2016). Simplified neutrosophic sets and their applications in multi-criteria group decision-making problems. *International Journal of Systems Science*. 47(10).

Peng, X. and Dai, J. (2017a). Algorithms for interval neutrosophic multiple attribute decision-making based on MABAC, similarity measure, and EDAS. *International Journal for Uncertainty Quantification*. 7(5).

Peng, X. and Dai, J. (2017b). Hesitant fuzzy soft decision making methods based on WASPAS, MABAC and COPRAS with combined weights. *Journal of Intelligent and Fuzzy Systems*. 33(2).

Peng, X. and Dai, J. (2018). Approaches to single-valued neutrosophic MADM based on MABAC, TOPSIS and new similarity measure with score function. *Neural Computing and Applications*. 29(10).

Peng, X. Dai, J. and Yuan, H. (2017). Interval-valued fuzzy soft decision making methods based on MABAC, similarity measure and EDAS. *Fundamenta Informaticae*. 152(4).

Peng, X. and Yang, Y. (2016). Pythagorean fuzzy choquet integral based MABAC Method for multiple attribute group decision making. *International Journal of Intelligent Systems*. 31(10).

Pramanik, S., Dalapati, S., Alam, S. and Roy, T. K. (2017). NC-TODIM-based MAGDM under a neutrosophic cubic set environment. *Information (Switzerland)*. 8(4).

Pramanik, S., Dalapati, S., Alam, S. and Roy, T. K. (2018a). NC-VIKOR based MAGDM strategy under neutrosophic cubic set environment. *Neutrosophic Sets and Systems*. 20.

Pramanik, S., Dalapati, S., Alam, S. and Roy, T. K. (2018c). VIKOR based MAGDM strategy under bipolar neutrosophic set environment. *Neutrosophic Sets and Systems*. 19.

Pramanik, S., Dey, P. P. and Smarandache, F. (2018b). Correlation coefficient measures of interval bipolar neutrosophic sets for solving multi-attribute decision making problems. *Neutrosophic Sets and Systems*. 19.

Roy, J., Chatterjee, K., Bandhopadhyay, A. and Kar, S. (2017). Evaluation and selection of Medical Tourism sites: A rough AHP based MABAC approach. *Expert Systems*. 35(1).

Roy, S., Lee, J. G., Pal, A. and Samanta, S. K. (2020). Similarity measures of quadripartitioned single valued bipolar neutrosophic sets and its application in multi-criteria decision making problems. *Symmetry*. 12(6).

Saaty, T. L. (1980). The analytical hierarchy process, planning, priority. *Priority Setting. Resource Allocation, MacGraw-Hill, New York International Book Company*.

Saaty, T. L. (1996). Decision making with dependence and feedback: The analytic network process. *RWS Publications, ISBN 0-9620317-9-8*.

Şahin, R. and Altun, F. (2020). Decision making with MABAC method under probabilistic single-valued neutrosophic hesitant fuzzy environment. *Journal of Ambient Intelligence and Humanized Computing*. 11(10).

Shahi, E., Alavipoor, F. S. and Karimi, S. (2018). The development of nuclear power plants by means of modified model of Fuzzy DEMATEL and GIS in Bushehr, Iran. *Renewable and Sustainable Energy Reviews*. 83.

Sharma, H. K., Roy, J., Kar, S. and Prentkovskis, O. (2018). Multi criteria evaluation framework for prioritizing indian railway stations using modified rough AHP-MABAC method. *Transport and Telecommunication*. 19(2), 113–127.

Si, S. L., You, X. Y., Liu, H. C. and Huang, J. (2017). Identifying key performance indicators for holistic hospital management with a modified DEMATEL approach. *International Journal of Environmental Research and Public Health*. 14(8).

Si, S. L., You, X. Y., Liu, H. C. and Zhang, P. (2018). DEMATEL Technique: A Systematic Review of the State-of-the-Art Literature on Methodologies and Applications. In *Mathematical Problems in Engineering*. 2018.

Siksnelyte, I., Zavadskas, E. K., Streimikiene, D. and Sharma, D. (2018). An overview of multi-criteria decision-making methods in dealing with sustainable energy development issues. *Energies*. 11 (10).

Smarandache, F. (1998). Neutrosophy: neutrosophic probability, set, and logic: analytic synthesis and synthetic analysis. *Rehoboth: American Research Press*.

Suh, Y., Park, Y. and Kang, D. (2019). Evaluating mobile services using integrated weighting approach and fuzzy VIKOR. *PLoS ONE*. 14(6).

Tan, Q., Gao, R., Wei, Y., Zhang, C. and Liu, Y. (2016). Analysis of biomass power generation based on the DEMATEL method. *Journal of Biobased Materials and Bioenergy*. 10(4).

Tan, R. and Zhang, W. (2020). Multiple attribute decision making method based on DEMATEL and fuzzy distance of trapezoidal fuzzy neutrosophic numbers and its application in typhoon disaster evaluation. *Journal of Intelligent and Fuzzy Systems*. 39(3).

Tian, G., Liu, X., Zhang, M., Yang, Y., Zhang, H., Lin, Y., Ma, F., Wang, X., Qu, T. and Li, Z. (2019). Selection of take-back pattern of vehicle reverse logistics in China via Grey-DEMATEL and fuzzy-VIKOR combined method. *Journal of Cleaner Production*. 220.

Tsai, S. B., Zhou, J., Gao, Y., Wang, J., Li, G., Zheng, Y., Ren, P. and Xu, W. (2017). Combining FMEA with DEMATEL models to solve production process problems. *PLoS ONE*. 12(8).

Tseng, M. L. (2009). Using the extension of DEMATEL to integrate hotel service quality perceptions into a cause-effect model in uncertainty. *Expert Systems with Applications*. 36(5).

Tseng, M. L. and Lin, Y. H. (2009). Application of fuzzy DEMATEL to develop a cause and effect model of municipal solid waste management in Metro Manila. *Environmental Monitoring and Assessment*. 158(1–4).

Tzeng, G. H. and Huang, J. J. (2011). Multiple attribute decision making: Methods and applications. *Multiple Attribute Decision Making: Methods and Applications*. 1–333.

United Nations (UN). Transforming our world: The 2030 agenda for sustainable development; United Nations: New York, NY, USA, 2015.

Uluçay, V., Deli, I. and Şahin, M. (2018). Similarity measures of bipolar neutrosophic sets and their application to multiple criteria decision making. *Neural Computing and Applications*. 29(3).

Venier, F. and Yabar, H. (2017). Renewable energy recovery potential towards sustainable cattle manure management in Buenos Aires Province: Site selection based on GIS spatial analysis and statistics. *Journal of Cleaner Production*. 162.

Vincke, P. and Brans, J. P. (1985). A preference ranking organization method. The PROMETHEE method for MCDM. *Management Science*. 31(6), 647–656.

Visalakshmi, S., Lakshmi, P., Shama, M. S. and Vijayakumar, K. (2015). An integrated fuzzy DEMATEL-TOPSIS approach for financial performance evaluation of GREENEX industries. *International Journal of Operational Research*. 23(3).

Wang, H., Madiraju, P., Zhang, Y. and Sunderraman, R. (2004). *Interval Neutrosophic Sets*.

Wang, H., Zhang, Y. and Sunderraman, R. (2010). Single valued neutrosophic sets. *Fuzzy Sets, Rough Sets and Multivalued Operations and Applications*. 3(1).

Wang, J. J., Jing, Y. Y., Zhang, C. F. and Zhao, J. H. (2009). Review on multi-criteria decision analysis aid in sustainable energy decision-making. *Renewable and Sustainable Energy Reviews*. 13(9).

Wang, J. Q. and Li, X. E. (2015). TODIM method with multi-valued neutrosophic sets. *Kongzhi Yu Juece/Control and Decision*. 30(6).

Wang, L., Zhang, H. Yu, and Wang, J. Qiang. (2018). Frank choquet bonferroni mean operators of bipolar neutrosophic sets and their application to multi-criteria decision-making problems. *International Journal of Fuzzy Systems*. 20(1).

Wang, M. and Liu, P. (2011). An extended VIKOR method for investment risk assessment of real estate based on the uncertain linguistic variables. *Advances in Information Sciences and Service Sciences*. 3(7).

Wang, P., Wang, J., Wei, G., Wei, C. and Wei, Y. (2019). The multi-attributive border approximation area comparison (MABAC) for multiple attribute group decision making under 2-tuple linguistic neutrosophic environment. *Informatica (Netherlands)*. 30(4).

Wang, W., Tian, Y., Zhu, Q. and Zhong, Y. (2017). Barriers for household e-waste collection in China: Perspectives from formal collecting enterprises in Liaoning Province. *Journal of Cleaner Production*. 153.

Wei, G., Wei, C., Wu, J. and Wang, H. (2019). Supplier selection of medical consumption products with a probabilistic linguistic MABAC method. *International Journal of Environmental Research and Public Health*. 16(24).

Wu, K. J., Chen, Q., Qi, Y., Jiang, X., Gao, S. and Tseng, M. L. (2019). Sustainable development performance for small and medium enterprises using a fuzzy synthetic method-DEMATEL. *Sustainability (Switzerland)*. 11(15).

Xu, D., Cui, X., Xian, H., Hong, Y. and Hu, D. (2020a). A novel TOPSIS-MABAC method for multi-attribute decision making with interval neutrosophic set. *IAENG International Journal of Applied Mathematics*. 50(2), 1–6.

Xu, D. S., Wei, C. and Wei, G. W. (2017). TODIM method for single-valued neutrosophic multiple attribute decision making. *Information (Switzerland)*. 8(4).

Xu, D., Xian, H., Cui, X. and Hong, Y. (2020b). A new single-valued neutrosophic distance for TOPSIS, MABAC and new similarity measure in multi-attribute decision-making. *IAENG International Journal of Applied Mathematics*. 50(1).

Xu, Z. (2006). A note on linguistic hybrid arithmetic averaging operator in multiple attribute group decision making with linguistic information. *Group Decision and Negotiation*. 15(6).

Xue-Guo, X., Shi, H., Li-Jun, Z. and Hu-Chen, L. (2019). Green supplier evaluation and selection with an extended MABAC method under the heterogeneous information environment. *Sustainability (Switzerland)*. 11(23).

Xue, Y. X., You, J. X., Lai, X. D. and Liu, H. C. (2016). An interval-valued intuitionistic fuzzy MABAC approach for material selection with incomplete weight information. *Applied Soft Computing Journal*. 38.

Yang, W. and Pang, Y. (2018). New multiple attribute decision making method based on DEMATEL and TOPSIS for multi-valued interval neutrosophic sets. *Symmetry*. 10(4).

Ye, J. (2014). Some aggregation operators of interval neutrosophic linguistic numbers for multiple attribute decision making. *Journal of Intelligent and Fuzzy Systems*. 27(5).

Ye, J. (2017). Multiple attribute group decision making based on interval neutrosophic uncertain linguistic variables. *International Journal of Machine Learning and Cybernetics*. 8(3), 837–848.

Ye, J., Fang, Z. and Cui, W. (2018). Vector similarity measures of Q-linguistic neutrosophic variable sets and their multi-attribute decision making method. *Symmetry*. 10(10).

Yuan, J. H., Kang, J. G., Zhao, C. H. and Hu, Z. G. (2008). Energy consumption and economic growth: Evidence from China at both aggregated and disaggregated levels. *Energy Economics*. 30(6).

Zadeh, L. A. (1965). Fuzzy sets. *Information and Control*. 8(3), 338–353.

Zadeh, L. A. (1975). The concept of a linguistic variable and its application to approximate reasoning-I. *Information Sciences*. 8(3).

Zamri, N. and Abdullah, L. (2014). A new positive and negative linguistic variable of interval triangular type-2 fuzzy sets for mcdm. *Advances in Intelligent Systems and Computing*. 287.

Zhang, J., Yang, D., Li, Q., Lev, B. and Ma, Y. (2021). Research on sustainable supplier selection based on the rough dematel and fvikor methods. *Sustainability (Switzerland)*. 13(1).

Zhang, L., Cheng, S. and Liu, P. (2020). Probability multi-valued neutrosophic ELECTRE method for multi-criteria group decision-making. *Journal of Intelligent and Fuzzy Systems*. 39(5).

Zhang, W. R. (1998). (Yin) (Yang) bipolar fuzzy sets. *1998 IEEE International Conference on Fuzzy Systems Proceedings - IEEE World Congress on Computational Intelligence*. 1, 835–840.

Zhang, X. and Su, J. (2019). A combined fuzzy DEMATEL and TOPSIS approach for estimating participants in knowledge-intensive crowdsourcing. *Computers and Industrial Engineering*. 137.

