Optimal Selection and Ranking of Countries Based On World Development Indicators Using Modified Fuzzy Distance Based Approach

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Submitted by:

ARUSHI GUPTA
2K18/ISY/02

Under the supervision of

DR. KAPIL SHARMA
Head of Department (HOD), Department of Information Technology

Department of Information Technology
Delhi Technological University
(Formerly Delhi College of Engineering)
Shahbad Daulatpur, Bawana Road, Delhi – 110042 (India)

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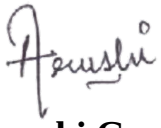
DECLARATION

I, Arushi Gupta, hereby declare that the dissertation (Major Project - II) entitled **" OPTIMAL SELECTION AND RANKING OF COUNTRIES BASED ON WORLD DEVELOPMENT INDICATORS USING MODIFIED FUZZY DISTANCE BASED APPROACH "** which is being submitted by me in partial fulfillment of the requirements for the award of the degree of Master of Technology (Information System) from Delhi Technological University, is an authentic and original record of my own work that is carried out under the mentorship of Dr. Kapil Sharma, Head of Department (HOD), Information Technology Department.

The material/work present in the report has not been submitted to any other University or Institution for the award of any Degree/Diploma/Fellowship or any other similar title or recognition.



Place: Delhi **Arushi Gupta**

Date: 29th June, 2020 **2K18/ISY/02**

CERTIFICATE

This is to certify that Major Project Report - II entitled "OPTIMAL SELECTION AND RANKING OF COUNTRIES BASED ON WORLD DEVELOPMENT INDICATORS USING MODIFIED FUZZY DISTANCE BASED APPROACH" submitted by **ARUSHI GUPTA (Roll No. 2K18/ISY/02)** for partial fulfillment of the requirement for the award of degree Master of Technology (Information System) is a record of the candidate work carried out by her under my supervision.

Place: Delhi

Date: 29th June, 2020

Dr. Kapil Sharma
SUPERVISOR,
Head of Department (HOD), Department of Information Technology
Delhi Technological University, Delhi

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ARUSHI GUPTA

2K18/ISY/02

ABSTRACT

World Development constitutes of the development and growth of each and every country. There are various factors that come into play for providing an apt environment for the growth of a country. It has always been quite arduous for the statisticians and financial economists to comprehend the evolving circumstances of nations quite efficiently. Thus making it necessary to comprehend various factors such as agriculture, health, economy, trade, etc. that contribute towards global development. Through the process of ranking, one can compare the strengths and weaknesses of several nations. Modified Fuzzy Distance Base Approach (MFDBA) is suggested. It is one such approach that helps to rank the countries and study various factors affecting the same and is an integration of both the fuzzy set theory and modified distance based approach. In this research, an exhaustive list of indicators and sub-indicators which contribute towards the ranking of country is prepared from the literature work. Thirty indicators were selected and assigned weights for the ranking process using Fuzzy Set Theory. There are many tools that can perform this ranking on the basis of single factor, but none that studies multiple factors. Hence, the proposed technique of Multi-Criteria Decision Making is used for determining the rank of twenty-seven countries. It also helps in further predicting the future trend and study the progress of various nations.

Keywords: *World Development Indicators, DBA, Fuzzy Set Theory, GDP, Modified Fuzzy Distance Base Approach, Data Mining, HDI, TFN.*

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S.No.	Abbreviated Names	Full Name
1.	AHP	Analytic Hierarchy Process
2.	FMDBA	Fuzzy Modified Distance Based Approach
3.	HDI	Human Development Index
4.	MCMD	Multi – Criteria Decision Making
5.	SI	Suitability Index
6.	TFN	Triangular Fuzzy Number
7.	TOPSIS	Theory of Order Preference by Similarity to Ideal Solution
8.	WDI	World Development Indicator
9.	WSM	Weighted Score Method

CHAPTER 1

INTRODUCTION

1.1 RESEARCH BACKGROUND

1.1.1 World Development

Behind a country's opulence, prosperity and success lie the underlying policies that are created by keeping in mind the impact these policies would have on global as well as on the national level. There exist many individuals who drive the exertion and the history that shapes the nature and point of view. Thus, it creates the need to compare various countries based on several indicators. A definitive motivation behind the improvement is to grow the abilities of individuals, to increment their capacity to have better life, by developing skills and enable them to live life with poise and self-respect. There are multiple ways to accomplish the same - by enhancing the physical capital stocks, developing improved and unique advancements, evolving foundations, changing motivations. It is necessary to understand that the enhanced outputs or GDP of the country doesn't entirely equate to appreciable development. National development is not vital or adequate, though enhancing per capita earnings might encourage in boosting of the human development and its abilities. The liaison among financial development and human improvement is powerless for an assortment of reasons that have been provided in various literatures [17].

The World Wide Economy related emergency has created the need for evaluating the various interlinked dependencies between the economies of various countries, developing unique and successful methodologies for hazard assessment and providing some preventive and relief measures [27]. Many huge and effectively discernable contrasts result in the way of life that is appreciated by residents of various nations. Few countries that give off an impression of being equivalent as far as their economies might have a very contrasting perspective in terms of standard of living as compared to others. For instance, according to a comparative analysis

of 2009, the average earning of a resident of Burkina Faso was 510 USD whereas that of Japanese residents was approximately 38K USD. Nonetheless, in Burkina Faso, only 29% of the grown-up populace was educated in comparison to 100% literacy of Japan. Similarly, a newborn baby was expected to live 53 years in Burkina Faso whereas in Japan the statistics showed an average of 83 years. This model shows that nations are abusing diversely their livelihoods and have different threshold levels for the same [22] [32].

For a better understanding of such countries, it is necessary to study various factors such as agriculture, health, economy, trade, etc. that contribute towards its ranking in the world. It has always been quite arduous for the statisticians and financial economists to comprehend the evolving circumstances of nations quite efficiently [26]. Earlier, the simplest method was the use of census that allowed the evaluation of the World Development Indicator [36]. There has been a huge number of world improvement indicators proposed to portray the improving circumstances in various angles, for example, infrastructure, financial aspects, wellbeing, etc. During the count of any single indicator of any particular nation, it will include an immense amount of information gathered and summed up from governments at all steps. The entire procedure consumes a great deal of capital value, labor, assets, and time.

With the upgradation of evaluation innovation, even though the speed of insights is quickened, it is as yet hard to fulfill the need for real-time monetary and political dynamics. It has been observed that the problem of country ranking can be modeled as a MCMD Problem. MCMD problem generally comprises a hierarchical structure where the selected optimal solution is present at the top and afterward the different alternatives are assessed against a predefined set of selected measures. MCDM is one of the most generally utilized decision techniques in different fields, for example, vitality and condition, business, economy, creation, etc. MCDM strategies can be extensively arranged into two classifications: discrete MCDM or discrete Multi-trait Decision-Making (MADM) and constant Multi-target Decision-Making (MODM) techniques. These methods and techniques enhance the quality of results by making the advancement increasingly effective, balanced, and comprehendible.

1.1.2 World Development Indicators

While performing this evaluation it is requisite to comprehend the significance and use of World Development Indicators (WDI). WDI is one of the leading global compilations of cross-country advancement data by the World Bank. It is a collection of important, well established, and consists of the global information insights ranging from the global changes happening every day and the root cause of poverty. It consists of a dataset of 1,600 time dependent parameters for a number of economies and also contains the nation groups in different manner. The database consists the data for more than 50 years. These WDI data are made available by the World Bank in the form of its Web API.

World Bank releases its updates every quarter. This includes new additions as well as changes in the existing dataset. The release highlights the updated national records, parity of installments, demography, wellbeing, employment, poverty and shared thriving, settlements, and the travel industry arrangement. New gauges are likewise accessible for law, power-related indicators, balanced total investment funds, and guidelines towards sexual orientation that is responsible for Global Findex, versatile web training arrangement [3]. Additional indicators were incorporated for wellbeing uses, esteem included per specialist by area, birth-disaggregated pointers on the fulfillment of birth enrollment, trade/import unit esteem list, populace presented to particulate matter PM2.5 contamination all over the world.

The World Bank Data has the following themes: Economy, Global Links, People, Environment, State Markets, and Poverty and Inequality. These criteria's are further divided into sub-criteria given as follows:

- Poverty and Inequality: This theme deals with the income distribution among the poor and rich and many indicators related to it.
- People: This theme deals with the literacy rate, health, gender, working class, monitoring the population growth, etc.
- Environment: The theme deals with biodiversity and the changes in climate over period of time.

- Economy: This deals with the economic structure and its growth in terms of salary, business, etc.
- States and Markets: It consists of the technology aspect, communications, business, transportation cost, defense, stock markets, etc.
- Global Links: Countries can be interrelated in terms of tourism, aids, migration, etc thus forming the indicators of global link.

In present research work, a review of various indicators used for ranking the countries and the correlation between these indicators is available in the literature for evaluating the ranks in a much more efficient manner, so that this can help the countries to develop and grow in a much more successful manner. For solving problems related to decision-making for multi-criteria, Matrix, and Distance Dependent Approximation are the best well-established methodologies. These techniques can adjust to the interrelation between the different assessment standards at each degree of the order that will help the decision-makers to settle on an optimal choice. These strategies are additionally deal with more mind-boggling organized issues in which a choice must be made. These philosophies are portrayed in this exploration to build up a ranking model distinguishing the significant measures for country evaluation and selection. Computer software was created by utilizing the incorporated proposed procedure for example Fuzzy Modified Distance Based Methodology technique in the current research work. These proposed approaches are validated by contrasting with the other accessible techniques/models present in the literature.