Zhao, C., Ma, L., Huo, L., Liu, Y. and Zhao, X. (2017). Important degree evaluation of test equipment based on fuzzy DEMATEL and fuzzy hierarchical TOPSIS. *Proceedings of 2016 11th International Conference on Reliability, Maintainability and Safety: Integrating Big Data, Improving Reliability and Serving Personalization, ICRMS 2016*.

LIST OF PUBLICATIONS

JOURNAL

1. Rahim, N., Abdullah, L. and Yusoff, B. (2020). A border approximation area approach considering bipolar neutrosophic linguistic variable for sustainable energy selection. *Sustainability*, 12(10), 3971. (SCOPUS)
2. Abdullah, L. and Rahim, S. N. (2020). Bipolar neutrosophic DEMATEL for urban sustainable development. *Journal of Intelligent and Fuzzy Systems*, 39(5), 6109-6119. (SCOPUS)

APPENDICES

Appendix 1

Summary of literature on MCDM methods

MCDM method	Abbreviation	Proposed by	Findings	Gaps
Decision making trial and evaluation laboratory	DEMATEL	Dalalah (2009)	• Could be able to address the cause-effect the relationship of the complex structure • Can be used to determine the weights of criteria	• Focused on identifying the interrelationship among criteria and weighting of the criteria
Analytical hierarchy process	AHP	Saaty (1980)	• Introduce an Eigen-value approach to the pairwise comparisons survey • A simple computation based on the hierarchical structure of the problem • The inconsistency index calculation to reduce the inconsistency of the decision makers' judgments	• Cannot be applied in complex decision environment
Analytic network process	ANP	Saaty (1996)	• Can deal with interdependencies and feedbacks among criteria • Can be used to weight the criteria and rank the alternatives	• Did not consider the different weights of clusters • The 9-scale pairwise comparisons is long and confusing
Multi-attributive border approximation area comparison	MABAC	Pamučar and Ćirović (2015)	• Can be used to rank the alternative from the border approximation area	• Focused to evaluate the alternatives

Preference ranking organization method for enrichment evaluation	PROMETHEE	Vincke and Brans (1985)	• An outranking method based on the preference function selection for each criterion of the MCDM problem	• Unable to differentiate the criteria
Technique for order preference by similarity to ideal solution	TOPSIS	Hwang and Yoon (1981a)	• Can be used to obtain the best of alternatives to the MCDM problem by choosing the closest to ideal solution	• Did not consider the bipolarity concept of decision makers during evaluation process
Elimination and choice translating reality	ELECTRE	Benayoun, R., Roy, B. and Sussman, (1966)	• Addressed outrank relations, concordances and discordances for a set of alternatives	• Neglect the importance of bipolar and indeterminacy information
VlseKriterijumska Optimizacija I Kompromisno Resenje	VIKOR	Opricovic (1998)	• Developed for multi-criteria optimization of complex systems • Technique for determining the comprise decision of a set or alternatives according to the nearest measure ideal solution	• Have not considered the conflicting criteria that indicate dependence and feedback
Multi-attribute utility theory	MAUT	Neumann and Morgenstern (1945)	• Making decisions by comparing the risk and uncertainty utility values of a set of criteria in terms of risk and uncertainty	• Used a simple weighting approach to obtain the weights of criteria

Appendix 2

Summary of literature on neutrosophic set

Set	Abbreviation	Proposed by	Findings	Gaps
Neutrosophic set	NS	Smarandache (1998)	• Generalizes the classical set, fuzzy set and intuitionistic fuzzy set • Introduce the indeterminacy membership degree • Can handle the incomplete information	• Cannot be applied to real world problem because of its open unit interval $]0^-, 1^+[$.
Single-valued neutrosophic set	SVNS	Wang *et al*., (2010)	• Can be applied to the real application with its standard unit interval [0,1] • Can handle the indeterminacy, incomplete and inconsistent information	• Only provide single judgements and did not consider bipolarity judgements
Interval neutrosophic set	INS	Wang *et al*., (2004)	• Generalizes the interval valued fuzzy set, intuitionistic fuzzy set and para	• Did not consider the bipolarity information
Neutrosophic soft set	NSS	Kumar Maji (2013)	• Can deal with uncertainty, indeterminacy and incomplete information in a parametric manner	• Focused on theoretical set development and has limitations on decision making applications
Multi-valued neutrosophic set	MVNS	Wang and Li, (2015)	• Can capture the hesitancy information by introducing a set of numerical numbers within [0,1]	• Did not consider the bipolarity information
Complex neutrosophic set	CNS	Ali and Smarandache, (2017)	• Introduce the complex-valued for truth membership, indeterminate membership and falsehood membership functions	• Did not consider the bipolarity information

Appendix 3

Summary of literature on sustainable energy

Current Method	Existing literature	Findings	Gaps
DEMATEL method	Kazemi *et al*., (2013)	• Help countries and cities to select most effective strategy against carbon dioxide and air pollution	• Did not investigate the weight of sustainable strategies factors
DEMATEL method	Tan *et al*., (2016)	• Explored the factors that affect the industry development • Provided to improve advice and constructive measures to the optimization of biomass power generation industries	• Only consider one alternative of renewable energy which is biomass power generation
DEMATEL and ANP methods	Büyüközkan and Güleryüz (2016)	• Selected the most appropriate renewable energy resources in Turkey from an investor-focused perspective	• Did not investigate the weight of factors
Delphi technique	(Barry *et al*., 2009b)	• Identified the most important factors that can be used by decision makers to ensure better selection of sustainable energy technologies and projects	• Did not use MCDM methods in analysing the sustainable energy
Delphi method, AHP and fuzzy logic	Hsueh and Yan (2011)	• Provided the government with a reference and criteria to evaluate the performance of low-carbon community construction projects	• Did not consider bipolarity, indeterminacy and uncertainty information
Entropy TOPSIS method	Bhowmik, Gangwar, *et al*., (2018)	• Selected the optimum green energy sources for sustainable energy planning from a set of alternatives	• Did not consider bipolarity, indeterminacy and uncertainty information
AHP and TOPSIS methods	Okokpujie *et al*., (2020)	• Selected the suitable material for developing the horizontal wind turbine blade for sustainable energy generation	• Did not consider bipolarity, indeterminacy

			and uncertainty information
Fuzzy AHP and Fuzzy VIKOR	Büyüközkan *et al.*, (2020)	• Selected the most appropriate sustainable energy technology	• Did not consider bipolarity, indeterminacy and uncertainty information
ARAS, MABAC, COPRAS and MOOSRA methods	Bose *et al.*, (2020)	• Selected the best hybrid composite material • Recovered of environmental friendly renewable energy for the society by fabricating the best hybrid green composite for sustainable development	• Focused on the ranking attribute

Appendix 4

Clarification from Prof. Dr. Florentin Smarandache

Gmail **siti nuraini <snaini276@gmail.com>**

Asking for Clarification

Florentin Smarandache <fsmarandache@gmail.com> Sat, Nov 7, 2020 at 1:56 AM
To: siti nuraini <snaini276@gmail.com>

Dear Nuraini,

Thank you for the message.
Yes, you are right.

As you know, each theory improves and improves.
At the beginning the neutrosophic inequalities and operators were less accurate.

I mean: (t1, i1, f1) <= (t2, i2, f2)
was defined as: t1 <= t2, i1 <= i2, and f1 >= f2.

But later it was improved because "i" and "f" are considered as negative qualities, so they should bear the same inequality symbol, while "t" is considered as positive quality, i.e.
(t1, i1, f1) <= (t2, i2, f2)
was improved to: t1 <= t2, i1 >= i2, and f1 >= f2.

Similarly for intervals' comparison:

[t1, t2] <= [t3, t4]
iff t1 <= t3 and t2 <= t4.

If we have interval neutrosophic sets:
([t1, t2], [i1, i2], [f1, f2]) <= ([t3, t4], [i3, i4], [f3, f4])
then:
t1 <= t3, t2 <= t4
i1 >= i3, i2 >= i4
f1 >= f3, f2 >= f4
See http://fs.unm.edu/INSL.pdf

Take the last developments of neutrosophics.

See also my next email.

Florentin
[Quoted text hidden]
--
Prof. Dr. Florentin Smarandache, Postdoc
University of New Mexico
Mathematics and Science Division
705 Gurley Ave., Gallup, NM 87301, USA
http://fs.unm.edu/FlorentinSmarandache.htm

Appendix 5

Details of decision makers

Decision makers	Name	Gender	Age	Email	Name of company/institute	Position in company/institute	Expertise in the Sustainable Energy field	Experience in the Sustainable Energy field (years)
d_1	Jafferi bin Jamaludin	Male	41 to 50	jafferi@um.edu.my	Universiti Malaya	Senior Lecturer	Power and Energy	5
d_2	Ahmad Firdaus	Male	31 to 40	ahmadfirdauszali@yahoo.com	Epic Solar Sdn Bhd	Electrical Executive	Operation and Maintenance Solar Power Plant	3
d_3	Ammar Husaini Bin Hussian	Male	31 to 40	ammarhusaini@uctati.edu.my	University College TATI	Lecturer	Electrical power	6
d_4	Jasrul Jamani Bin Jamian	Male	31 to 40	jasrul@fke.utm.my	Universiti Teknologi Malaysia	Senior Lecturer	Power System	7
d_5	Mohd Najib Bin Razali	Male	31 to 40	najibrazali@ump.edu.my	Universiti Malaysia Pahang	Lecturer	Recycling Technology, Separation, Wastewater Treatment, Renewable Energy	10

Appendix 6

Questionnaire to decision makers

QUESTIONNAIRE FOR SUSTAINABLE ENERGY SELECTION

This questionnaire is constructed to assist the assessment of the importance criteria and influence criteria or alternative in Sustainable Energy.

The data collected through this questionnaire could be used to find weight of criteria and rank the alternative using mathematical methods named Decision Making Trial and Evaluation Laboratory (DEMATEL) and Multi-Attributive Border Approximation Area Comparison (MABAC) based on Bipolar Neutrosophic Set.

Fourteen criteria and seven alternatives of Sustainable Energy are adopted in this research.

The questionnaire will take approximately 15-20 minutes to complete.

Your voluntary participation and response are very important to complete my Master's research at the University Malaysia Terengganu.

If you have any inquiry, do not hesitate to contact the researcher:
snaini276@gmail.com or 010-9030291.

* Required

Background & General Information: Personal Details

Please provide us the personal details below. Individual responses to the survey will remain confidential.

1. Name: *

____

2. Gender: *

Mark only one oval.

( ) Male

( ) Female

3. Age: *

Mark only one oval.

- 21 to 30
- 31 to 40
- 41 to 50
- 51 to 60
- 61 above

4. Email: *

5. Name of company/institute: *

6. Position in company/institute: *

7. Expertise: *

8. How many years in the Sustainable Energy field: *

Background of criteria and alternative

Alternative

Seven alternatives of Sustainable Energy that use in this research.

A1: Biomass energy
A2: Biogas energy
A3: Geothermal energy
A4: Hydro energy
A5: Solar energy
A6: Tidal energy
A7: Wind energy

Criteria

Description of research fourteen criteria.

C1) Efficiency:

Efficiency refers to how much useful energy can get from energy resources. The efficiency coefficient is the ratio of output energy to the input energy which is used to evaluate the energy system.

C2) Exergy efficiency:

Exergy efficiency is a second-law efficiency or rational efficiency computes efficiency of a process taking the second law of thermodynamic into account. Exergy accounts for the irreversibility of a process due to an increase in entropy.

C3) Safety:

Safety is one of the groups of related disciplines to the quality, reliability, availability, maintainability, and safety.

C4) NOX emission:

NOX emission is a generic term for mono-nitrogen oxides (NO and NOX emission) which comprises a group of molecules that can contribute to local air pollution, acid deposition and global climate change. NOX is produced during the combustion of fossil fuel and biomass especially combustion at high temperature.

C5) CO2 emission:

CO2 emission is colorless, odorless and tasteless gas that is about one and half times as dense as air under ordinary conditions of temperature and pressure. CO2 is mainly released through the combustion of coal or lignite, oil and natural gas in energy systems.

C6) CO emission:

CO emission is produced from the partial combustion of carbon-containing compounds, notably in internal-combustion engines.

C7) Land use:

Land use is energy systems occupies the environment and landscape are affected directly by the land occupied by energy systems. Land use can also be a social criterion to evaluate energy systems.

C8) Noise:

Noise pollution from energy systems is displeasing machine-created sound that disrupts the activity or balances human and animal life.

C9) Social acceptability:

Social acceptability expresses the overview of opinions related to the energy systems by the local population regarding the hypnotized realization of the projects under review from the consumer point of view.

C10) Job creation:

Energy supply systems employ many people during their life cycle, from construction and operation till decommissioning.

C11) Investment costs:

Investments costs comprise of all costs relating to the purchases of mechanical equipment, technological installations, construction of roads or connections to the national grid, engineering services, drilling and other incidental construction work.

C12) Operation and maintenance cost:

Operation costs include employees' wages and funds spent on the energy, the products and services for the energy system operation. Maintenance costs aims to its operation suspension.

C13) Fuel costs:

Fuel costs are the fund spent on the provision of raw material necessary for energy supply system operation include extraction or mining, transportation and possible fuel processing that use in the power plants.

C14) Electric costs:

Electric costs are the product cost of the power plants to evaluate economic performance from the viewpoint of customers.

PART 1: Importance criteria in Sustainable Energy

This questionnaire to find out the important criteria of Sustainable energy in general.

Please fill the form based on your opinion and experience in Sustainable Energy.

9. What is the importance scale of the following criteria towards Sustainable Energy? *

Mark only one oval per row.

	Very Unimportance	Unimportance	Medium	Importance	Very Importance
Efficiency	⬭	⬭	⬭	⬭	⬭
Exergy efficiency	⬭	⬭	⬭	⬭	⬭
Safety	⬭	⬭	⬭	⬭	⬭
NOX emission	⬭	⬭	⬭	⬭	⬭
CO2 emission	⬭	⬭	⬭	⬭	⬭
CO emission	⬭	⬭	⬭	⬭	⬭
Land use	⬭	⬭	⬭	⬭	⬭
Noise	⬭	⬭	⬭	⬭	⬭
Social acceptability	⬭	⬭	⬭	⬭	⬭
Job creation	⬭	⬭	⬭	⬭	⬭
Investment cost	⬭	⬭	⬭	⬭	⬭
Operation and maintenance cost	⬭	⬭	⬭	⬭	⬭
Fuel cost	⬭	⬭	⬭	⬭	⬭
Electric cost	⬭	⬭	⬭	⬭	⬭

PART 2 : Weight between criteria

This questionnaire aims to find out the weight of criteria by using the Bipolar Neutrosophic DEMATEL method. This form asks whether one criterion will influence by other criteria in Sustainable Energy.

Please fill the form based on your opinion and experience in Sustainable Energy.

10. 1) Does Efficiency (C1) influence the criteria below in Sustainable Energy? *

Mark only one oval per row.

	No Influence	Low Influence	Medium Influence	High Influence	Very High Influence
Exergy efficiency	◯	◯	◯	◯	◯
Safety	◯	◯	◯	◯	◯
NOX emission	◯	◯	◯	◯	◯
CO2 emission	◯	◯	◯	◯	◯
CO emission	◯	◯	◯	◯	◯
Land use	◯	◯	◯	◯	◯
Noise	◯	◯	◯	◯	◯
Social acceptability	◯	◯	◯	◯	◯
Job creation	◯	◯	◯	◯	◯
Investment cost	◯	◯	◯	◯	◯
Operation and maintenance cost	◯	◯	◯	◯	◯
Fuel cost	◯	◯	◯	◯	◯
Electric cost	◯	◯	◯	◯	◯

11. 2) Does Exergy efficiency (C2) influence the criteria below in Sustainable Energy? *

Mark only one oval per row.

	No Influence	Low Influence	Medium Influence	High Influence	Very High Influence
Efficiency	⬭	⬭	⬭	⬭	⬭
Safety	⬭	⬭	⬭	⬭	⬭
NOX emission	⬭	⬭	⬭	⬭	⬭
CO2 emission	⬭	⬭	⬭	⬭	⬭
CO emission	⬭	⬭	⬭	⬭	⬭
Land use	⬭	⬭	⬭	⬭	⬭
Noise	⬭	⬭	⬭	⬭	⬭
Social acceptability	⬭	⬭	⬭	⬭	⬭
Job creation	⬭	⬭	⬭	⬭	⬭
Investment cost	⬭	⬭	⬭	⬭	⬭
Operation and maintenance cost	⬭	⬭	⬭	⬭	⬭
Fuel cost	⬭	⬭	⬭	⬭	⬭
Electric cost	⬭	⬭	⬭	⬭	⬭

12. 3) Does Safety (C3) influence the criteria below in Sustainable Energy? *

Mark only one oval per row.

	No Influence	Low Influence	Medium Influence	High Influence	Very High Influence
Efficiency	⬭	⬭	⬭	⬭	⬭
Exergy efficiency	⬭	⬭	⬭	⬭	⬭
NOX emission	⬭	⬭	⬭	⬭	⬭
CO2 emission	⬭	⬭	⬭	⬭	⬭
CO emission	⬭	⬭	⬭	⬭	⬭
Land use	⬭	⬭	⬭	⬭	⬭
Noise	⬭	⬭	⬭	⬭	⬭
Social acceptability	⬭	⬭	⬭	⬭	⬭
Job creation	⬭	⬭	⬭	⬭	⬭
Investment cost	⬭	⬭	⬭	⬭	⬭
Operation and maintenance cost	⬭	⬭	⬭	⬭	⬭
Fuel cost	⬭	⬭	⬭	⬭	⬭
Electric cost	⬭	⬭	⬭	⬭	⬭

13. 4) Does NOX emission (C4) influence the criteria below in Sustainable Energy? *

Mark only one oval per row.

	No Influence	Low Influence	Medium Influence	High Influence	Very High Influence
Efficiency					
Exergy efficiency					
Safety					
CO2 emission					
CO emission					
Land use					
Noise					
Social acceptability					
Job creation					
Investment cost					
Operation and maintenance cost					
Fuel cost					
Electric cost					

14. 5) Does CO2 emission (C5) influence the criteria below in Sustainable Energy? *

Mark only one oval per row.

	No Influence	Low Influence	Medium Influence	High Influence	Very High Influence
Efficiency	⬭	⬭	⬭	⬭	⬭
Exergy efficiency	⬭	⬭	⬭	⬭	⬭
Safety	⬭	⬭	⬭	⬭	⬭
NOX emission	⬭	⬭	⬭	⬭	⬭
CO emission	⬭	⬭	⬭	⬭	⬭
Land use	⬭	⬭	⬭	⬭	⬭
Noise	⬭	⬭	⬭	⬭	⬭
Social acceptability	⬭	⬭	⬭	⬭	⬭
Job creation	⬭	⬭	⬭	⬭	⬭
Investment cost	⬭	⬭	⬭	⬭	⬭
Operation and maintenance cost	⬭	⬭	⬭	⬭	⬭
Fuel cost	⬭	⬭	⬭	⬭	⬭
Electric cost	⬭	⬭	⬭	⬭	⬭

15. 6) Does CO emission (C6) influence the criteria below in Sustainable Energy? *

Mark only one oval per row.

	No Influence	Low Influence	Medium Influence	High Influence	Very High Influence
Efficiency	⬭	⬭	⬭	⬭	⬭
Exergy efficiency	⬭	⬭	⬭	⬭	⬭
Safety	⬭	⬭	⬭	⬭	⬭
NOX emission	⬭	⬭	⬭	⬭	⬭
CO2 emission	⬭	⬭	⬭	⬭	⬭
Land use	⬭	⬭	⬭	⬭	⬭
Noise	⬭	⬭	⬭	⬭	⬭
Social acceptability	⬭	⬭	⬭	⬭	⬭
Job creation	⬭	⬭	⬭	⬭	⬭
Investment cost	⬭	⬭	⬭	⬭	⬭
Operation and maintenance cost	⬭	⬭	⬭	⬭	⬭
Fuel cost	⬭	⬭	⬭	⬭	⬭
Electric cost	⬭	⬭	⬭	⬭	⬭

16. 7) Does Land use (C7) influence the criteria below in Sustainable Energy? *

Mark only one oval per row.

	No Influence	Low Influence	Medium Influence	High Influence	Very High Influence
Efficiency	⬭	⬭	⬭	⬭	⬭
Exergy efficiency	⬭	⬭	⬭	⬭	⬭
Safety	⬭	⬭	⬭	⬭	⬭
NOX emission	⬭	⬭	⬭	⬭	⬭
CO2 emission	⬭	⬭	⬭	⬭	⬭
CO emission	⬭	⬭	⬭	⬭	⬭
Noise	⬭	⬭	⬭	⬭	⬭
Social acceptability	⬭	⬭	⬭	⬭	⬭
Job creation	⬭	⬭	⬭	⬭	⬭
Investment cost	⬭	⬭	⬭	⬭	⬭
Operation and maintenance cost	⬭	⬭	⬭	⬭	⬭
Fuel cost	⬭	⬭	⬭	⬭	⬭
Electric cost	⬭	⬭	⬭	⬭	⬭

17. 8) Does Noise (C8) influence the criteria below in Sustainable Energy? *

Mark only one oval per row.

	No Influence	Low Influence	Medium Influence	High Influence	Very High Influence
Efficiency	⬭	⬭	⬭	⬭	⬭
Exergy efficiency	⬭	⬭	⬭	⬭	⬭
Safety	⬭	⬭	⬭	⬭	⬭
NOX emission	⬭	⬭	⬭	⬭	⬭
CO2 emission	⬭	⬭	⬭	⬭	⬭
CO emission	⬭	⬭	⬭	⬭	⬭
Land use	⬭	⬭	⬭	⬭	⬭
Social acceptability	⬭	⬭	⬭	⬭	⬭
Job creation	⬭	⬭	⬭	⬭	⬭
Investment cost	⬭	⬭	⬭	⬭	⬭
Operation and maintenance cost	⬭	⬭	⬭	⬭	⬭
Fuel cost	⬭	⬭	⬭	⬭	⬭
Electric cost	⬭	⬭	⬭	⬭	⬭

18. 9) Does Social acceptability (C9) influence the criteria below in Sustainable Energy? *

Mark only one oval per row.

	No Influence	Low Influence	Medium Influence	High Influence	Very High Influence
Efficiency	⬭	⬭	⬭	⬭	⬭
Exergy efficiency	⬭	⬭	⬭	⬭	⬭
Safety	⬭	⬭	⬭	⬭	⬭
NOX emission	⬭	⬭	⬭	⬭	⬭
CO2 emission	⬭	⬭	⬭	⬭	⬭
CO emission	⬭	⬭	⬭	⬭	⬭
Land use	⬭	⬭	⬭	⬭	⬭
Noise	⬭	⬭	⬭	⬭	⬭
Job creation	⬭	⬭	⬭	⬭	⬭
Investment cost	⬭	⬭	⬭	⬭	⬭
Operation and maintenance cost	⬭	⬭	⬭	⬭	⬭
Fuel cost	⬭	⬭	⬭	⬭	⬭
Electric cost	⬭	⬭	⬭	⬭	⬭

19. 10) Does Job creation (C10) influence the criteria below in Sustainable Energy? *

Mark only one oval per row.

	No Influence	Low Influence	Medium Influence	High Influence	Very High Influence
Efficiency					
Exergy efficiency					
Safety					
NOX emission					
CO2 emission					
CO emission					
Land use					
Noise					
Social acceptability					
Investment cost					
Operation and maintenance cost					
Fuel cost					
Electric cost					

20. 11) Does Investment cost (C11) influence the criteria below in Sustainable Energy? *

Mark only one oval per row.

	No Influence	Low Influence	Medium Influence	High Influence	Very High Influence
Efficiency	◯	◯	◯	◯	◯
Exergy efficiency	◯	◯	◯	◯	◯
Safety	◯	◯	◯	◯	◯
NOX emission	◯	◯	◯	◯	◯
CO2 emission	◯	◯	◯	◯	◯
CO emission	◯	◯	◯	◯	◯
Land use	◯	◯	◯	◯	◯
Noise	◯	◯	◯	◯	◯
Social acceptability	◯	◯	◯	◯	◯
Job creation	◯	◯	◯	◯	◯
Operation and maintenance cost	◯	◯	◯	◯	◯
Fuel cost	◯	◯	◯	◯	◯
Electric cost	◯	◯	◯	◯	◯

21. 12) Does Operation and maintenance cost (C12) influence the criteria below in Sustainable Energy? *

Mark only one oval per row.

	No Influence	Low Influence	Medium Influence	High Influence	Very High Influence
Efficiency	⬭	⬭	⬭	⬭	⬭
Exergy efficiency	⬭	⬭	⬭	⬭	⬭
Safety	⬭	⬭	⬭	⬭	⬭
NOX emission	⬭	⬭	⬭	⬭	⬭
CO2 emission	⬭	⬭	⬭	⬭	⬭
CO emission	⬭	⬭	⬭	⬭	⬭
Land use	⬭	⬭	⬭	⬭	⬭
Noise	⬭	⬭	⬭	⬭	⬭
Social acceptability	⬭	⬭	⬭	⬭	⬭
Job creation	⬭	⬭	⬭	⬭	⬭
Investment cost	⬭	⬭	⬭	⬭	⬭
Fuel cost	⬭	⬭	⬭	⬭	⬭
Electric cost	⬭	⬭	⬭	⬭	⬭

22. 13) Does Fuel cost (C13) influence the criteria below in Sustainable Energy? *

Mark only one oval per row.