1.2 RESEARCH PROBLEM

To provide a system where we can easily understand and help the decision-makers, with the issue of Country ranking. This is also of extraordinary importance as it helps in the development of the world in the current situation. It has consistently been proven as a difficult subject for the economist and statisticians. Since there are great deals of indicator data sets that are readily accessible in the market, it turns out to be increasingly troublesome and complex for the evaluators to make the ultimate choice about the country comparison. Along these lines, it is

alluring to assess the country's performance based on some recognized assessment standards/sub-measures, for example, agriculture and health assessment indicators/sub-indicators. Country evaluation and the ranking issue has been one of the most perplexing issues because the exhibition of every country must be assessed on the basis of a predefined multidimensional scale. The major issue with the previous researches is that the countries are compared based on a single major parameter. The current work is essentially centered around assessment, ranking and determination of country, which will not only help the economists and statistician to study the country indexes but also help the decision-makers to focus on the problematic area and enhance the development process using multi-measures dynamic to encourage the assessment, selection, and ranking. This will help in the overall growth and development effectively.

1.3 OBJECTIVES OF THE STUDY

While performing this work it is vital to understand and state the importance of the current work. The main objectives of our research work are stated below:

1. To contemplate the general ideas of World Development Indicators and assess its significance regarding nation advancement.
2. To examine the existing literature in the form of contextual analyses, books, articles, publications, research papers and so forth for the improvement of country assessment, ranking, and determination strategy. It is proposed to cover country development parameters, country assessment models/sub-standards, indicator selection strategies with their benefits, and demerits.
3. Improvement of the country indicator selection system that will incorporate the identification of country assessment standards/sub-rules.
4. To understand the case study of the country ranking methodology.
5. To develop a decision support system to carry out analysis, assessment, and ranking of countries based on developed methodology FMDBA.
6. To review the outcomes which distinguish with the previously created country ranking techniques for validation and significance of the created system.

7. To do affectability investigation so as to distinguish the criticality of the assessment measures and to consider and break down the effect of assessment standards/sub-models on the ranking of different countries.
8. To dissect and gather the significant discoveries of the exploration work completed in the theory and further to make proposals and to investigate the potential outcomes of future research.

1.4 SCOPE OF THE STUDY

The extent of the current examination is constrained to build up a methodology for the country assessment and ranking by demonstrating it as a multi-criteria decision-making problem. Various collaborating assessment indicators/sub-indicators must be recognized for the evaluation of different countries in the current investigation. The research work is centered on valid identification of evaluation measures, strategy and method development, and estimation of weights for the indicators/sub-indicators. With this, the development of a computer-based multi-criteria decision-making system concerning the developed procedure to perform ranking of countries will be another scope of this examination. The recognized strategy is delineated through models and analysis of the developed methodology is also under the extent of this research.

1.5 SIGNIFICANCE OF THE RESEARCH

The world has been developing at a very fast rate but it isn't necessary that all the countries will develop at the same speed. Some countries might be developing at a tremendous speed whereas others might be at a standstill. This leads to a classification of poor income and affluent income based countries. There are a multiple causes that make the use of ranking countries much more significant. Intensifying the issue of missing or insufficient worldwide establishments are basic highlights of the world economy. Firstly, there exists an inflated level of worldwide imbalance in the dispersion of salary. Secondly, there are gigantic contrasts in the innovation accessible to affluent nations and the poor. Third, it consists of a general absence of portability of work universally when contrasted with a lot of higher level

of versatility broadly. Subsequently, low salary work can't move promptly from poor nations to rich and in this way guarantee, on a worldwide level, that the profits to proportionate aptitudes and exertion are evened out. Forth, in the best case there is a small difference between the affluent and poor countries. Most capital developments are starting with one rich nation then onto the next and consequently do nothing to spread the advantages of development to the most reduced salary individuals in the least pay nations. To study such an analysis, it is necessary to rank the countries for further advancement and taking preventive measures.

The major issue with country assessment and indicator selection is that it has become a huge difficult activity for the economist and statisticians for studying the development of the country due to number unforeseen indicators. It is necessary to improve the existing techniques which are based on the basis of a single major indicator as a parameter for comparison to get optimized results. Thus, a successful strategy that is competent to choose the most appropriate indicators for country ranking among the different options is required. In the literature, various determination standards are suited for country ranking, for example, health, trade, environment, Gross Domestic Rate, labor force, CO2 emissions, permit, and so forth. A number of different techniques to deal with country assessment and ranking issues have been created by the numerous analysts in the literature.

The techniques created by scientists in the past are commonly founded on the idea of crisp evaluation. At any rate, decision-makers may not unequivocally characterize the different abstract assessment qualities, for example, crisis issues, neighborhood country risks, etc. No arrangement is available in the current indicator selection techniques while keeping mind the weight for these parameters. It is necessary to identify an efficient technique for allotting the weights to the countries.

Therefore, still exists the need to build up a model that can deal with all the country ranking measures/sub-rules along with their respective priority weights. In this situation, the current investigation is significant as a multi-criteria decision support system based on the technique of the fuzzy modified distance based

methodology (FMDBA) system that can deal with the dynamic procedure thinking about both target and abstract parameters/sub-parameters is created.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Economists/Statisticians have always found that developing an effective model for ranking the countries at a very enormous scale to be a cumbersome task. During the most recent couple of decades, to accomplish a successful and effective model, the researchers have moved towards the reusability of existing models. According to the recent works that have been carried out in this research problem domain, it is first necessary to understand the importance of the Human Development Index (HDI).

The HDI was developed for featuring a person and highlighting their abilities that could be a definitive parameter for surveying whether the nation has improved or degenerated and just not deals with the monetary growth. The HDI can moreover be used to address national plan selection, asking how two countries with a comparative level of GNI per capita can end up with different human progression results. These intricacies can then debate about government strategy [1]. It is a rundown proportion of average manoeuvre in key elements of development: fitness level of the individual, being proficient and have an above average lifestyle and environment. It can be said to be the geometric mean of the collected normalized records based on the indicator values. The major disadvantage of this is that it takes only these 3 dimensions into account while trying to compare the countries.

The examination of nation improvement is the subject of numerous conversations and problems from the very start. Also, there has been a huge dilemma to identify the set of indicators. A few parameters are utilized as an extensive pointer for this process. The major issue is the accessibility of legitimate indicator data. For the analysis process, it is necessary to have information regarding the most basic indicator. Now while identifying these indicators the major question that arises is that whether the most commonly used indicators are of

any importance, also does there exist any indicator that might not have been uncovered but would have been able to provide information of great importance. This limitation is additionally the availability of such information. It is important to identify a relative number of all well-selected macroeconomic markers that would have a correlation between them [38].

It is also necessary to understand that exist an abundance of indicators. Thus making it crucial to perform the process of dimension reduction on these indicators in order to obtain only the significant ones. In the process of ranking the countries, the success of country development is purely dependent on the world development indicators that are going to be used for the same. So, the identification and the selection of the World Development Indicators is a very significant step for the ranking of the countries. If the selection is not performed properly then it can result in an inaccurate ranking of countries, low quality, and more cost. The process of identifying the indicators is a very tedious task for the decision-makers nowadays. The list of indicators has increased tremendously, which results in difficulty in the selection of countries and indicators. The research on the ranking of countries is of great significance because the effective and efficient ranking of countries will lead to the identification of strengths and weaknesses of each, thus resulting in world development.

2.2 MOTIVATION AND FRAMEWORK FOR THE REVIEW

Achieving the successful identification and classification of countries according to its indicators is a very important and cumbersome task, given that the idea of developed, developing and underdeveloped countries is very intricate and majorly includes numerous parameters, for example, social and economic factors. The requirement for such a characterization is extremely accentuated, even though there is no single arrangement with definitely characterized standards that can be applied to every nation to give applicable data and dependable image of improvement of nations in the world. Modern Theory hypothesis characterizes development as a multidimensional and complex marvel, which is thus difficult to gauge with only one macroeconomic marker, it takes the entire arrangement of

them. Today, extraordinary global associations utilize various frameworks grouping the countries. This development has elevated a major issue of a suitable selection of countries for creating the desired ranking system. Due to the constant increase in availability and new additions of the world development indicators, the selection of apt parameters is becoming more and more complex for the decision-makers.

Along these lines, a procedure or system is required that will be able to perform proficient nation's determination and assessment. The most tedious task faced by the leaders in the selection of the nation is the recognizable proof of assessment standards for which the distinguished nations' parts will be assessed. The identification and evaluation rules may vary from social indicators to monetary ones and further topographical factors. The issue of the countries evaluation and determination can be seen as Multi-Criteria Decision-Making (MCMD) issue. Various methodologies have been created which are proficient to deal with the issues related to the nation’s selection procedures.

2.3 REVIEW OF EXISTING LITERATURE

For recognizing a novel domain of research, understand the state-of-the-art, substantial literature is gathered from various diversified fields of country ranking, World Development Indicators, and its choice. To comprehend and decipher the previous researches based on differing viewpoints that leads to the formulation of the current research issue, the literature accessible in different sub-regions of country choice that incorporates predominantly, history of world development indicators, WDI correlation, WDI determination, country selection standards, and methodologies and other explicit writing are considered for the development of the research.

An attempt is made to summarize and comprehend the literature based on described major objectives and recognized literature highlights identified with proposed work. It is past the extent of this thesis to descriptively elucidate all the references recorded under the different headings. Subsequently, an endeavor is made to depict the whole literature in an arrangement with the goal that only a

couple of research articles are shrouded in the explanation for every domain as a representative work in that specific classification. It helps in inferring significant inductions concerning the pattern and potential for additional examination in that field. Due to the non-accessibility of certain journals, literature, books, researches, etc., the literature has not been comprehensive and consequently, is just a characteristic example; nevertheless, it bolsters the improvement of the system for ideal determination of world development indicators and countries. The accompanying few sections delineate about just the major compelling articles in different classifications which are imperative to the issue detailing for the current research work.

2.3.1 Search Methodology

Numerous resources like conference proceedings, conference research papers, and books, doctoral dissertations, and authenticated articles/blogs, national and international well-known journals were used for deriving the data for the current research work. In order to establish and find pertinent data for country evaluation and selection important keywords, for example, World Development Indicators, HDI, WDI selection and evaluation, country evaluation criteria, etc. were used.