	No Influence	Low Influence	Medium Influence	High Influence	Very High Influence
Efficiency					
Exergy efficiency					
Safety					
NOX emission					
CO2 emission					
CO emission					
Land use					
Noise					
Social acceptability					
Job creation					
Investment cost					
Operation and maintenance cost					
Electric cost					

23. 14) Does Electric cost (C14) influence the criteria below in Sustainable Energy? *

Mark only one oval per row.

	No Influence	Low Influence	Medium Influence	High Influence	Very High Influence
Efficiency					
Exergy efficiency					
Safety					
NOX emission					
CO2 emission					
CO emission					
Land use					
Noise					
Social acceptability					
Job creation					
Investment cost					
Operation and maintenance cost					
Fuel cost					

PART 3 : Rank the alternative

This questionnaire aims to select the optimal alternative with rank the alternative by using the Bipolar Neutrosophic MABAC method. This form asks whether each alternative influences the criteria in Sustainable Energy.

Please fill the form based on your opinion and experience in Sustainable Energy. Thank you.

24. 1) To what extent, the following criteria influence Biomass energy (A1)? *

Mark only one oval per row.

	No Influence	Low Influence	Medium Influence	High Influence	Very High Influence
Efficiency	⬭	⬭	⬭	⬭	⬭
Exergy efficiency	⬭	⬭	⬭	⬭	⬭
Safety	⬭	⬭	⬭	⬭	⬭
NOX emission	⬭	⬭	⬭	⬭	⬭
CO2 emission	⬭	⬭	⬭	⬭	⬭
CO emission	⬭	⬭	⬭	⬭	⬭
Land use	⬭	⬭	⬭	⬭	⬭
Noise	⬭	⬭	⬭	⬭	⬭
Social acceptability	⬭	⬭	⬭	⬭	⬭
Job creation	⬭	⬭	⬭	⬭	⬭
Investment cost	⬭	⬭	⬭	⬭	⬭
Operation and maintenance cost	⬭	⬭	⬭	⬭	⬭
Fuel cost	⬭	⬭	⬭	⬭	⬭
Electric cost	⬭	⬭	⬭	⬭	⬭

25. 2) To what extent, the following criteria influence Biogas energy (A2)? *

Mark only one oval per row.

	No Influence	Low Influence	Medium Influence	High Influence	Very High Influence
Efficiency	⬭	⬭	⬭	⬭	⬭
Exergy efficiency	⬭	⬭	⬭	⬭	⬭
Safety	⬭	⬭	⬭	⬭	⬭
NOX emission	⬭	⬭	⬭	⬭	⬭
CO2 emission	⬭	⬭	⬭	⬭	⬭
CO emission	⬭	⬭	⬭	⬭	⬭
Land use	⬭	⬭	⬭	⬭	⬭
Noise	⬭	⬭	⬭	⬭	⬭
Social acceptability	⬭	⬭	⬭	⬭	⬭
Job creation	⬭	⬭	⬭	⬭	⬭
Investment cost	⬭	⬭	⬭	⬭	⬭
Operation and maintenance cost	⬭	⬭	⬭	⬭	⬭
Fuel cost	⬭	⬭	⬭	⬭	⬭
Electric cost	⬭	⬭	⬭	⬭	⬭

26. 3) To what extent, the following criteria influence Geothermal energy (A3)? *

Mark only one oval per row.

	No Influence	Low Influence	Medium Influence	High Influence	Very High Influence
Efficiency	⬭	⬭	⬭	⬭	⬭
Exergy efficiency	⬭	⬭	⬭	⬭	⬭
Safety	⬭	⬭	⬭	⬭	⬭
NOX emission	⬭	⬭	⬭	⬭	⬭
CO2 emission	⬭	⬭	⬭	⬭	⬭
CO emission	⬭	⬭	⬭	⬭	⬭
Land use	⬭	⬭	⬭	⬭	⬭
Noise	⬭	⬭	⬭	⬭	⬭
Social acceptability	⬭	⬭	⬭	⬭	⬭
Job creation	⬭	⬭	⬭	⬭	⬭
Investment cost	⬭	⬭	⬭	⬭	⬭
Operation and maintenance cost	⬭	⬭	⬭	⬭	⬭
Fuel cost	⬭	⬭	⬭	⬭	⬭
Electric cost	⬭	⬭	⬭	⬭	⬭

27. 4) To what extent, the following criteria influence Hydro energy (A4)? *

Mark only one oval per row.

	No Influence	Low Influence	Medium Influence	High Influence	Very High Influence
Efficiency	⬭	⬭	⬭	⬭	⬭
Exergy efficiency	⬭	⬭	⬭	⬭	⬭
Safety	⬭	⬭	⬭	⬭	⬭
NOX emission	⬭	⬭	⬭	⬭	⬭
CO2 emission	⬭	⬭	⬭	⬭	⬭
CO emission	⬭	⬭	⬭	⬭	⬭
Land use	⬭	⬭	⬭	⬭	⬭
Noise	⬭	⬭	⬭	⬭	⬭
Social acceptability	⬭	⬭	⬭	⬭	⬭
Job creation	⬭	⬭	⬭	⬭	⬭
Investment cost	⬭	⬭	⬭	⬭	⬭
Operation and maintenance cost	⬭	⬭	⬭	⬭	⬭
Fuel cost	⬭	⬭	⬭	⬭	⬭
Electric cost	⬭	⬭	⬭	⬭	⬭

28. 5) To what extent, the following criteria influence Solar energy (A5) ? *

Mark only one oval per row.

	No Influence	Low Influence	Medium Influence	High Influence	Very High Influence
Efficiency	⬭	⬭	⬭	⬭	⬭
Exergy efficiency	⬭	⬭	⬭	⬭	⬭
Safety	⬭	⬭	⬭	⬭	⬭
NOX emission	⬭	⬭	⬭	⬭	⬭
CO2 emission	⬭	⬭	⬭	⬭	⬭
CO emission	⬭	⬭	⬭	⬭	⬭
Land use	⬭	⬭	⬭	⬭	⬭
Noise	⬭	⬭	⬭	⬭	⬭
Social acceptability	⬭	⬭	⬭	⬭	⬭
Job creation	⬭	⬭	⬭	⬭	⬭
Investment cost	⬭	⬭	⬭	⬭	⬭
Operation and maintenance cost	⬭	⬭	⬭	⬭	⬭
Fuel cost	⬭	⬭	⬭	⬭	⬭
Electric cost	⬭	⬭	⬭	⬭	⬭

29. 6) To what extent, the following criteria influence Tidal energy (A6)? *

Mark only one oval per row.

	No Influence	Low Influence	Medium Influence	High Influence	Very High Influence
Efficiency	⬭	⬭	⬭	⬭	⬭
Exergy efficiency	⬭	⬭	⬭	⬭	⬭
Safety	⬭	⬭	⬭	⬭	⬭
NOX emission	⬭	⬭	⬭	⬭	⬭
CO2 emission	⬭	⬭	⬭	⬭	⬭
CO emission	⬭	⬭	⬭	⬭	⬭
Land use	⬭	⬭	⬭	⬭	⬭
Noise	⬭	⬭	⬭	⬭	⬭
Social acceptability	⬭	⬭	⬭	⬭	⬭
Job creation	⬭	⬭	⬭	⬭	⬭
Investment cost	⬭	⬭	⬭	⬭	⬭
Operation and maintenance cost	⬭	⬭	⬭	⬭	⬭
Fuel cost	⬭	⬭	⬭	⬭	⬭
Electric cost	⬭	⬭	⬭	⬭	⬭

30. 7) To what extent, the following criteria influence Wind energy (A7)? *

Mark only one oval per row.

	No Influence	Low Influence	Medium Influence	High Influence	Very High Influence
Efficiency					
Exergy efficiency					
Safety					
NOX emission					
CO2 emission					
CO emission					
Land use					
Noise					
Social acceptability					
Job creation					
Investment cost					
Operation and maintenance cost					
Fuel cost					
Electric cost					

Appendix 7

Decision maker evaluation in linguistic variable of bipolar neutrosophic for DEMATEL method

Decision maker 1 (d_1) evaluation in linguistic variable of bipolar neutrosophic for DEMATEL method

Criteria	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**
C_1	0	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
C_2	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	0	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>
C_3	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	0	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>
C_4	<0.80, 0.20,	<0.50, 0.40,	<0.35, 0.60,	0	<0.50, 0.40,	<0.50, 0.40,	<0.35, 0.60,	<0.35, 0.60,	<0.80, 0.20,	<0.50, 0.40,	<0.50, 0.40,	<0.50, 0.40,	<0.80, 0.20,	<0.50, 0.40,

	0.15, -0.80, -0.20, -0.15>	0.45, -0.50, -0.40, -0.45>	0.70, -0.35, -0.60, -0.70>		0.45, -0.50, -0.40, -0.45>	0.45, -0.50, -0.40, -0.45>	0.70, -0.35, -0.60, -0.70>	0.70, -0.35, -0.60, -0.70>	0.15, -0.80, -0.20, -0.15>	0.45, -0.50, -0.40, -0.45>	0.45, -0.50, -0.40, -0.45>	0.45, -0.50, -0.40, -0.45>	0.15, -0.80, -0.20, -0.15>	0.45, -0.50, -0.40, -0.45>
C5	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	0	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>
C6	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	0	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>
C7	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	0	<0.10, 0.80, 0.90, -0.10, -0.80, -0.90>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>
C8	<0.10, 0.80, 0.90, -0.10, -	<0.10, 0.80, 0.90, -0.10, -	<0.10, 0.80, 0.90, -0.10, -	<0.10, 0.80, 0.90, -0.10, -	<0.10, 0.80, 0.90, -0.10, -	<0.10, 0.80, 0.90, -0.10, -	<0.10, 0.80, 0.90, -0.10, -	0	<0.80, 0.20, 0.15, -0.80, -	<0.35, 0.60, 0.70, -0.35, -	<0.35, 0.60, 0.70, -0.35, -	<0.50, 0.40, 0.45, -0.50, -	<0.35, 0.60, 0.70, -0.35, -	<0.35, 0.60, 0.70, -0.35, -

	0.80, - 0.90>	0.80, - 0.90>	0.80, - 0.90>	0.80, - 0.90>	0.80, - 0.90>	0.80, - 0.90>	0.80, - 0.90>		0.20, - 0.15>	0.60, - 0.70>	0.60, - 0.70>	0.40, - 0.45>	0.60, - 0.70>	0.60, - 0.70>
C_9	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	0	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>
C_{10}	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.10, 0.80, 0.90, - 0.10, - 0.80, - 0.90>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	0	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>
C_{11}	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	0	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>
C_{12}	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	0	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>

C13	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	0	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>
C14	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	0

Decision maker 2 (d_2) evaluation in linguistic variable of bipolar neutrosophic for DEMATEL method

Criteria	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**
C1	0	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>
C2	<0.80, 0.20, 0.15, -0.80, -	0	<0.80, 0.20, 0.15, -0.80, -	<0.80, 0.20, 0.15, -0.80, -	<0.80, 0.20, 0.15, -0.80, -	<0.80, 0.20, 0.15, -0.80, -	<0.50, 0.40, 0.45, -0.50, -	<0.50, 0.40, 0.45, -0.50, -	<0.50, 0.40, 0.45, -0.50, -	<0.80, 0.20, 0.15, -0.80, -	<0.80, 0.20, 0.15, -0.80, -	<0.80, 0.20, 0.15, -0.80, -	<0.50, 0.40, 0.45, -0.50, -	<0.50, 0.40, 0.45, -0.50, -

	0.20, - 0.15>		0.20, - 0.15>	0.20, - 0.15>	0.20, - 0.15>	0.20, - 0.15>	0.40, - 0.45>	0.40, - 0.45>	0.40, - 0.45>	0.20, - 0.15>	0.20, - 0.15>	0.20, - 0.15>	0.40, - 0.45>	0.40, - 0.45>
C_3	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	0	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>
C_4	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	0	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>
C_5	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	0	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>
C_6	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	0	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>

C_7	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	0	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>
C_8	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	0	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>
C_9	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	0	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>
C_{10}	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	0	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>
C_{11}	<0.80, 0.20,	<0.80, 0.20,	<0.80, 0.20,	<0.80, 0.20,	<0.80, 0.20,	<0.80, 0.20,	<0.50, 0.40,	<0.50, 0.40,	<0.80, 0.20,	<0.80, 0.20,	0	<0.90, 0.10,	<0.50, 0.40,	<0.50, 0.40,