2.3.2 World Development Indicators

Numerous resources like conference proceedings, conference research papers, and books, doctoral dissertations, and authenticated articles/blogs, national and international well-known journals were used for deriving the data for the current research work. In order to establish and find pertinent data for country many factors contribute towards the advancement of the country, be it financial, social, or political. These parameters that indicate towards the development of the country are known as World Development Indicators. It is the compilation and collection of all the national, international, and regional statistics on world development. It includes data country-wise as well as a country-category wise like penurious, average, affluent income based countries, etc. It provides us with 1600 indicators for 217 economies since 1960 [4]. Due to numerous amounts of indicators, it is necessary to identify the significant indicators and the correlation between them. Numerous

works have been carried out in this domain and thus will be discussed further. Evaluation and selection of important keywords, for example, World Development Indicators, HDI, WDI selection and evaluation, country evaluation criteria, etc. was necessary to understand this methodology.

In the research paper of Samah Hijazi, et. al. [20], fisher and relief scores were used for selecting the indicator under a supervised study. The author proposed that utilizing these scores will result in choosing the pertinent human development factors that accord the most in the improvement of classes that were influenced by the diversified Middle Eastern nations. The test results depicted the level of significance for parameter determination. They additionally uncovered the significance of certain pointers identified in the level of participation of women's work power for the improvement of these Center Eastern nations. In the fisher score analysis, higher score is more relevant parameter and the WDI were ranked in their descending order. Similarly, the relief algorithm assigns the weight to each indicator as indicated by its pertinence [24]. Firstly all the weights are assigned 0, after which its value gets modified iteratively. To refresh these loads, on each step, an arbitrary sample is selected over the dataset and its closest neighbor having a place with a similar class (closest hit) and its closest neighbor having a place with an alternate class (closest miss) are recognized. These weights will get updated by taking into account the difference between the distance of the nearest miss and the nearest hits for the corresponding indicator. Finally, the weights were then normalized in the range of [-1, 1]. Through this research selection of the most significant human improvement pointers for the grouping of the Middle Eastern nations was performed. These two scores were at first intended for regulated parameter determination. Results show the enthusiasm of the selection procedure since not all the factors need to be significant for the categorization of the Central Eastern nations. The disadvantage of this research was that by using the fisher score one can’t understand the correlation between the sub-parameters. Due to this, it is difficult to understand the mutual interaction between the various indicators.

In numerous areas, for example, income, agriculture, private sector, etc., data sets are portrayed by input and output parameters. Every data sample utilizes information pointers to create the output ones. Furthermore, these information tests

are ordered into various gatherings that mirror the productivity of utilizing the contributions to request to deliver the yields [5][6][32]. Thus resulting in large computation power and storage capacity, which further leads to very poor performance. Hence it is necessary to perform a selection of indicators.

In the research work of Mariam Kalakech, et.al. [21][22], the Laplacian score was used for identifying and choosing the most pertinent income parameters for Central Eastern nations. This had demonstrated great characterization performances for those nations while decreasing their parameter space. The author had proposed a novel approach to figure the similarity matrix i.e. utilized by this Laplacian score to play out the determination of indicators. This comparability grid is determined by utilizing the chosen result (yield) pointers. According to the given matrix, a Laplacian score is credited to individual indicator. Then the indicators under study are ranked by their corresponding values and the one with highest value i.e. the most important one were chosen. According to the experimental results, it was observed that outcomes of the o/p indicator space were more favorable than the ones obtained using the supervised Laplacian score. But these researches were based only on the 14 countries of the Middle East. Thus it doesn't take into consideration the countries of various ethnicities and geographical boundaries.

Dan Yang, et. al. [45], revealed a stark correlation among the various world development parameters that have noteworthy use in improvement of advancement parameter frameworks and forecast of undetermined factors. The outcomes aid to satisfy the need for constant financial, legislature dynamic and spare assets. The author has selected more than 1000 indicators for many countries above 100. To measure the value of correlation, the author has selected the Pearson Correlation Coefficient. This technique is quite helpful for determining the level of correlation between the variables. The value of coefficient obtained ranges from -1 to 1 where, 0 is for no linear correlation, 1 for purely positive linear correlation and -1 for purely negative linear correlation. The Table 2.1 represents that the indicator pairs are not just related through time but have a strong correlation among the countries. In this r_c and r_t represents the correlation coefficients for development indicators of China and Time.

Table 2.1. Correlated Indicators [45]

Indicator i	Indicator j	r_c	r_t
Public and Publicly guaranteed Commercial Banks (Interest Payments)	Public and Publicly guaranteed Private Creditors (Interest Payments)	0.88	0.92
Number of infant deaths	Number of under-five deaths	0.99	0.99
Mortality Rate, infants	Mortality Rate, under 5	0.99	0.99
Public and Publicly guaranteed Multilateral (Interest Payments)	Public and Publicly guaranteed Official Creditors (Interest Payments)	0.94	0.93
Bilateral Disbursements (Long term Debt)	Official Creditors Disbursements (Long term Debt)	0.91	0.89
Public Sector Commercial Banks(Long term Debt)	Private Creditors (Long term Debt)	0.99	0.87
Official Creditors (Principal repayments)	Long Term External debt (Principal repayments)	0.88	0.86
Public and Publicly guaranteed Bilateral (Long term Debt)	Public and Publicly guaranteed Official Creditors (Long term Debt)	0.96	0.87
Multilateral(Principal repayments)	Official Creditors (Principal repayments)	0.86	0.87

With the development of countries, new indicators are also been discovered gradually, According to the research work of Nakul P Raykar, et. al. [39], new indicators related to the field of surgical and anesthesia have been discovered. These indicators are access time to Surgical volume, providing the surgery on time, Preoperative mortality, providing the protection against malnourishment, Specialist surgical workforce density, and catastrophic cost. Thus this paper discussed the importance of these indicators in the domain of health.

2.3.3 Ranking Based Methodologies

As the primary focus of this research is to provide an optimal ranking mechanism for countries using the world development indicators, this section provides a summarized version of the existing research works.

K.Peniwati, et. al. [33], considered the lifestyle indicator for the determination of the advancement level of a country. Even though there are many discrepancies with using GNP, the author still has considered it to be the best mechanism for the same. Morawetz [29] observed that there exists a frail relationship between's the degree of gross national product and indicator for

contentment of the essentials and a far superior one between the development of GNP and upgrades in fundamental pointers. The parameters utilized in this research were: GNP per capita, physical personal satisfaction, level of national pay got by the most impecunious 40%, populace thickness in horticultural zones, political rights and common freedoms, total amount of phones per capita and medication-related offenses. Nearly two dozen countries were utilized for getting the total estimation. The experimental results showed that Australia was ranked 1st followed by the United States. The author used the AHP technique (discussed in the next section) for the ranking system. This uses both the tangible and intangible factors. The problem with this research was that several issues were found using the GNP mechanism.

In the research performed by Dr. Anna Sheila, et.al. [14], ten Asian countries were taken into account for the observation and ranking of the countries based on four vital factors of tourism: food, the travel spots in the nation, security and average cost for basic items. The author has used the AHP for performing the computation for the corresponding countries. These positions had a scope of being utilized for the travel industry advancements, acknowledgments, and even for selecting vacation spots. Loads of the corresponding four parameters (food, visitor goals, security, and the average cost for basic items) were balanced by the need of the individual for picking which nation to visit or an organization that will perceive the travel industry positions among Asian nations. The introduced process yielded the greatest consistency proportion of 8.55%. The author calculated the normalized weights for the countries: China (HK), India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Thailand and Vietnam for the cost of tourism, food, safety measures and tourist. Each of these indicators was given equal weight-age of 0.25. The highest value was for South Korea and lowest to India. South Korea was ranked first followed by Indonesia and Malaysia. The lowest ranks were allotted to India, China and Singapore.

Andry Alamsyah, et. al. [7], developed an Artificial Neural Network (ANN) inspired network for predicting the future economic conditions. An economic crisis is a scenario that can be quite unpredictable at times, due to which the author has

suggested a novel mechanism for the same. This research was based on the Indonesian Economy growth and the indicators used were that of macroeconomic variables. A multilayer perceptron model based on ANN was used for solving this convoluted and non-linear problem [19] [23]. The information factors utilized were: GDP consistent value, absolute speculation, government all-out consumption, export, and import. Around 11 hidden neurons were used for carrying out this research which is further depicted in Figure 2.1. The accuracy score obtained during this prediction was that of 95.81% with an error rate of 4.19%. This research was limited to only the economic indicators of the Indonesian economy due to which one can't predict the impact this economy could have on the world economy.

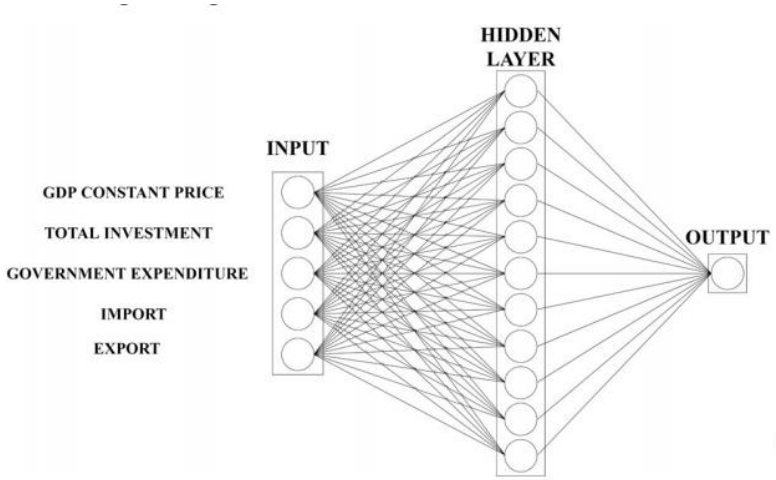

Figure 2.1: ANN Architecture for the Economic indicators [7]

Health is also one of the major contributors to the ranking of countries as it deals with the population that impacts the country's development [31], thus to study about its death rate, healthy lifestyle of the populace is also very vital. Chris Preethi, et. al. [35], gave their contribution in this domain. According to their research work, they used the factor scoring approach to identify the ranks of the various nations based on the indicators related to the health domain using data science techniques. The approaches used were direct weighted method, ordinary least square mechanism, Regression method, and Scoring method of SPSS. In this factor analysis [9][13] was used not only for determining the factors but also to study the significance of the factors so that the less important parameters can be removed, thus leading to the dimensionality reduction. Additionally, the direct-weighted method was used to study the cause of differential weights among the

factors. This in turn helps the decision-makers to decide which dimension of health needs more focus. A total of 22 health-related indicators were taken into observation for carrying out the said research.

Alan L., et. al. [34], brought light to three new indicators based on the high technological competitiveness for 29 countries. High Technology-based parameters mirrored the accomplishment of a country's yields' of innovation-based items and services in universal markets. These are pointers that get from a broad investigation of elective measures. Rules utilized to build these pointers were accessibility of segment measures for a wide arrangement of nations, particularly incorporating the NICs; relevance to the methodology of competition; information quality; information availability for biennial marker development, and comprehending level, which consists of face validation and degree of contrast among nations.

According to the comparative study conducted by Vijay Kumar [41], it is necessary to analyze and contrast the 3 countries namely India, China, and the USA to comprehend world development in terms of agriculture. In horticulture, the output product per sector land which was highly below the global standards. India could thus become central hub for exporting the food, only if certain parameters were able to meet the world agriculture development standards. Even though China has a small amount of cultivable land, yet it can generate twofold the food grains than India. India is certainly blessed with vast daylight, river, lakes, adequate rains and dedicated residents due to its topology. Yet due to lack of better governance India’s output doesn’t come out more significantly. Globally where the government strategies and administration are bad, the presentation of its residents is likewise low.

Keith Wiebe, et. al. [44], represented a cross country differences in terms of the resource quality as well as Agricultural Productivity. In this paper, the author dealt with the prior investigations of rural profitability by consolidating spatially referenced information and statistics on soil and atmosphere joined with high-goals land-spread information. Econometric examination of this information, alongside broadly classified information on agrarian sources of input and outputs from 196 to 1997 for around 110 nations, measures the huge effect that distinctions in land

quality have on horticultural efficiency. The outcomes of this research showed that ameliorated markers of asset quality contribute to detected global contrasts in rural work efficiency, well beyond the impact of pointers utilized in the previous literature. Better soils and atmosphere were related to increments of 20 percent or more in rural yield per laborer in many areas, rest being equivalent. Improved evaluations of land quality's results on rural yield per specialist may result in improved estimations of the impacts of other ordinary and nonconventional factors on profitability.

Anilkumar M, et.al. [25], discussed the need to employ a novel framework that helps in ranking the Higher Education Colleges/ Institutes of India. The Indian higher education system has been secluded due to many reasons. The major objective of this research was to build up an exhaustive arrangement investigation structure on approach received by NIRF (2017), methodically enlist the procedure received by various advanced literacy positioning organizations and fundamentally break down the overall accentuation of NIRF strategy at various degrees of granularity when coded on QS and Times positioning.

While comparing the countries, it is also necessary to understand the factors affecting both affluent and non affluent countries. In this study of Pei Lee. Teh, etc. [43], had analyzed the effect of improvements in the state of health and safety, laborer's aspirations, fulfillment, and maintaining a work/life stability approaches on changes in item quality and authenticity by distinguishing between the developing and developed nations. A survey has exhibited that a progressively important focus on work/life balance courses of action doesn't majorly affect the quality and realness of the item for the comparing developed and under-developed countries. Conversely, boosting the health and security conditions of nations has had crucial effects.

In the research work of Ernesto Araujo [8], the fuzzy approach for dimensionality reduction was proposed for examining the economic activities. The requirement for observing the monetary effect is essential to quantify the financial development and the adequacy of national and international financial strategy. The fuzzy dimensionality reduction is utilized with fuzzy computation, which is utilized

to depict and demonstrate social relations. World Bank supplies information for representing the capability of the proposed approach. Such a methodology consolidates them into a straightforward realistic and multidimensional dynamic demonstrating for financial execution investigations and correlations.

The domain of research education also impacts the development of the country. One such research was conducted by Xolani Makhoba, et. al.[28]. The author deals with identifying the efficiency level of the research and development field of nanotechnology and biotechnology for the African countries. This is examined through the evaluation of outputs concerning input. The investigation found that, inside South Africa, nanotechnology is successful in terms of patent and distributions productivity. In comparison with BRICS nations, it was discovered that the country with the most noteworthy R&D proficiency was South Africa as estimated by both factors: licenses and distributions. This showed that efficiency wasn't a component of assets accessible. The limitation of this research was that it deals with only a small number of indicators in the convoluted situation. The efficiency of R&D was calculated as follows:

$$Efficiency = (Number\ of\ patents)/\ (R\&D\ Expenditure) \quad (2.1)$$

2.3.4 Human Development Index (HDI)

It consists of statistical records regarding the average expected years an individual is alive, education, and income factors [29]. This in turn is used for ranking the countries in terms of advancement as a human being. If the average lifespan of an individual id greater, the degree of education is higher and the DNI is also greater than the nation scores a higher HDI. Indian economist analyst Amartya Sen and Pakistani financial specialist Mahbub ul Haq were responsible for developing HDI. Additionally, it is also used to determine a nation's growth through UNDP's. The main advantages of using HDI are [2]:

i. HDI indicators are accepted and used globally due to its application in comparing the financial patterns, etc.

ii. Enhanced education level and wellbeing of people's prompts an improvement in the nation's foundation.
iii. Since it has 3 major factors in different domains, it is thus able to maintain a balance in the development process.
iv. It can empower decision-makers in the nation to conveniently modify and apply financial strategies.
v. It takes estimation in three territories; wellbeing, education, and financial level, thus providing with good precision.
vi. It is more dependable as it not only incorporates the financial aspects but also the standard of living and maintains the literacy rate.
vii. It also deals with the average contribution an individual makes in terms of financial welfare.
viii. HDI information empowers the administration to know regions that need quick consideration and to think of fitting measures for advancement.
ix. The government can utilize HDI information to designate assets to ventures/ projects being developed.
x. HDI evaluates the social monetary advancement of the nation from different viewpoints.

As the use of HDI leads to the great benefits to world development, some demerits are also associated with the use of HDI as:

i. Different nations have distinctive HDI values and access various gatherings diversely bringing about a wide difference inside the nations.
ii. It only deals with the long lasting changes in the nation for example, future of citizens, etc.
iii. It doesn’t consider other parameters like death rate, agriculture, economic distribution, etc.
iv. It is hard to quantify whether poor families can get to essential, auxiliary, tertiary, and high education.
v. It can also lead to high inequality among the people of the country. Higher GNI brings about elevated levels of imbalance.
vi. It is dependent on certain elements in terms of an economy like the level of populace, availability of clean water, etc.

vii. There is a ton of analysis that the GDP doesn't gauge inconsistent dissemination inside the nation in this manner giving an erroneous degree of monetary turn of events.

viii. There are different methods of evaluating the wellbeing or lifespan and degree of education, thus there isn't any definitive approach/ measure to be followed.

ix. The data is not always consistent as some of the parameters calculated might not be evaluated yearly.

2.3.5 Multi – Criteria Decision Making (MCMD) techniques

While ranking the countries it is necessary to identify the numerous parameters according to which it is going to be ranked. Existing country ranking models/strategies utilize the methods dependent on dynamic. The two most regularly utilized methodologies are:

(i)Analytic Hierarchy Process (AHP)

(ii) Weighted Score Method (WSM).

2.3.5.1 Weighted Score Method (WSM)

It measures the total fitness for each criterion, using the formula:

$$Final\ Score = \sum_{j=1}^{n} (W_i * S_{ij}) \quad for\ i = 1,2,\dots,m \tag{2.2}$$

Where W_j is the weight related with the jth measure, and S_{ij} is the fitness score of the ith elective w.r.t. j^{th} measure.

The weights are allotted by decision-makers, and the fitness score represents to the satisfaction of the item with a particular measure. An example is represented in Table 2.2, where the weights are depicted using a 9-point scale. The weight scale ranges as 1 for the most unimportant indicator, 9 for the most important indicator and the ranges in between 1 to 9 depict intermediate level of indicators.

Table 2.2: Final Scores using WSM

Development Indicator		**Country**		
Indicator	**Weight**	**Country-1**	**Country-2**	**Country-3**
C1-Agriculture	3	0.5	1	0.5
C2-Economy	9	1	0.9	0.3
C3-Education	5	0.7	1	0.5
Total Score		14	16.1	6.7
Ranking of Countries		2	1	3

The indicator are for corresponding nations are then standardized between the range of 0 to 1, where, 0 delineates the lowest level of fulfillment and 1 delineates the highest value of fulfillment.

The overall scores are determined to utilize Equation (2.2). In the WSM strategy [40], the calculated scores delineate the ultimate positioning of countries. Nevertheless, the difference in the evaluated score doesn't demonstrate the mediocrity or predominance of the other countries.

Ncube and Dean [30] depict a few restrictions related to weighted score technique (WSM) as: (1) In WSM, results appear as real numbers, which can thus be misconstrued as genuine contrasts among the selection. (2) Estimating the loads is troublesome when there exist countless indicators as it is quite tedious to depict the correlation between them. (3) The outcome when converted to a real number can suppress the performance of some poor-performing indicators.

2.3.5.2 Analytic Hierarchy Process (AHP)

The AHP strategy deals with aligning the selected development indicators in a hierarchy such that it begins from the general objective and ending on the various options through the indicator/sub-indicators. The significance of the

standards at each degree of the chain is evaluated by pair-wise correlations. Saaty gave the accompanying 9-point scale which can be utilized in this correlation:

- 1 – Depicts the indicator DI1 and DI2 have equivalent importance.
- 9 – Depicts the indicator DI1 is of exceptional significance than DI2.
- Between 1to 9 – Depicts the indicator DI2 relatively significant than DI1.