	0.15, - 0.80, - 0.20, - 0.15>	0.15, - 0.80, - 0.20, - 0.15>	0.15, - 0.80, - 0.20, - 0.15>	0.15, - 0.80, - 0.20, - 0.15>	0.15, - 0.80, - 0.20, - 0.15>	0.15, - 0.80, - 0.20, - 0.15>	0.45, - 0.50, - 0.40, - 0.45>	0.45, - 0.50, - 0.40, - 0.45>	0.15, - 0.80, - 0.20, - 0.15>	0.15, - 0.80, - 0.20, - 0.15>		0.10, - 0.90, - 0.10, - 0.10>	0.45, - 0.50, - 0.40, - 0.45>	0.45, - 0.50, - 0.40, - 0.45>
C_{12}	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	0	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>
C_{13}	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	0	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>
C_{14}	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	0

Decision maker 3 (d_3) evaluation in linguistic variable of bipolar neutrosophic for DEMATEL method

Criteria	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**
C_1	0	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
C_2	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	0	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>
C_3	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	0	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
C_4	<0.80, 0.20, 0.15, -0.80, -	<0.80, 0.20, 0.15, -0.80, -	<0.50, 0.40, 0.45, -0.50, -	0	<0.50, 0.40, 0.45, -0.50, -	<0.80, 0.20, 0.15, -0.80, -	<0.50, 0.40, 0.45, -0.50, -	<0.50, 0.40, 0.45, -0.50, -	<0.80, 0.20, 0.15, -0.80, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.80, 0.20, 0.15, -0.80, -	<0.80, 0.20, 0.15, -0.80, -	<0.80, 0.20, 0.15, -0.80, -

	0.20, - 0.15>	0.20, - 0.15>	0.40, - 0.45>		0.40, - 0.45>	0.20, - 0.15>	0.40, - 0.45>	0.40, - 0.45>	0.20, - 0.15>	0.10, - 0.10>	0.10, - 0.10>	0.20, - 0.15>	0.20, - 0.15>	0.20, - 0.15>
C_5	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	0	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>
C_6	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	0	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>
C_7	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	0	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>
C_8	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	0	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>

C9	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	0	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>
C10	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	0	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>
C11	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	0	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>
C12	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	0	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>
C13	<0.80, 0.20,	<0.50, 0.40,	<0.50, 0.40,	<0.50, 0.40,	<0.50, 0.40,	<0.80, 0.20,	<0.80, 0.20,	<0.90, 0.10,	<0.90, 0.10,	<0.80, 0.20,	<0.50, 0.40,	<0.80, 0.20,	0	<0.90, 0.10,

	0.15, -0.80, -0.20, -0.15>	0.45, -0.50, -0.40, -0.45>	0.45, -0.50, -0.40, -0.45>	0.45, -0.50, -0.40, -0.45>	0.45, -0.50, -0.40, -0.45>	0.15, -0.80, -0.20, -0.15>	0.15, -0.80, -0.20, -0.15>	0.10, -0.90, -0.10, -0.10>	0.10, -0.90, -0.10, -0.10>	0.15, -0.80, -0.20, -0.15>	0.45, -0.50, -0.40, -0.45>	0.15, -0.80, -0.20, -0.15>		0.10, -0.90, -0.10, -0.10>
C_{14}	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	0

Decision maker 4 (d_4) evaluation in linguistic variable of bipolar neutrosophic for DEMATEL method

Criteria	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**
C_1	0	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
C_2	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	0	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>

C_3	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	0	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>
C_4	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	0	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>
C_5	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	0	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>
C_6	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	0	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>
C_7	<0.50, 0.40,	<0.80, 0.20,	<0.80, 0.20,	<0.50, 0.40,	<0.90, 0.10,	<0.35, 0.60,	0	<0.35, 0.60,	<0.50, 0.40,	<0.50, 0.40,	<0.90, 0.10,	<0.35, 0.60,	<0.50, 0.40,	<0.80, 0.20,

	0.45, - 0.50, - 0.40, - 0.45>	0.15, - 0.80, - 0.20, - 0.15>	0.15, - 0.80, - 0.20, - 0.15>	0.45, - 0.50, - 0.40, - 0.45>	0.10, - 0.90, - 0.10, - 0.10>	0.70, - 0.35, - 0.60, - 0.70>		0.70, - 0.35, - 0.60, - 0.70>	0.45, - 0.50, - 0.40, - 0.45>	0.45, - 0.50, - 0.40, - 0.45>	0.10, - 0.90, - 0.10, - 0.10>	0.70, - 0.35, - 0.60, - 0.70>	0.45, - 0.50, - 0.40, - 0.45>	0.15, - 0.80, - 0.20, - 0.15>
C_8	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	0	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>
C_9	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	0	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>
C_{10}	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	0	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>
C_{11}	<0.80, 0.20, 0.15, - 0.80, -	<0.90, 0.10, 0.10, - 0.90, -	<0.90, 0.10, 0.10, - 0.90, -	<0.80, 0.20, 0.15, - 0.80, -	<0.80, 0.20, 0.15, - 0.80, -	<0.80, 0.20, 0.15, - 0.80, -	<0.80, 0.20, 0.15, - 0.80, -	<0.80, 0.20, 0.15, - 0.80, -	<0.80, 0.20, 0.15, - 0.80, -	<0.80, 0.20, 0.15, - 0.80, -	0	<0.80, 0.20, 0.15, - 0.80, -	<0.80, 0.20, 0.15, - 0.80, -	<0.80, 0.20, 0.15, - 0.80, -

	0.20, - 0.15>	0.10, - 0.10>	0.10, - 0.10>	0.20, - 0.15>	0.20, - 0.15>	0.20, - 0.15>	0.20, - 0.15>	0.20, - 0.15>	0.20, - 0.15>	0.20, - 0.15>		0.20, - 0.15>	0.20, - 0.15>	0.20, - 0.15>
C_{12}	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	0	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>
C_{13}	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	0	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>
C_{14}	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	0

Decision maker 5 (d_5) evaluation in linguistic variable of bipolar neutrosophic for DEMATEL method

Criteria	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**
C_1	0	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>
C_2	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	0	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>
C_3	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	0	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>
C_4	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	0	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -

	0.10, - 0.10>	0.10, - 0.10>	0.10, - 0.10>		0.10, - 0.10>	0.10, - 0.10>	0.10, - 0.10>	0.10, - 0.10>	0.10, - 0.10>	0.10, - 0.10>	0.10, - 0.10>	0.10, - 0.10>	0.10, - 0.10>	0.10, - 0.10>
C_5	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	0	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>
C_6	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	0	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>
C_7	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	0	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>
C_8	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	0	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>

C9	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	0	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>
C10	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	0	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>
C11	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	0	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>
C12	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	0	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>
C13	<0.90, 0.10,	<0.90, 0.10,	<0.90, 0.10,	<0.90, 0.10,	<0.90, 0.10,	<0.90, 0.10,	<0.90, 0.10,	<0.90, 0.10,	<0.90, 0.10,	<0.90, 0.10,	<0.90, 0.10,	<0.90, 0.10,	0	<0.90, 0.10,

	0.10, - 0.90, - 0.10, - 0.10>	0.10, - 0.90, - 0.10, - 0.10>	0.10, - 0.90, - 0.10, - 0.10>	0.10, - 0.90, - 0.10, - 0.10>	0.10, - 0.90, - 0.10, - 0.10>	0.10, - 0.90, - 0.10, - 0.10>	0.10, - 0.90, - 0.10, - 0.10>	0.10, - 0.90, - 0.10, - 0.10>	0.10, - 0.90, - 0.10, - 0.10>	0.10, - 0.90, - 0.10, - 0.10>	0.10, - 0.90, - 0.10, - 0.10>	0.10, - 0.90, - 0.10, - 0.10>		0.10, - 0.90, - 0.10, - 0.10>
C_{14}	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	0

Appendix 8

Decision maker evaluation in linguistic variable of bipolar neutrosophic for MABAC method

Decision maker 1 (d_1) evaluation in linguistic variable of bipolar neutrosophic for MABAC method

Criteria	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}
A_1	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
A_2	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
A_3	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.35, 0.60, 0.70, -0.35, -0.60, -0.70>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
A_4	<0.80, 0.20,	<0.50, 0.40,	<0.80, 0.20,	<0.80, 0.20,	<0.80, 0.20,	<0.80, 0.20,	<0.35, 0.60,	<0.35, 0.60,	<0.90, 0.10,	<0.50, 0.40,	<0.80, 0.20,	<0.80, 0.20,	<0.80, 0.20,	<0.80, 0.20,

	0.15, - 0.80, - 0.20, - 0.15>	0.45, - 0.50, - 0.40, - 0.45>	0.15, - 0.80, - 0.20, - 0.15>	0.15, - 0.80, - 0.20, - 0.15>	0.15, - 0.80, - 0.20, - 0.15>	0.15, - 0.80, - 0.20, - 0.15>	0.70, - 0.35, - 0.60, - 0.70>	0.70, - 0.35, - 0.60, - 0.70>	0.10, - 0.90, - 0.10, - 0.10>	0.45, - 0.50, - 0.40, - 0.45>	0.15, - 0.80, - 0.20, - 0.15>	0.15, - 0.80, - 0.20, - 0.15>	0.15, - 0.80, - 0.20, - 0.15>	0.15, - 0.80, - 0.20, - 0.15>
A_5	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>
A_6	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>
A_7	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.35, 0.60, 0.70, - 0.35, - 0.60, - 0.70>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>

Decision maker 2 (d_2) evaluation in linguistic variable of bipolar neutrosophic for MABAC method

Criteria	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}
A_1	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
A_2	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
A_3	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>
A_4	<0.80, 0.20, 0.15, -0.80, -	<0.50, 0.40, 0.45, -0.50, -	<0.80, 0.20, 0.15, -0.80, -	<0.80, 0.20, 0.15, -0.80, -	<0.80, 0.20, 0.15, -0.80, -	<0.80, 0.20, 0.15, -0.80, -	<0.80, 0.20, 0.15, -0.80, -	<0.50, 0.40, 0.45, -0.50, -	<0.50, 0.40, 0.45, -0.50, -	<0.80, 0.20, 0.15, -0.80, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -

	0.20, - 0.15>	0.40, - 0.45>	0.20, - 0.15>	0.20, - 0.15>	0.20, - 0.15>	0.20, - 0.15>	0.20, - 0.15>	0.40, - 0.45>	0.40, - 0.45>	0.20, - 0.15>	0.10, - 0.10>	0.10, - 0.10>	0.10, - 0.10>	0.10, - 0.10>
A_5	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>
A_6	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>
A_7	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.80, 0.20, 0.15, - 0.80, - 0.20, - 0.15>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.90, 0.10, 0.10, - 0.90, - 0.10, - 0.10>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>	<0.50, 0.40, 0.45, - 0.50, - 0.40, - 0.45>

Decision maker 3 (d_3) evaluation in linguistic variable of bipolar neutrosophic for MABAC method

Criteria	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**
A_1	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>
A_2	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
A_3	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
A_4	<0.90, 0.10, 0.10, -0.90, -	<0.80, 0.20, 0.15, -0.80, -	<0.90, 0.10, 0.10, -0.90, -	<0.50, 0.40, 0.45, -0.50, -	<0.50, 0.40, 0.45, -0.50, -	<0.50, 0.40, 0.45, -0.50, -	<0.90, 0.10, 0.10, -0.90, -	<0.80, 0.20, 0.15, -0.80, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.50, 0.40, 0.45, -0.50, -	<0.90, 0.10, 0.10, -0.90, -