The outcomes of the analysis are then changed into standardized rankings through an eigen value method on the matrix. The standardized rankings show loads of the various indicators present for comparison. Then all the weighted scores of various items can be assessed by contrasting these items in a pair of two concerning every measure. Examination of the standards (or items) in pair produces increased outcomes because of the following factors:

(i) AHP matrix incorporates a great deal of repetition that permits consistency check

(ii) Pair-wise correlation is increasingly accurate and simpler to act in contrast with allocating absolute value for indicators in a huge data.

The AHP method ends up being exceptionally viable in issues that require dynamic and positioning as executed in [42], [37], [46] and [47] in fundamental ordinary issues as well as in the fields of designing, the executives and the travel industry, for example, those in [18]. Table 2.3 depicts an instance of using the AHP method which consists of 4 major criteria with a single hierarchical level.

The outcomes are depicted using a 9-point scale, after performing a pair-wise comparison between the criteria. The table below shows that DI1 is more significant that DI2, whereas DI4 is more significant that DI1. Likewise, development indicator DI2 is more significant that DI3, whereas DI4 is more significant that DI2. The results are then normalized which are also shown in Table 2.3.

Table 2.3: AHP Instance

	DI1	DI2	DI3	DI4
DI1	1	4	2	1/7
DI2		1	9	1/9
DI3			1	1/6
DI4				1

Indicators	Normalized Ranking
I1	0.204
I2	0.066
I3	0.042
I4	0.685

Though AHP [10][15][40] has been used in many literatures and researches for performing the ranking, yet it consists of some drawbacks:

(i) Since there are huge amount of pair-wise comparison, it will perform great number of computations, time and effort for large number of indicators.

(ii)In real life situations it is not possible to have all the independent indicators. The indicators of real-time consist of some amount of dependencies.

2.4 FUZZY SET THEORY

FST was formulated by Zadeh in 1965; has ended up being crucial for various applications [48][49]. In a fuzzy set hypothesis, the information is gathered from the respondents in semantic factors which are subjective, for example Extremely Less Important, Very Less Important, Less Important, Important, More Important, Very More Important, Extremely More Important and so on. These semantic factors are then changed over into a crisp score, a real number, through the membership functions of the FST. FST is utilized for allotting weights to the development indicators/sub-indicators, thus contributing to the country ranking system.

2.4.1 Triangular Fuzzy Numbers

In the fuzzy set theory, the TFN are a way of expressing the membership function of an element of a specific set and are shown in Figure 2.2. The utilization of the TFNs is intuitively simple for the specialists or the experts to utilize; analyze and evaluate. The membership function of any TFN can be indicated as:

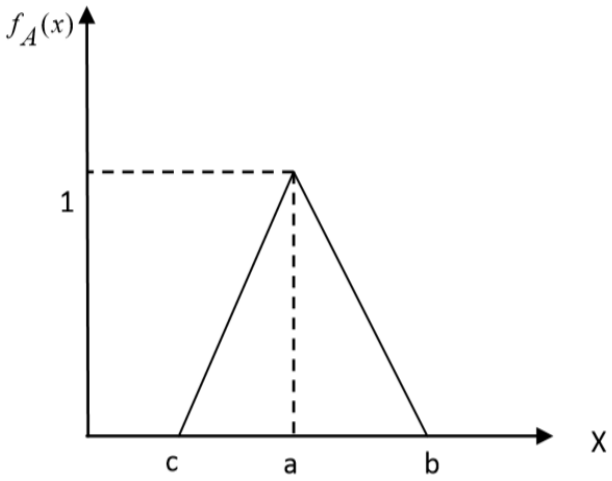

Figure 2.2: Membership Function

$$f(x) = \begin{cases} \frac{(x-c)}{(a-c)}, & c \le x \le a \\ \frac{(b-x)}{(b-a)}, & a \le x \le b \\ 0, & otherwise\ wherer\ a, b, c\ are\ real\ numbers \end{cases} \quad (2.3)$$

The membership function is calculated using the Zadeh's extension law and the TFN can be represented as a triplet i.e. if Z_1 and Z_2 are two TFNs; then $Z_1 = (l_1, m_1, n_1)$ and $Z_2 = (l_2, m_2, n_2)$. Mathematically:

Addition:

$$Z_2\ (+)\ Z_1: \left(l_{2,} m_{2,} n_2\right)\ (+)\ \left(l_{1,} m_{1,} n_1\right) = (l_{1,} + l_{2,} m_1 + m_2, n_{1,} + n_{2,}) \quad (2.4)$$

Multiplication:

$$Z_2\ (*)\ Z_1: \left(l_{2,} m_{2,} n_2\right)\ (*)\ \left(l_{1,} m_{1,} n_1\right) = (l_1 * l_{2,} m_1 * m_2, n_1 * n_{2,}) \quad (2.5)$$

2.4.2 Linguistic Terms in Triangular Fuzzy Numbers

In real-life problems, the human mind doesn't work according to a fixed set of numbers instead it consists of several semantic terms. Due to the unambiguous nature of human perceptions, it is tough to perform mathematical calculations. This problem is solved using linguistic terms of fuzzy which help in converting to crisp numbers. Each linguistic term represents the weight o the evaluation criteria and sub-criteria. The words or sentences in regular language are named as semantic factors. In this thesis, a seven-point fuzzy scale is chosen for assessment of the loads using semantic terms, for example, amazingly progressively significant (EMI), increasingly significant (VMI), extremely more important (EMI), very more important (VMI), more important (MI), important (I), less important (LI), very less important (VLI) and extremely less important (ELI). The 7-point fuzzy scale is delineated in Figure 2.3.

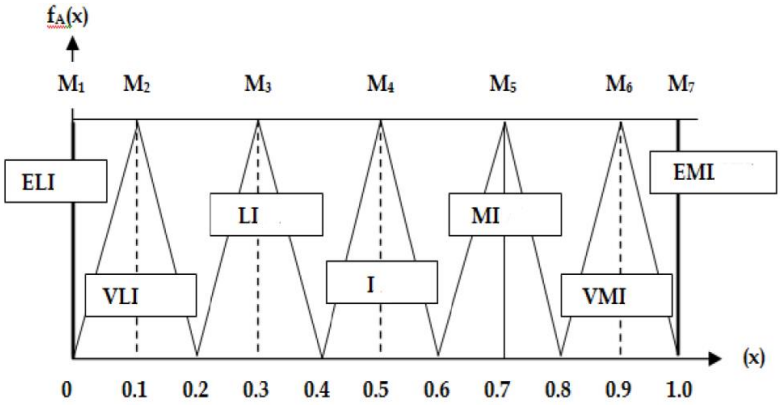

Figure 2.3: Seven Point Fuzzy Scale

2.4.3 Fuzzy Algorithms

Mathematical terms like mean, median, mode, averages, etc. are used for the statistical aggregation of the experts' evaluation. A group of 'n' number of experts (E_i) evaluates the weights of 'k' number of indicators (C_i). If any expert 'E_i' assigns a weight of 'W_t' to any criterion 'C_t'; then

$$W_t = \left(\frac{1}{n}\right)(*)\ (W_{t1}\ (+)\ W_{t2}\ (+)\ \dots\ (+)\ W_{tn}) = \left(\frac{1}{n}\right)\sum_{e=1}^{n} W_{te} \quad \text{for } t = 1, 2, \dots, k \text{ and } e = 1, 2, \dots, n \tag{2.6}$$

2.4.4 Transforming Fuzzy Numbers to Crisp Scores

The linguistic terms obtained by the expert judgment is transformed to the TFN. These are then converted into fuzzy number using the method of maximization and minimization methods for set. The maximizing set is defined by Chen [11][12] is M = {(x, fM(x)) | x∈ R} with

$$\mu(x) = \begin{cases} \frac{(x - x_{min})}{(x_{max} - x_{min})}, & x_{min} \leq 0 \leq x_{max} \\ 0, & otherwise \end{cases} \tag{2.7}$$

$$zing\ set, G = \{(x, f_G(x) |\ x\ \in R)\} \tag{2.8}$$

$$\mu(x) = \begin{cases} \frac{(x - x_{max})}{(x_{min} - x_{max})}, & x_{min} \leq 0 \leq x_{max} \\ 0, & otherwise \end{cases} \tag{2.9}$$

$$x_{min} = \inf\ S, x_{max} = \sup\ S, S = \ U_{i=1}^{m}\ F_i\ , F_i = \{x\ | f_{F_{i,}}(x) > 0\}$$

$$for\ i = 1,2, \dots, m$$

$$Utility\ value, U_M(F_i) = \sup\left(f_{F_i}(x) \cap\ f_M(x)\right), \quad for\ i = 1,2, \dots, m \tag{2.10}$$

$$Utility\ value, U_G(F_i) = \sup\left(f_{F_i}(x) \cap\ f_G(x)\right), \quad for\ i = 1,2, \dots, m \tag{2.11}$$

$$Utility\ value, U_T(F_i) = (U_M(F_i) +\ 1 -\ U_G(F_i))/2 \tag{2.12}$$

2.4.5 Defuzzification

Defuzzification is defined as a procedure of converting the fuzzy value to numerical ones. There exist a significant number of strategies formulated by different researchers earlier however no heed was paid to it. The current strategies depend on the calculation of fuzzy values into a an accurate numerical score which is utilized for the correlation. Weighted standardized defuzzification approach is utilized for defuzzification. The equation is given as:

$$x^* = \frac{\sum_{i=1}^{n} m^i w_i}{\sum_{i=1}^{n} m^i} \tag{2.13}$$

Where memberships 'm_i' and weights 'w_i' determines x* is defuzzified output. The approach is very simple, easy and suitable for accurate computations.

The seven-point fuzzy scale helps in determining the crisp scores as given in Table 2.4.