	0.10, -	0.20, -	0.10, -	0.40, -	0.40, -	0.40, -	0.10, -	0.20, -	0.10, -	0.10, -	0.10, -	0.10, -	0.40, -	0.10, -
	0.10>	0.15>	0.10>	0.45>	0.45>	0.45>	0.10>	0.15>	0.10>	0.10>	0.10>	0.10>	0.45>	0.10>
A_5	<0.90,	<0.90,	<0.50,	<0.50,	<0.50,	<0.50,	<0.90,	<0.50,	<0.50,	<0.50,	<0.90,	<0.80,	<0.90,	<0.90,
	0.10,	0.10,	0.40,	0.40,	0.40,	0.40,	0.10,	0.40,	0.40,	0.40,	0.10,	0.20,	0.10,	0.10,
	0.10, -	0.10, -	0.45, -	0.45, -	0.45, -	0.45, -	0.10, -	0.45, -	0.45, -	0.45, -	0.10, -	0.15, -	0.10, -	0.10, -
	0.90, -	0.90, -	0.50, -	0.50, -	0.50, -	0.50, -	0.90, -	0.50, -	0.50, -	0.50, -	0.90, -	0.80, -	0.90, -	0.90, -
	0.10, -	0.10, -	0.40, -	0.40, -	0.40, -	0.40, -	0.10, -	0.40, -	0.40, -	0.40, -	0.10, -	0.20, -	0.10, -	0.10, -
	0.10>	0.10>	0.45>	0.45>	0.45>	0.45>	0.10>	0.45>	0.45>	0.45>	0.10>	0.15>	0.10>	0.10>
A_6	<0.90,	<0.80,	<0.80,	<0.80,	<0.80,	<0.50,	<0.50,	<0.50,	<0.80,	<0.80,	<0.80,	<0.80,	<0.90,	<0.90,
	0.10,	0.20,	0.20,	0.20,	0.20,	0.40,	0.40,	0.40,	0.20,	0.20,	0.20,	0.20,	0.10,	0.10,
	0.10, -	0.15, -	0.15, -	0.15, -	0.15, -	0.45, -	0.45, -	0.45, -	0.15, -	0.15, -	0.15, -	0.15, -	0.10, -	0.10, -
	0.90, -	0.80, -	0.80, -	0.80, -	0.80, -	0.50, -	0.50, -	0.50, -	0.80, -	0.80, -	0.80, -	0.80, -	0.90, -	0.90, -
	0.10, -	0.20, -	0.20, -	0.20, -	0.20, -	0.40, -	0.40, -	0.40, -	0.20, -	0.20, -	0.20, -	0.20, -	0.10, -	0.10, -
	0.10>	0.15>	0.15>	0.15>	0.15>	0.45>	0.45>	0.45>	0.15>	0.15>	0.15>	0.15>	0.10>	0.10>
A_7	<0.90,	<0.80,	<0.80,	<0.80,	<0.90,	<0.90,	<0.80,	<0.80,	<0.80,	<0.80,	<0.80,	<0.80,	<0.90,	<0.90,
	0.10,	0.20,	0.20,	0.20,	0.10,	0.10,	0.20,	0.20,	0.20,	0.20,	0.20,	0.20,	0.10,	0.10,
	0.10, -	0.15, -	0.15, -	0.15, -	0.10, -	0.10, -	0.15, -	0.15, -	0.15, -	0.15, -	0.15, -	0.15, -	0.10, -	0.10, -
	0.90, -	0.80, -	0.80, -	0.80, -	0.90, -	0.90, -	0.80, -	0.80, -	0.80, -	0.80, -	0.80, -	0.80, -	0.90, -	0.90, -
	0.10, -	0.20, -	0.20, -	0.20, -	0.10, -	0.10, -	0.20, -	0.20, -	0.20, -	0.20, -	0.20, -	0.20, -	0.10, -	0.10, -
	0.10>	0.15>	0.15>	0.15>	0.10>	0.10>	0.15>	0.15>	0.15>	0.15>	0.15>	0.15>	0.10>	0.10>

Decision maker 4 (d_4) evaluation in linguistic variable of bipolar neutrosophic for MABAC method

Criteria	**C$_1$**	**C$_2$**	**C$_3$**	**C$_4$**	**C$_5$**	**C$_6$**	**C$_7$**	**C$_8$**	**C$_9$**	**C$_{10}$**	**C$_{11}$**	**C$_{12}$**	**C$_{13}$**	**C$_{14}$**
A$_1$	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
A$_2$	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
A$_3$	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
A$_4$	<0.80, 0.20, 0.15, -0.80, -	<0.80, 0.20, 0.15, -0.80, -	<0.50, 0.40, 0.45, -0.50, -	<0.80, 0.20, 0.15, -0.80, -	<0.80, 0.20, 0.15, -0.80, -	<0.80, 0.20, 0.15, -0.80, -	<0.80, 0.20, 0.15, -0.80, -	<0.50, 0.40, 0.45, -0.50, -	<0.80, 0.20, 0.15, -0.80, -	<0.80, 0.20, 0.15, -0.80, -	<0.80, 0.20, 0.15, -0.80, -	<0.80, 0.20, 0.15, -0.80, -	<0.80, 0.20, 0.15, -0.80, -	<0.80, 0.20, 0.15, -0.80, -

	0.20, -0.15>	0.20, -0.15>	0.40, -0.45>	0.20, -0.15>	0.20, -0.15>	0.20, -0.15>	0.20, -0.15>	0.40, -0.45>	0.20, -0.15>	0.20, -0.15>	0.20, -0.15>	0.20, -0.15>	0.20, -0.15>	0.20, -0.15>
A_5	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.10, 0.80, 0.90, -0.10, -0.80, -0.90>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
A_6	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
A_7	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.50, 0.40, 0.45, -0.50, -0.40, -0.45>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>

Decision maker 5 $\left(d_5\right)$ evaluation in linguistic variable of bipolar neutrosophic for MABAC method

Criteria	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}
A_1	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>
A_2	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>
A_3	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>
A_4	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -	<0.90, 0.10, 0.10, -0.90, -

	0.10, -0.10>	0.10, -0.10>	0.10, -0.10>	0.10, -0.10>	0.10, -0.10>	0.10, -0.10>	0.10, -0.10>	0.10, -0.10>	0.10, -0.10>	0.10, -0.10>	0.10, -0.10>	0.10, -0.10>	0.10, -0.10>	0.10, -0.10>
A_5	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>
A_6	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>	<0.90, 0.10, 0.10, -0.90, -0.10, -0.10>
A_7	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>	<0.80, 0.20, 0.15, -0.80, -0.20, -0.15>

Appendix 9

Aggregation of bipolar neutrosophic for DEMATEL and MABAC methods

Aggregation of bipolar neutrosophic for DEMATEL method

Criteria	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**
C_1	0	<0.8135, 0.1805, 0.1565, -0.7727, -0.2062, -0.1895>	<0.7599, 0.2270, 0.2169, -0.6516, -0.3092, -0.3423>	<0.8070, 0.1852, 0.1630, -0.7594, -0.2146, -0.2024>	<0.8070, 0.1852, 0.1630, -0.7594, -0.2146, -0.2024>	<0.8070, 0.1852, 0.1630, -0.7594, -0.2146, -0.2024>	<0.7250, 0.2515, 0.2552, -0.6077, -0.3380, -0.3834>	<0.6580, 0.3082, 0.3394, -0.5215, -0.4178, -0.4916>	<0.7250, 0.2515, 0.2552, -0.6077, -0.3380, -0.3834>	<0.7450, 0.2394, 0.2272, -0.5167, -0.3924, -0.4634>	<0.8258, 0.1671, 0.1535, -0.7727, -0.2007, -0.1957>	<0.7936, 0.1900, 0.1882, -0.7083, -0.2422, -0.2580>	<0.8359, 0.1587, 0.1452, -0.7897, -0.1886, -0.1809>	<0.8135, 0.1805, 0.1565, -0.7727, -0.2062, -0.1895>
C_2	<0.8371, 0.1629, 0.1330, -0.8284, -0.1716,	0	<0.7014, 0.2782, 0.2884, -0.5591, -0.3924,	<0.7974, 0.1996, 0.1769, -0.7108, -0.2714,	<0.7599, 0.2270, 0.2169, -0.6516, -0.3092,	<0.7599, 0.2270, 0.2169, -0.6516, -0.3092,	<0.7679, 0.2212, 0.2082, -0.6630, -0.3018,	<0.7113, 0.2711, 0.2769, -0.5689, -0.3859,	<0.7381, 0.2333, 0.2351, -0.6492, -0.2864,	<0.7599, 0.2270, 0.2169, -0.6516, -0.3092,	<0.7989, 0.1852, 0.1854, -0.7114, -0.2389,	<0.7713, 0.2105, 0.1998, -0.6961, -0.2553,	<0.7381, 0.2333, 0.2351, -0.6492, -0.2864,	<0.7696, 0.2052, 0.2181, -0.6636, -0.2707,

	-0.1355>		-0.4577>	-0.2871>	-0.3423>	-0.3423>	-0.3316>	-0.4489>	-0.3102>	-0.3423>	-0.2564>	-0.2642>	-0.3102>	-0.3028>
C3	<0.7480, 0.2447, 0.2353, -0.6099, -0.3592, -0.4122>	<0.7480, 0.2447, 0.2353, -0.6099, -0.3592, -0.4122>	0	<0.7290, 0.2394, 0.2449, -0.6380, -0.2939, -0.3212>	<0.7433, 0.2329, 0.2503, -0.6078, -0.3335, -0.3881>	<0.7599, 0.2270, 0.2169, -0.6516, -0.3092, -0.3423>	<0.7599, 0.2270, 0.2169, -0.6516, -0.3092, -0.3423>	<0.7974, 0.1996, 0.1769, -0.7108, -0.2714, -0.2871>	<0.8507, 0.1432, 0.1403, -0.7932, -0.1795, -0.1854>	<0.7713, 0.2105, 0.1998, -0.6961, -0.2553, -0.2642>	<0.8568, 0.1432, 0.1234, -0.8467, -0.1533, -0.1263>	<0.8070, 0.1852, 0.1630, -0.7594, -0.2146, -0.2024>	<0.7381, 0.2333, 0.2351, -0.6492, -0.2864, -0.3102>	<0.7381, 0.2333, 0.2351, -0.6492, -0.2864, -0.3102>
C4	<0.8568, 0.1432, 0.1234, -0.8467, -0.1533, -0.1263>	<0.8303, 0.1629, 0.1512, -0.7761, -0.1972, -0.1940>	<0.7599, 0.2270, 0.2169, -0.6516, -0.3092, -0.3423>	0	<0.8070, 0.1852, 0.1630, -0.7594, -0.2146, -0.2024>	<0.7713, 0.2105, 0.1998, -0.6961, -0.2553, -0.2642>	<0.6742, 0.2859, 0.3128, -0.5571, -0.3724, -0.4312>	<0.7250, 0.2515, 0.2552, -0.6077, -0.3380, -0.3834>	<0.7790, 0.2052, 0.1918, -0.7083, -0.2473, -0.2523>	<0.7155, 0.2580, 0.2658, -0.5973, -0.3450, -0.3933>	<0.8070, 0.1852, 0.1630, -0.7594, -0.2146, -0.2024>	<0.7713, 0.2105, 0.1998, -0.6961, -0.2553, -0.2642>	<0.7381, 0.2333, 0.2351, -0.6492, -0.2864, -0.3102>	<0.7790, 0.2052, 0.1918, -0.7083, -0.2473, -0.2523>
C5	<0.8371, 0.1629, 0.1330,	<0.7713, 0.2105, 0.1998,	<0.7155, 0.2580, 0.2658,	<0.7713, 0.2105, 0.1998,	0	<0.7713, 0.2105, 0.1998,	<0.7582, 0.2212, 0.2367,	<0.6580, 0.3082, 0.3394,	<0.7790, 0.2052, 0.1918,	<0.7290, 0.2394, 0.2449,	<0.8070, 0.1852, 0.1630,	<0.8070, 0.1852, 0.1630,	<0.7790, 0.2052, 0.1918,	<0.6896, 0.2653, 0.2882,

	-0.8284, -0.1716, -0.1355>	-0.6961, -0.2553, -0.2642>	-0.5973, -0.3450, -0.3933>	-0.6961, -0.2553, -0.2642>		-0.6961, -0.2553, -0.2642>	-0.6211, -0.3234, -0.3768>	-0.5215, -0.4178, -0.4916>	-0.7083, -0.2473, -0.2523>	-0.6380, -0.2939, -0.3212>	-0.7594, -0.2146, -0.2024>	-0.7594, -0.2146, -0.2024>	-0.7083, -0.2473, -0.2523>	-0.5951, -0.3234, -0.3636>
C_6	<0.837, 0.1629, 0.1330, -0.8284, -0.1716, -0.1355>	<0.7713, 0.2105, 0.1998, -0.6961, -0.2553, -0.2642>	<0.7014, 0.2782, 0.2884, -0.5591, -0.3924, -0.4577>	<0.7713, 0.2105, 0.1998, -0.6961, -0.2553, -0.2642>	<0.7713, 0.2105, 0.1998, -0.6961, -0.2553, -0.2642>	0	<0.7113, 0.2711, 0.2769, -0.5689, -0.3859, -0.4489>	<0.6580, 0.3082, 0.3394, -0.5215, -0.4178, -0.4916>	<0.7790, 0.2052, 0.1918, -0.7083, -0.2473, -0.2523>	<0.7713, 0.2105, 0.1998, -0.6961, -0.2553, -0.2642>	<0.8070, 0.1852, 0.1630, -0.7594, -0.2146, -0.2024>	<0.8070, 0.1852, 0.1630, -0.7594, -0.2146, -0.2024>	<0.8359, 0.1587, 0.1452, -0.7897, -0.1886, -0.1809>	<0.7790, 0.2052, 0.1918, -0.7083, -0.2473, -0.2523>
C_7	<0.7679, 0.2212, 0.2082, -0.6630, -0.3018, -0.3316>	<0.7679, 0.2212, 0.2082, -0.6630, -0.3018, -0.3316>	<0.7599, 0.2270, 0.2169, -0.6516, -0.3092, -0.3423>	<0.7599, 0.2270, 0.2169, -0.6516, -0.3092, -0.3423>	<0.7599, 0.2270, 0.2169, -0.6516, -0.3092, -0.3423>	<0.7599, 0.2270, 0.2169, -0.6516, -0.3092, -0.3423>	0	<0.6934, 0.2859, 0.2901, -0.4511, -0.4599, -0.5503>	<0.6896, 0.2653, 0.2882, -0.5951, -0.3234, -0.3636>	<0.7113, 0.2711, 0.2769, -0.5689, -0.3859, -0.4489>	<0.8258, 0.1671, 0.1535, -0.7727, 0.2007, -0.1957>	<0.7974, 0.1996, 0.1769, -0.7108, -0.2714, -0.2871>	<0.7959, 0.1946, 0.1931, -0.6776, -0.2864, -0.3245>	<0.7679, 0.2212, 0.2082, -0.6630, -0.3018, -0.3316>

C_8	<0.7323, 0.2580, 0.2466, -0.4836, -0.4364, -0.5204>	<0.7323, 0.2580, 0.2466, -0.4836, -0.4364, -0.5204>	<0.7323, 0.2580, 0.2466, -0.4836, -0.4364, -0.5204>	<0.6828, 0.2934, 0.3022, -0.4433, -0.4656, -0.5575>	<0.6828, 0.2934, 0.3022, -0.4433, -0.4656, -0.5575>	<0.6828, 0.2934, 0.3022, -0.4433, -0.4656, -0.5575>	<0.6367, 0.3251, 0.3556, -0.4135, -0.4879, -0.5852>	0	<0.7599, 0.2270, 0.2169, -0.6516, -0.3092, -0.3423>	<0.7480, 0.2447, 0.2353, -0.6099, -0.3592, -0.4122>	<0.7974, 0.1996, 0.1769, -0.7108, -0.2714, -0.2871>	<0.7713, 0.2105, 0.1998, -0.6961, -0.2553, -0.2642>	<0.7959, 0.1946, 0.1931, -0.6776, -0.2864, -0.3245>	<0.7959, 0.1946, 0.1931, -0.6776, -0.2864, -0.3245>
C_9	<0.8371, 0.1629, 0.1330, -0.8284, -0.1716, -0.1355>	<0.8070, 0.1852, 0.1630, -0.7594, -0.2146, -0.2024>	<0.8507, 0.1432, 0.1403, -0.7932, -0.1795, -0.1854>	<0.8371, 0.1629, 0.1330, -0.8284, -0.1716, -0.1355>	<0.7974, 0.1996, 0.1769, -0.7108, -0.2714, -0.2871>	<0.8218, 0.1756, 0.1641, -0.7265, -0.2553, -0.2795>	<0.7381, 0.2333, 0.2351, -0.6492, -0.2864, -0.3102>	<0.7974, 0.1996, 0.1769, -0.7108, -0.2714, -0.2871>	0	<0.7974, 0.1996, 0.1769, -0.7108, -0.2714, -0.2871>	<0.8303, 0.1629, 0.1512, -0.7761, -0.1972, -0.1940>	<0.8303, 0.1629, 0.1512, -0.7761, -0.1972, -0.1940>	<0.8056, 0.1805, 0.1780, -0.7239, -0.2307, -0.2443>	<0.8056, 0.1805, 0.1780, -0.7239, -0.2307, -0.2443>
C_{10}	<0.7783, 0.2152, 0.2183, -0.6234,	<0.7783, 0.2152, 0.2183, -0.6234,	<0.8218, 0.1756, 0.1641, -0.7265,	<0.7783, 0.2152, 0.2183, -0.6234,	<0.7480, 0.2447, 0.2353, -0.6099,	<0.7014, 0.2782, 0.2884, -0.5591,	<0.6539, 0.3016, 0.3277, -0.4417,	<0.7480, 0.2447, 0.2353, -0.6099,	<0.8568, 0.1432, 0.1234, -0.8467,	0	<0.7974, 0.1996, 0.1769, -0.7108,	<0.8258, 0.1671, 0.1535, -0.7727,	<0.7959, 0.1946, 0.1931, -0.6776,	<0.7790, 0.2052, 0.1918, -0.7083,

	-0.3450, -0.4059>	-0.3450, -0.4059>	-0.2553, -0.2795>	-0.3450, -0.4059>	-0.3592, -0.4122>	-0.3924, -0.4577>	-0.4480, -0.5359>	-0.3592, -0.4122>	-0.1533, -0.1263>		-0.2714, -0.2871>	-0.2007, -0.1957>	-0.2864, -0.3245>	-0.2473, -0.2523>
C11	<0.8070, 0.1852, 0.1630, -0.7594, -0.2146, -0.2024>	<0.7974, 0.1996, 0.1769, -0.7108, -0.2714, -0.2871>	<0.8371, 0.1629, 0.1330, -0.8284, -0.1716, -0.1355>	<0.8218, 0.1756, 0.1641, -0.7265, -0.2553, -0.2795>	<0.8070, 0.1852, 0.1630, -0.7594, -0.2146, -0.2024>	<0.7713, 0.2105, 0.1998, -0.6961, -0.2553, -0.2642>	<0.8359, 0.1587, 0.1452, -0.7897, -0.1886, -0.1809>	<0.7113, 0.2711, 0.2769, -0.5689, -0.3859, -0.4489>	<0.8070, 0.1852, 0.1630, -0.7594, -0.2146, -0.2024>	<0.7599, 0.2270, 0.2169, -0.6516, -0.3092, -0.3423>	0	<0.7834, 0.2048, 0.2042, -0.6630, -0.2970, -0.3367>	<0.7250, 0.2515, 0.2552, -0.6077, -0.3380, -0.3834>	<0.7250, 0.2515, 0.2552, -0.6077, -0.3380, -0.3834>
C12	<0.7936, 0.1900, 0.1882, -0.7083, -0.2422, -0.2580>	<0.8172, 0.1801, 0.1666, -0.7233, -0.2586, -0.2811>	<0.8468, 0.1470, 0.1424, -0.7898, -0.1831, -0.1871>	<0.7599, 0.2270, 0.2169, -0.6516, -0.3092, -0.3423>	<0.8185, 0.1671, 0.1746, -0.7239, -0.2255, -0.2501>	<0.7936, 0.1900, 0.1882, -0.7083, -0.2422, -0.2580>	<0.7834, 0.2048, 0.2042, -0.6630, -0.2970, -0.3367>	<0.7480, 0.2447, 0.2353, -0.6099, -0.3592, -0.4122>	<0.7290, 0.2394, 0.2449, -0.6380, -0.2939, -0.3212>	<0.8172, 0.1801, 0.1666, -0.7233, -0.2586, -0.2811>	<0.8172, 0.1801, 0.1666, -0.7233, -0.2586, -0.2811>	0	<0.7959, 0.1946, 0.1931, -0.6776, -0.2864, -0.3245>	<0.7679, 0.2212, 0.2082, -0.6630, -0.3018, -0.3316>
C13	<0.8303 ,	<0.7974 ,	<0.8070 ,	<0.7974 ,	<0.8303 ,	<0.8303 ,	<0.7989 ,	<0.7461 ,	<0.7381 ,	<0.7974 ,	<0.7974 ,	<0.7974 ,	0	<0.7679 ,

	0.1629, 0.1512, - 0.7761, - 0.1972, - 0.1940>	0.1996, 0.1769, - 0.7108, - 0.2714, - 0.2871>	0.1852, 0.1630, - 0.7594, - 0.2146, - 0.2024>	0.1996, 0.1769, - 0.7108, - 0.2714, - 0.2871>	0.1629, 0.1512, - 0.7761, - 0.1972, - 0.1940>	0.1629, 0.1512, - 0.7761, - 0.1972, - 0.1940>	0.1852, 0.1854, - 0.7114, - 0.2389, - 0.2564>	0.2385, 0.2569, - 0.5814, - 0.3724, - 0.4430>	0.2333, 0.2351, , 0.6492, - 0.2864, - 0.3102>	0.1996, 0.1769, - 0.7108, - 0.2714, - 0.2871>	0.1996, 0.1769, - 0.7108, - 0.2714, - 0.2871>	0.1996, 0.1769, - 0.7108, - 0.2714, - 0.2871>		0.2212, 0.2082, - 0.6630, - 0.3018, - 0.3316>
C_{14}	<0.8070 , 0.1852, 0.1630, - 0.7594, - 0.2146, - 0.2024>	<0.8218 , 0.1756, 0.1641, - 0.7265, - 0.2553, - 0.2795>	<0.7713 , 0.2105, 0.1998, - 0.6961, - 0.2553, - 0.2642>	<0.7599 , 0.2270, 0.2169, - 0.6516, - 0.3092, - 0.3423>	<0.7713 , 0.2105, 0.1998, - 0.6961, - 0.2553, - 0.2642>	<0.7713 , 0.2105, 0.1998, - 0.6961, - 0.2553, - 0.2642>	<0.8070 , 0.1852, 0.1630, - 0.7594, - 0.2146, - 0.2024>	<0.7679 , 0.2212, 0.2082, - 0.6630, - 0.3018, - 0.3316>	<0.7696 , 0.2052, 0.2181, - 0.6636, - 0.2707, - 0.3028>	<0.8218 , 0.1756, 0.1641, - 0.7265, - 0.2553, - 0.2795>	<0.8218 , 0.1756, 0.1641, - 0.7265, - 0.2553, - 0.2795>	<0.7889 , 0.1996, 0.2012, - 0.6659, - 0.2939, - 0.3353>	<0.7959 , 0.1946, 0.1931, - 0.6776, - 0.2864, - 0.3245>	0

Aggregation of bipolar neutrosophic for MABAC method

Criteria	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**
A_1	<0.8371 , 0.1629,	<0.7790 , 0.2052,	<0.7790 , 0.2052,	<0.8568 , 0.1432,	<0.8568 , 0.1432,	<0.8568 , 0.1432,	<0.8290 , 0.1587,	<0.7381 , 0.2333,	<0.8568 , 0.1432,	<0.7790 , 0.2052,	<0.8568 , 0.1432,	<0.8568 , 0.1432,	<0.8568 , 0.1432,	<0.8568 , 0.1432,

	0.1330, -0.8284, -0.1716, -0.1355>	0.1918, -0.7083, -0.2473, -0.2523>	0.1918, -0.7083, -0.2473, -0.2523>	0.1234, -0.8467, -0.1533, -0.1263>	0.1234, -0.8467, -0.1533, 0.1263>	0.1234, -0.8467, -0.1533, -0.1263>	0.1651, -0.7399, -0.2138, -0.2363>	0.2351, -0.6492, -0.2864, -0.3102>	0.1234, -0.8467, -0.1533, -0.1263>	0.1918, -0.7083, -0.2473, 0.2523>	0.1234, -0.8467, -0.1533, -0.1263>	0.1234, -0.8467, -0.1533, -0.1263>	0.1234, -0.8467, -0.1533, -0.1263>	0.1234, -0.8467, -0.1533, 0.1263>
A_2	<0.8371, 0.1629, 0.1330, -0.8284, -0.1716, -0.1355>	<0.8070, 0.1852, 0.1630, -0.7594, -0.2146, -0.2024>	<0.8303, 0.1629, 0.1512, -0.7761, -0.1972, -0.1940>	<0.8568, 0.1432, 0.1234, -0.8467, -0.1533, -0.1263>	<0.8568, 0.1432, 0.1234, -0.8467, -0.1533, -0.1263>	<0.8568, 0.1432, 0.1234, -0.8467, -0.1533, -0.1263>	<0.7974, 0.1996, 0.1769, -0.7108, -0.2714, -0.2871>	<0.7599, 0.2270, 0.2169, -0.6516, -0.3092, -0.3423>	<0.8359, 0.1587, 0.1452, -0.7897, -0.1886, -0.1809>	<0.8303, 0.1629, 0.1512, -0.7761, -0.1972, -0.1940>	<0.8568, 0.1432, 0.1234, -0.8467, -0.1533, -0.1263>	<0.8568, 0.1432, 0.1234, -0.8467, -0.1533, -0.1263>	<0.8371, 0.1629, 0.1330, -0.8284, -0.1716, -0.1355>	<0.8371, 0.1629, 0.1330, -0.8284, -0.1716, -0.1355>
A_3	<0.7709, 0.2216, 0.1765, -0.7462, -0.2334,	<0.7286, 0.2520, 0.2163, -0.6840, -0.2732,	<0.6784, 0.2865, 0.2651, -0.6270, -0.3109,	<0.7709, 0.2216, 0.1765, -0.7462, -0.2334,	<0.7709, 0.2216, 0.1765, -0.7462, -0.2334, -0.2031>	<0.7709, 0.2216, 0.1765, -0.7462, -0.2334,	<0.7494, 0.2389, 0.2178, -0.6544, -0.3109,	<0.7030, 0.2716, 0.2669, -0.5998, -0.3466,	<0.8228, 0.1714, 0.1519, -0.7795, -0.1992,	<0.7286, 0.2520, 0.2163, -0.6840, -0.2732, -0.2648>	<0.7985, 0.1949, 0.1637, -0.7626, -0.2165,	<0.7985, 0.1949, 0.1637, -0.7626, -0.2165,	<0.7985, 0.1949, 0.1637, -0.7626, -0.2165,	<0.7709, 0.2216, 0.1765, -0.7462, -0.2334, -0.2031>