Table 2.4: Transformation Table for Linguistic Terms to Crisp Score Values

Qualitative measures of criteria/sub-criteria (Linguistic Variables)	**Triangular Fuzzy Number**	**Membership Function $\mu(x)$**	Right Score $\mu_R(M_1)$	Left Score $\mu_L(M_1)$	Crisp Score $\mu_T(M_1)$
Extremely Less Important	M_1 (0,0,0)	$\mu_{M_1}(x) = 0, x = 0$	0	1	0
Very Less Important	M_1 (0,0.1,0.2)	$\mu_{M_2}(x) = \begin{cases} \frac{x-0}{0.1}, & 0 \le x \le 0.1 \\ \frac{0.2-x}{0.1}, & 0.1 \le x \le 0.2 \end{cases}$	0.181	0.909	0.136
Less Important	M_1 (0.2,0.3,0.4)	$\mu_{M_2}(x) = \begin{cases} \frac{x-0.2}{0.1}, & 0.2 \le x \le 0.3 \\ \frac{0.4-x}{0.1}, & 0.3 \le x \le 0.4 \end{cases}$	0.363	0.727	0.318
Important	M_1 (0.4,0.5,0.6)	$\mu_{M_2}(x) = \begin{cases} \frac{x-0.4}{0.1}, & 0.4 \le x \le 0.5 \\ \frac{0.6-x}{0.1}, & 0.5 \le x \le 0.6 \end{cases}$	0.545	0.545	0.5
More Important	M_1 (0.6,0.7,0.8)	$\mu_{M_2}(x) = \begin{cases} \frac{x-0.6}{0.1}, & 0.6 \le x \le 0.7 \\ \frac{0.8-x}{0.1}, & 0.7 \le x \le 0.8 \end{cases}$	0.727	0.363	0.681
Very More Important	M_1 (0.8,0.9,1)	$\mu_{M_2}(x) = \begin{cases} \frac{x-0.8}{0.1}, & 0.8 \le x \le 0.9 \\ \frac{1-x}{0.1}, & 0.9 \le x \le 1 \end{cases}$	0.909	0.181	0.863
Extremely More Important	M_1 (1,1,)	$\mu_{M_1}(x) = 1, x = 1$	1	0	1

2.5 INFERENCES OF THE LITERATURE REVIEW

The primary concerns that can be derived from the comprehensive investigation identified with country assessment and indicator determination are summed up underneath:

1. Various ranking approaches for identifying the ranks of the countries have been reviewed and extensively grouped in two significant classes as subjective and quantitative methodologies.
2. For enhancing the efficiency of the country evaluation and ranking, data mining and ANN techniques can be applied to draw the structure examples and some indicators by examining the comparative choices concerning country evaluation.

3. For performing the optimal selection of indicators and ranking the countries, optimization techniques can have its application by delineating the fitness function.
4. The majority of the research work deals with only a single parameter which is further classified to sub-indicators. Thus it is necessary to develop a model that deals with the major as well as the sub-indicators.
5. None of the current country assessment and choice methodologies -addresses the significance of assessment standards in the country and indicator determination process.
6. The issue of country assessment and indicator determination can be characterized as Multi-Criteria Decision Making (MCDM) problem.
7. The mechanism of using the Fuzzy Set Theory to convert the linguistic terms to the crisp scores is comprehended.

2.6 SUMMARY

This chapter has helped to review the literature work in the present state of research by investigating and examining numerous literatures on the ranking of countries and world development indicators. The literature has been classified in major group's world development indicators, country ranking criteria, and methods. It also discusses the techniques used in the Fuzzy set Theory to obtain the numerical worth/ weightage of the indicators. Since it covers vast domains of work, it might not be necessary that these topics are mutually exclusive but overlapping in nature. By studying this literature one can recognize the potential areas that need the attention of researchers for future research work.

CHAPTER 3

THE PROPOSED WORK

3.1 INTRODUCTION

The system of ranking is intertwined with the constant quest of human beings to evolve and grow. Ranking engenders competition and the desire to raise the bar. It is a tool for reflection and sets achievable standards. Assigning positions evaluates different levels of progress and encourages self-improvement. Human beings, by nature, are prone to making comparisons. This trait, when channelized in a positive direction, fosters growth, and the courage to challenge boundaries. Countries of the world are ranked according to attributes covering all aspects of life. The criteria range from economic, medical, military, lifestyle, cleanliness, and many more parameters. The purpose of this system, in a utopian world, is to offer a benchmark, so that the human race prospers as a whole. It creates and puts forth role models that aim for the 'common good' of mankind. Ranking, when associated with global progress, is a motivational tool. For instance, if a country is awarded the first position in terms of healthcare, other countries can surely benefit from the 'blueprint' that it can offer. This will ensure tried and tested solutions in healthcare, for the entire world to emulate. Conversely, ranking can also result in 'branding' and thereby contributing to racism or unhealthy labeling. Revealing the lacunae of a country can make it more vulnerable vis a vis high ranking nations. Here comes the need for a global conscience, where the system is used as an instrument for growth, rather than persecution.

Hence it is necessary to have an appropriate assessment and selection of world development indicators and countries to develop a ranking system for the decision-makers to analyze the countries' index keeping in mind the certain time, cost, and effort constraints and take certain measures to enhance its growth and development. In the current research work, an unparalleled endeavor by utilizing the technique of Fuzzy Modified Distance-Based Approach (FMDBA) for the assessment, ranking, and selection of world development indicators and countries.

The utilized procedures include basic numerical computations and matrix operations that are proficient to comprehend the problem related to the domain of multi-criteria decision making. Fuzzy Set Theory (FST) is additionally integrated into the proposed MDBA techniques to make them increasingly productive, viable, and reasonable for subjective qualities. The techniques used in the current work take into account the intense interrelationships that exist among the world development indicators and decision levels in comparison to the Analytical Hierarchy Processing (AHP). The exploration highlights the advancement of techniques that can lead the country selection and assessment in a progressively accurate and efficient manner. Based on the proposed work, a hierarchical methodology is developed which capable of solving the MCMD problem.

3.2 RESEARCH QUALITY

Research quality plays a significant role. It is relevant to comprehend that validity and reliability are reasonably distinct i.e. they are interrelated to one another in the way that if the information and the outcomes are not reliable, then they can't be proved to be valid.

3.2.1 Validity

To conduct quality research, validity plays a very pertinent role as it is responsible for maintaining the integrity and consistency of its outcomes and conclusions. It helps in proving the authenticity of the research findings.

According to many literature works, it can be concluded that the quality of the research should be assessed based on the different parameters that have its use in quantitative research. The two primary measures proposed by the analyst for the evaluation of subjective exploration are (i) trustworthiness and (ii) authenticity. A trustworthiness measure, for the most part, comprises of four sub-models as:

- Credibility: It includes the estimation according to the level of belief based on the research work and outcomes.
- Dependability: It deals with the level of consistency of the outcomes or the exploration discoveries.

- Transferability: It measures whether the current research can be applied in some other work and to what context.
- Conformability: It measures the degree of acceptability by others to the current research and outcomes.

3.2.2 Reliability

The reliability of information and experimental results majorly deals with the level of consistency if the outcome concluded from the research analysis. Since the data used is of numerical structure, it can be said that while performing a quantitative investigation the results obtained are similar. Though due to the subjective data, obtaining similar outcomes becomes a cumbersome job while performing as qualitative analysis. Reliability is arranged into two classifications as (i) internal (ii) external reliability. Internal reliability of the information in any exploration focuses on the estimation of consistency of the gathering and investigating the information, whereas, the external one deals with the replication of the exploration study. Thus, external reliability is said to concentrates on the degree to which the current exploration can be duplicated.

3.3 RESEARCH METHODOLOGY

Research Methodologies furnishes the basic framework and outlines the fundamental principle necessary for the production of information and valuable data during the research. The researcher must keep in mind the significance of having a real-time perspective. Further, the exploration issue and the conditions under examination are prepared with the end goal in mind. It has been comprehensively discussed that the subjective examination delivers better extensive bits of knowledge into the research issue in contrast with the quantitative strategies. As the analyst's elucidations impact the research, the qualitative examination primarily underlines the depiction and importance of the specific content, research process received and the different ideas and speculations for information assortment used to complete the exploration in an influential and effective manner.

The primary reason for the current research was to plan a powerful question by getting the hard and complete comprehension of the undertaking that will be done. When the problem domain is detailed, it would assist with satisfying the research objective and significant comprehension of the exploration. After the broad investigation of the problem domain, the following step was to concentrate on the country assessment and determination process. The research methodology for the current exploration work is planned as given in Figure 3.1.

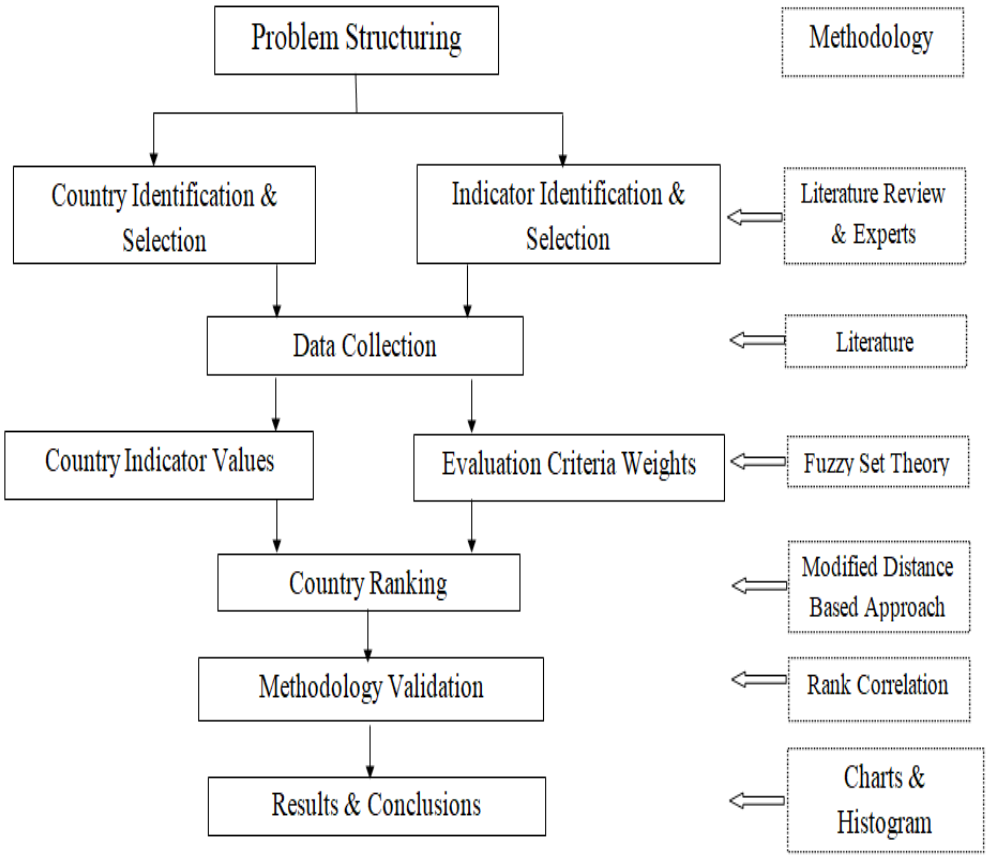

Figure 3.1: Research Methodology

3.3.1 Problem Structuring

There is a consistent relationship between the framework of the model and the various related performance measures. The country ranking system for any nation is a mind-boggling issue where various selection models and sub-indicators influence the ranking of any country. For a better correspondence and introduction, Graph Theory is utilized to structure the selection issue having a structured system for indicator/sub-indicators and association among them.