	-0.2031>	-0.2648>	-0.3218>	-0.2031>		-0.2031>	-0.3359>	-0.3873>	-0.1860>		-0.1946>	-0.1946>	-0.1946>	
A4	<0.8568, 0.1432, 0.1234, -0.8467, -0.1533, -0.1263>	<0.7790, 0.2052, 0.1918, -0.7083, -0.2473, -0.2523>	<0.8303, 0.1629, 0.1512, -0.7761, -0.1972, -0.1940>	<0.8070, 0.1852, 0.1630, -0.7594, -0.2146, -0.2024>	<0.8070, 0.1852, 0.1630, -0.7594, -0.2146, -0.2024>	<0.8070, 0.1852, 0.1630, -0.7594, -0.2146, -0.2024>	<0.8218, 0.1756, 0.1641, -0.7265, -0.2553, -0.2795>	<0.7250, 0.2515, 0.2552, -0.6077, -0.3380, -0.3834>	<0.8557, 0.1396, 0.1347, -0.8071, -0.1708, -0.1721>	<0.8303, 0.1629, 0.1512, -0.7761, -0.1972, -0.1940>	<0.8707, 0.1293, 0.1162, -0.8616, -0.1384, -0.1189>	<0.8707, 0.1293, 0.1162, -0.8616, -0.1384, -0.1189>	<0.8258, 0.1671, 0.1535, -0.7727, -0.2007, -0.1957>	<0.8707, 0.1293, 0.1162, -0.8616, -0.1384, -0.1189>
A5	<0.8707, 0.1293, 0.1162, -0.8616, -0.1384, -0.1189>	<0.8303, 0.1629, 0.1512, -0.7761, -0.1972, -0.1940>	<0.7713, 0.2105, 0.1998, -0.6961, -0.2553, -0.2642>	<0.8070, 0.1852, 0.1630, -0.7594, -0.2146, -0.2024>	<0.7790, 0.2052, 0.1918, -0.7083, -0.2473, -0.2523>	<0.8070, 0.1852, 0.1630, -0.7594, -0.2146, -0.2024>	<0.8863, 0.1137, 0.1078, -0.8806, -0.1194, -0.1095>	<0.6367, 0.3251, 0.3556, -0.4135, -0.4879, -0.5852>	<0.8056, 0.1805, 0.1780, -0.7239, -0.2307, -0.2443>	<0.7713, 0.2105, 0.1998, -0.6961, -0.2553, -0.2642>	<0.8568, 0.1432, 0.1234, -0.8467, -0.1533, -0.1263>	<0.8530, 0.1470, 0.1253, -0.8430, -0.1570, -0.1281>	<0.8359, 0.1587, 0.1452, -0.7897, -0.1886, -0.1809>	<0.8359, 0.1587, 0.1452, -0.7897, -0.1886, -0.1809>
A6	<0.8359, 0.1587, 0.1452,	<0.7790, 0.2052, 0.1918,	<0.7790, 0.2052, 0.1918,	<0.8135, 0.1805, 0.1565,	<0.8135, 0.1805, 0.1565,	<0.7790, 0.2052, 0.1918,	<0.7250, 0.2515, 0.2552,	<0.7250, 0.2515, 0.2552,	<0.8359, 0.1587, 0.1452,	<0.7790, 0.2052, 0.1918,	<0.8135, 0.1805, 0.1565,	<0.8135, 0.1805, 0.1565,	<0.8359, 0.1587, 0.1452,	<0.8359, 0.1587, 0.1452,

	-0.7897, -0.1886, -0.1809>	-0.7083, -0.2473, -0.2523>	-0.7083, -0.2473, -0.2523>	-0.7727, -0.2062, -0.1895>	-0.7727, -0.2062, -0.1895>	-0.7083, -0.2473, -0.2523>	-0.6077, -0.3380, -0.3834>	-0.6077, -0.3380, -0.3834>	-0.7897, -0.1886-0.1809>	-0.7083, -0.2473, -0.2523>	-0.7727, -0.2062, -0.1895>	-0.7727, -0.2062, -0.1895>	-0.7897, -0.1886, -0.1809>	-0.7897, -0.1886, -0.1809>
A_7	<0.8413, 0.1587, 0.1310, -0.8320, -0.1680, -0.1336>	<0.7630, 0.2274, 0.1838, -0.7333, -0.2415, -0.2158>	<0.7286, 0.2520, 0.2163, -0.6840, -0.2732, -0.2648>	<0.7709, 0.2216, 0.1765, -0.7462, -0.2334, -0.2031>	<0.7985, 0.1949, 0.1637, -0.7626, -0.2165, -0.1946>	<0.7985, 0.1949, 0.1637, -0.7626, -0.2165, -0.1946>	<0.7286, 0.2520, 0.2163, -0.6840, -0.2732, -0.2648>	<0.7150, 0.2716, 0.2348, -0.6403, -0.3257, -0.3429>	<0.7985, 0.1949, 0.1637, -0.7626, -0.2165, -0.1946>	<0.7286, 0.2520, 0.2163, -0.6840, -0.2732, -0.2648>	<0.8195, 0.1805, 0.1413, -0.8141, -0.1859, -0.1428>	<0.8195, 0.1805, 0.1413, -0.8141, -0.1859, -0.1428>	<0.7985, 0.1949, 0.1637, -0.7626, -0.2165, -0.1946>	<0.7985, 0.1949, 0.1637, -0.7626, -0.2165, -0.1946>

Appendix 10

Deneutrosophication of bipolar neutrosophic for DEMATEL and MABAC methods

Deneutrosophication of bipolar neutrosophic for the DEMATEL method

Criteria	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}
C_1	0.0000	0.4746	0.4920	0.4771	0.4771	0.4771	0.4958	0.4952	0.4958	0.5133	0.4754	0.4870	0.4721	0.4746
C_2	0.4629	0.0000	0.4964	0.4840	0.4920	0.4920	0.4907	0.4962	0.4937	0.4920	0.4868	0.4878	0.4937	0.4938
C_3	0.4942	0.4942	0.0000	0.4947	0.4975	0.4920	0.4920	0.4840	0.4721	0.4878	0.4595	0.4771	0.4937	0.4937
C_4	0.4595	0.4749	0.4920	0.0000	0.4771	0.4878	0.4971	0.4958	0.4860	0.4964	0.4771	0.4878	0.4937	0.4860
C_5	0.4629	0.4878	0.4964	0.4878	0.0000	0.4878	0.4968	0.4952	0.4860	0.4947	0.4771	0.4771	0.4860	0.4974
C_6	0.4629	0.4878	0.4964	0.4878	0.4878	0.0000	0.4962	0.4952	0.4860	0.4878	0.4771	0.4771	0.4721	0.4860
C_7	0.4907	0.4907	0.4920	0.4920	0.4920	0.4920	0.0000	0.5101	0.4974	0.4962	0.4754	0.4840	0.4902	0.4907
C_8	0.5117	0.5117	0.5117	0.5094	0.5094	0.5094	0.5048	0.0000	0.4920	0.4942	0.4840	0.4878	0.4902	0.4902
C_9	0.4629	0.4771	0.4721	0.4629	0.4840	0.4825	0.4937	0.4840	0.0000	0.4840	0.4749	0.4749	0.4847	0.4847
C_{10}	0.4948	0.4948	0.4825	0.4948	0.4942	0.4964	0.5097	0.4942	0.4595	0.0000	0.4840	0.4754	0.4902	0.4860
C_{11}	0.4771	0.4840	0.4629	0.4825	0.4771	0.4878	0.4721	0.4962	0.4771	0.4920	0.0000	0.4919	0.4958	0.4958
C_{12}	0.4870	0.4828	0.4727	0.4920	0.4855	0.4870	0.4919	0.4942	0.4947	0.4828	0.4828	0.0000	0.4902	0.4907
C_{13}	0.4749	0.4840	0.4771	0.4840	0.4749	0.4749	0.4868	0.4981	0.4937	0.4840	0.4840	0.4840	0.0000	0.4907
C_{14}	0.4771	0.4825	0.4878	0.4920	0.4878	0.4878	0.4771	0.4907	0.4938	0.4825	0.4825	0.4918	0.4902	0.0000

Deneutrosophication of bipolar neutrosophic for the MABAC method

Alternative	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	C_{14}
A_1	0.4629	0.4860	0.4860	0.4595	0.4595	0.4595	0.4828	0.4937	0.4595	0.4860	0.4595	0.4595	0.4595	0.4595
A_2	0.4629	0.4771	0.4749	0.4595	0.4595	0.4595	0.4840	0.4920	0.4721	0.4749	0.4595	0.4595	0.4629	0.4629
A_3	0.4774	0.4865	0.4915	0.4774	0.4774	0.4774	0.4906	0.4948	0.4736	0.4865	0.4758	0.4758	0.4758	0.4774
A_4	0.4595	0.4860	0.4749	0.4771	0.4771	0.4771	0.4825	0.4958	0.4690	0.4749	0.4564	0.4564	0.4754	0.4564
A_5	0.4564	0.4749	0.4878	0.4771	0.4860	0.4771	0.4523	0.5048	0.4847	0.4878	0.4595	0.4602	0.4721	0.4721
A_6	0.4721	0.4860	0.4860	0.4746	0.4746	0.4860	0.4958	0.4958	0.4721	0.4860	0.4746	0.4746	0.4721	0.4721
A_7	0.4623	0.4795	0.4865	0.4774	0.4758	0.4758	0.4865	0.4898	0.4758	0.4865	0.4653	0.4653	0.4758	0.4758

AUTHOR BIODATA

SITI NURAINI BINTI RAHIM

A-06 Taman Sri Kalongan, Teluk Kalong,
24000, Kemaman, Terengganu.
+6010-9030291
snaini276@gmail.com

EDUCATIONAL BACKGROUND

Universiti Malaysia Terengganu (UMT)
Bachelor of Science (Financial Mathematics)
Major: Science in Financial Mathematics

Currently pursuing Master of Science at Universiti Malaysia Terengganu in Mathematical Science full-time research mode.

RESEARCH AND TEACHING EXPERIENCE

Tutor/Demonstrator, Faculty of Ocean Engineering Technology and Informatics, UMT, April 2022-June 2022

- Responsible to teach first year degree students for lab session in Biostatistics subject using SPSS Software.

Tutor/Demonstrator, Faculty of Ocean Engineering Technology and Informatics, UMT, Okt 2021-Jan 2022

- Responsible to teach first year degree students for lab session in Linear Algebra subject using MAPLE Software.

Graduate Research Assistant (GRA) to Prof Dr. Mohd Lazim Bin Abdullah, Jan 2019-Dis 2020, Universiti Malaysia Terengganu (UMT) Kuala Nerus, Terengganu

- A combine DEMATEL method with neutrosophic numbers for decision making.

Fellow Scientist Islam Terengganu Kohort V/2019, UMT, 17th February 2019 – 7th March 2019 (3 weeks)

- Assist in implementing program.

TECHNICAL SKILLS

MAPLE, MATLAB, SPSS C++ Programming Language

EXTRA CURRICULUM ACTIVITIES AND REWARDS

- Vice President of Muslim Youth Volunteer Club 2016/2017
- Committee member Software Statistics Workshop (SPSS) 2014
- Crew International Mathematics Convention 2015
- Facilitator Training of Trainer (TOT) or Minggu Jalinan Mesra (MJM) UMT 2015
- Protocol committee member Olympiad Mathematics Terengganu 2015
- Crew Majlis Konvokesyen ke-13 Universiti Malaysia Terengganu 201
- Volunteer of Kembara Solat Syifa at Hospital Sultanah Nur Zahirah, Terengganu 201
- Participated Derivatives Workshop 2015
- Committee member Basic Statistics and Research Methodology for Mmed (Year 2), MSc and Phd Candidates 2017