3.3.1.1 Graph Theory

It is a mathematical and statistical model used for any framework and it delineates various relations between its basic components as a result of its graphical links. Combinatorial mathematics has many branches; Graph Theory is one of the branches. Graph Theory is represented through diagraph, matrix and functions. The digraph is the chart portrayal of the properties/factors and their interdependencies which influences its performance properties. The matrix represents the digraph into numerical structure. Graph theory accepts the system perspective and considers different traits and relation among them. It is a 3-stage framework approach.

1. The structure of the diagraph is represented through nodes and the edges joining them. It is simple to comprehend and understand the various interdependencies among them through visual analysis.
2. In the second phase this digraph is converted into a matrix which can be easily comprehended by the computer systems. So the mathematical analysis performs the conversion of the diagraph to the matrix form. There exist different representation forms for the nodes and edges.
3. Permanent function is a type of science utilized in combinatorial arithmetic which exists as an articulation. It examines different permutations among the standards/indicators and their interdependencies.

The problem of country ranking and selection can be modeled through the graphical structure of the given system. It is a disposition of the components that are linked together to form a structure. The components present in the graph are the indicators and sub-indicators that assess the country ranks.

This graph is represented as $G_s = [V_i, E_i]$, where V_i represents the nodes and E_i depicts the edges. The nodes relate to the indicators/sub-indicators and the edges delineates to the interdependencies between them. The framework digraph depicts the framework graphically. As the number of components i.e. criteria/sub-criteria, indicator/sub-indicators increases, the graph becomes more complex and thus making the graph more complex to comprehend. Figure 3.2 shows a 3-parameter structure graph.

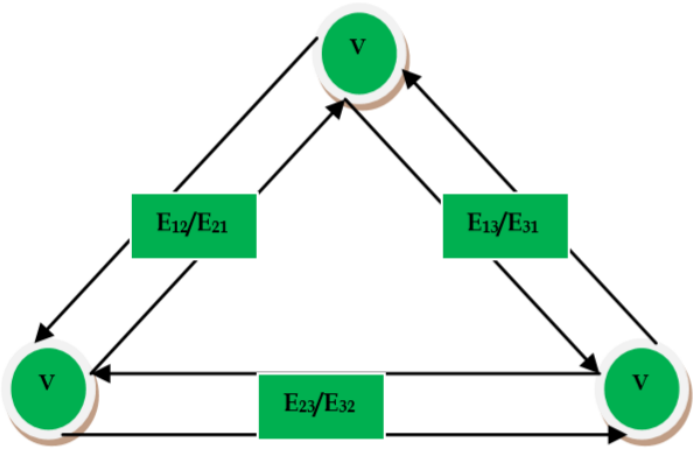

Figure 3.2: Three Parameter Structure Diagraph

Through the given diagraph it can be concluded that the given research problem can be modeled using graph theory and is shown in the Figure 3.3.

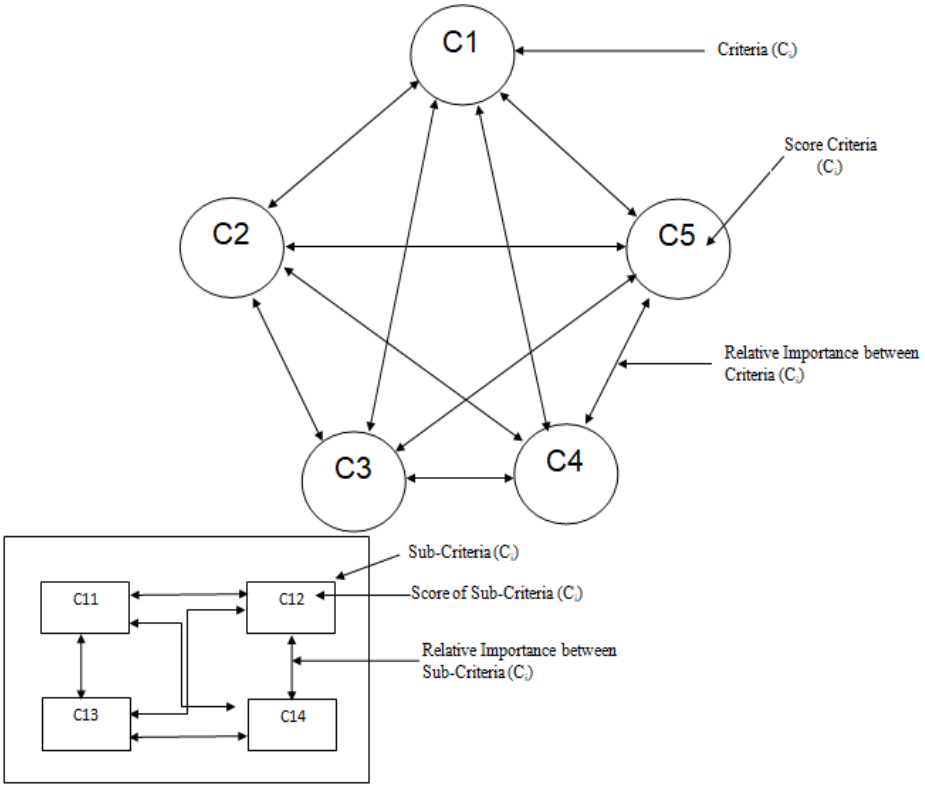

Figure 3.3: Problem Structure

Thus is can be observed that the Graph Theory is an efficient and user-friendly way for presenting the visually analyzing a system that is not fit for computer processing. To conquer this issue, the numerical models of the framework are created utilizing Matrix Methods.

3.3.2 Development Indicator: Evaluation Criteria

In order to develop an efficient ranking and selection mechanism, it is mandatory to know the parameters which are responsible for generating the same. The appropriate measure needs to be taken for proper selection and allocation of accurate weights to these parameters. The step-by-step diagram for the proposed ranking is shown in Figure 3.4.

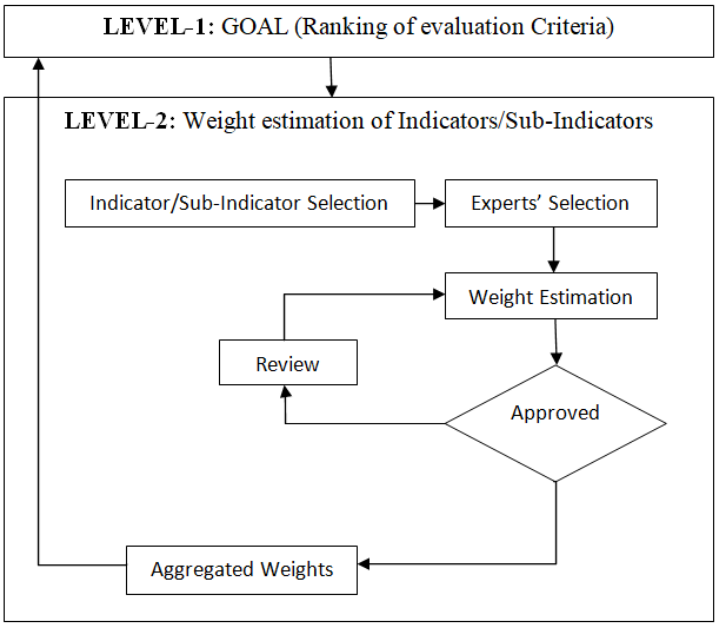

Figure 3.4: Ranking flowchart for Evaluation Criteria/ Sub-Criteria

3.3.2.1 Identification and Selection

The inceptive step for performing the country selection and assessment issue is to set up the evaluation parameters. The selected parameters should comprise recognizing indicators that might be essential to country ranking and have inflated utility value which would depict that the capability of the selected indicator for assessing the country rank is high. Countries can be juxtaposed on the basis of these parameters called the Evaluation Criteria. Through exhaustive research on numerous literatures, information is collected to abide by the indicators/sub-indicators. A total of 5 indicators and 30 sub-indicators have been selected to perform the ranking of 27 countries. Each indicator present in research is related to performing country ranking system in some way or the other. Utilizing the experience gained from the reports, publications, literature, and expert discussions,

thirty rules are recognized and assembled in five significant classifications to be specific:

i. Agriculture and Rural Development :
    a. Agriculture, forestry and fishing value added: It takes into account the net yield produced after calculating all yield and deducting the intermediate products.
    b. Arable land: It identifies the land under impermanent harvests, meadows, land under market, home gardens, and the abandoned land.
    c. Crop production index: It delineates agricultural yields for the period of 2004-2006.
    d. Fertilizer consumption (% of fertilizer production): It gauges amount of artificial supplements supplied per unit of arable land to the flora and fauna. .
    e. Forest area (% of land area): It refers to at least 5m land that consists of tress, which may or may not be productive. It excludes any kind of agricultural production system.
    f. Livestock production index: This consists of meat and milk, dairy items, for example, cheddar, and eggs, nectar, crude silk, fleece, and stows away and skins.
    g. Employment in agriculture: It refers to any individual engaged in the work related to the manufacturing and production of goods and services for salary and profits in agricultural domain.

ii. Economy & Growth:
    a. Exports of goods and services: This generally refers to the transaction that takes place between a person belonging to a country and the rest of the world which involves transfer of authority from citizens to nonresidents excluding the compensation of employees, investment income and transfer payments.
    b. GDP per capita growth: It is defined as the population increment rate per capita i.e. total population rate by the total number of people living in the country.
    c. Imports of goods and services: Goods and services which increase the stock of a country’s textile capital through its trade and industry.

d. Inflation, consumer prices: It is an index measuring retail inflation in the financial system by accumulating the cost variation of the goods and services used by customers.
e. Foreign direct investment, net inflows: This is the value of hidden investment made by foreign investors in the equity capital, repayment of loans, intra-company loans and short-term capital.
f. Unemployment: It refers to the amount of the laborers who are jobless but available for employment and searching for the right opportunity.
g. Population growth (annual %): The increase in the amount of entities in a population. It takes into account all the residents needless of their citizenship.

iii. Education:

a. Government expenditure on education: It is defines as the amount that is spent by the government on schools, any other public and private educational institutions/colleges. The total amount spent on the esucation is considered.
b. Literacy rate, adult total: It is the percentage of the population aged 15 years or over who can both read and write with respect to their daily life, i.e. in the means of the individual's communication.
c. Literacy rate, youth total: It is the ratio of people aged 15 - 24 years who can both read and write with respect to their daily life i.e. in the means of the individual's communication.
d. School enrollment, primary and secondary: It is defined as the ratio of girls and boys enrolled in either a public or private school in primary or secondary education.
e. Gender parity index (GPI): It is a socio-economic index which is planned to calculate the comparative admittance to education of boys and girls.
f. Research and development expenditure: It is a key indicator of efforts of the public and private sectors to acquire benefit in science and technology. The amount that is spent in the advancement of technology, various resources requires for the same, providing a proper research environment are considered for this.

iv. Health:

a. Life expectancy at birth: It is defined as how long a newborn can be expected to survive if there is no change in mortality at the present time for the corresponding country.
b. Mortality rate, infant: In any topological area, the number of deaths of the infants within a year when the live births are calculated is called infant mortality rate.
c. Death rate, crude: Within a year and within a fixed proximity, the ratio of deaths occurring among the populace of a country is known as Death Rate.
d. Prevalence of undernourishment: The prevalence of undernourishment is an approximation of the ratio of the populace whose habitual food intake is inadequate to supply the nutritional energy levels that are needed to continue a standard energetic and fit life.
e. Age dependency ratio: It is known as the number of dependents below 14 years and above 65 years, compared with the total population aged 15 to 64.
f. Fertility rate, total (births per woman): It is defines total number of children born per lady in a year.

v. Private & Public sector:

a. Domestic credit to private sector: It is referred as th economical assets made available to the commercial sector by other reservoir companies/institutions.
b. Fuel exports (% of merchandise exports): All supplies like fuels, lubricants oils, minerals, and related products can be exported by following Standard International Trade Classification (SITC).
c. High-technology exports: They are related to the products belonging to high R&D intensity for example in pharmaceuticals industry, machines, high-productivity computers/GPU's, scientific instruments, robots, AI based industry, aerospace, etc.
d. Military expenditure: A defense budget is the quantity of fiscal reserves granted by the government for advancing and keeping an armed forces or other means necessary for defense purposes.

e. Net lending (+) / net borrowing (-) (% of GDP): It is defined as the revenue made by the government after subtracting the expenses and investments in nonfinancial assets.

3.3.2.2. Evaluation Team

Development is absent in this field and it is difficult to distinguish information in the open publications that could comprise the reason for ranking the development indicators. Subsequently, there is just another way to gather essential information and under such conditions, dependence on specialists' assessment is the main ideal methodology for an assortment of information.

An expert is adequate for a specialist elicitation process if it has vast information and never blunders meaning in this manner impeccable in the field of specialization. The odds of committing an error or because of restricted and deficiency of the information, it is in every case preferred to have progressively over one master. In this research five potential experts were taken into account to perform the analysis of the development indicators.

3.3.3 Data Collection

The exploration will utilize the two sorts of sources that give both the primary and secondary information. The literature regarding these types of data with their usage is summarized below.

3.3.3.1 Primary Data

It is defined as the recently created or gathered information at the initial step to illuminate the thoughts, questions, or examination issues present in the problem. It has various favorable circumstances related to it. Such kind of information especially centers and focuses on the particular subject of the exploration issue and observing and accommodating in deriving the strong conclusions. Interviews can be classified into three categories structures, semi-organized and unorganized. Through organized interviews, there are high chances of getting information yet it

doesn’t remove the possibilities of inaccuracy. To overcome this semi-structured and unstructured data can be used.

3.3.3.2 Secondary Data

It is defined as the information effectively accessible in the open literature or on authentic sites of the associations and utilized for any reason. Its sources offer sufficient foundation information on the exploration point or topic. The sources utilized were of crucial importance for giving an efficient conclusion for the research work. Research studies or papers distributed in diaries of notoriety, books, and articles were gathered and concentrated to increase intensive information on the exploration issue and to recognize the possible development indicators. In this efficient use of both primary and subsidiary information was used. Primary Data is used to determine the weights of the development indicators and the secondary data was used for collecting data regarding the selection of countries and development indicators.

3.3.4 Assigning weights to World Development Indicators

The weights of the indicators and sub-indicators and subsequently their ranking are done which depends on the specialists' decisions utilizing the essentials of the Fuzzy Set Theory. In this five experts have been taken into account to carry out the evaluation.

3.3.4.1 Fuzzy Scale Rating

In this a seven-point fuzzy scale is taken into account for evaluating the weights of the indicators /sub-indicators. It consists of semantic terms which are then later converted to decimal numbers. Some fundamental principles of the fuzzy scale are followed:

- ‘Extremely more important’ is assigned to the most significant attribute.
- ‘Extremely less important’ is assigned to the least significant attribute.
- The in-between terms for based on the comparative significance of the indicators.

3.3.4.2 Data Collection

The data is then collected from the five evaluators which consist of the linguistic terms EMI, VMI, MI, I, LI and VLI based on the seven-point fuzzy scale for allotting weights to the indicators as delineated in Table 3.1.

Table 3.1. Linguistic Terms assigned by the experts for the weights of Evaluation Criteria

S. No.	Indicator / Sub-Indicator	E 1	E 2	E 3	E 4	E 5
1	**Agricultural and Rural Development**					
1.1	Agriculture, forestry, and fishing, value added	VMI	EMI	VMI	VMI	VMI
1.2	Arable land	VMI	MI	VMI	MI	VMI
1.3	Crop production index	EMI	VMI	MI	EMI	VMI
1.4	Fertilizer consumption	I	EMI	MI	I	MI
1.5	Forest area	MI	VMI	I	I	VMI
1.6	Livestock production index	I	I	EMI	VMI	VMI
1.7	Employment in agriculture, male	VMI	VMI	MI	VMI	VMI
2	**Economy & Growth**					
2.1	Exports of goods and services	EMI	EMI	EMI	MI	VMI
2.2	GDP per capita growth	EMI	EMI	VMI	EMI	EMI
2.3	Imports of goods and services	EMI	VMI	MI	VMI	VMI
2.4	Inflation, consumer prices	EMI	EMI	VMI	MI	VMI
2.5	Foreign direct investment, net inflows	EMI	EMI	MI	MI	VMI
2.6	Unemployment, total	EMI	EMI	MI	MI	MI
2.7	Population growth	EMI	VMI	MI	MI	MI
3	**Education**					
3.1	Government expenditure on education, total	MI	I	I	MI	MI
3.2	Literacy rate, adult total	EMI	VMI	MI	VMI	VMI
3.3	Literacy rate, youth total	I	LI	I	MI	MI
3.4	School enrollment, primary (gross), gender parity index (GPI)	MI	MI	VMI	VMI	I
3.5	Research and development expenditure	VMI	VMI	MI	VMI	MI
4	**Health**					
4.1	Life expectancy at birth, total	VMI	I	MI	EMI	MI
4.2	Mortality rate, infant	MI	MI	MI	I	MI
4.3	Death rate, crude	LI	MI	LI	I	VLI
4.4	Prevalence of undernourishment	LI	MI	I	I	MI
4.5	Age dependency ratio	LI	LI	I	VLI	MI
4.6	Fertility rate, total	MI	I	LI	MI	MI
5	**Private & Public Sector**					
5.1	Domestic credit to private sector	EMI	VMI	I	MI	MI
5.2	Fuel exports	I	VMI	I	VMI	VMI
5.3	High-technology exports	LI	MI	EMI	MI	MI
5.4	Net lending (+) / net borrowing (-)	VMI	I	MI	EMI	EMI
5.5	Military expenditure	EMI	MI	VMI	VMI	I

3.3.4.3 Data Analysis

The compiled data i.e. collected linguistic terms are first transformed into the TFN and then to the corresponding real numbers which have range between 0-1 based on the FST as listed in the literature review. This is shown in Table 3.2.

Table 3.2. Crisp Scores Values of Weights of country Evaluation Criteria/Sub-criteria

S. No.	Indicator / Sub –Indicator	E 1	E 2	E 3	E 4	E 5
1	**Agricultural and Rural Development**					
1.1	Agriculture, forestry, and fishing, value added	0.86	1.00	0.86	0.86	0.86
1.2	Arable land	0.86	0.68	0.86	0.68	0.68
1.3	Crop production index	1.00	0.86	0.68	1.00	0.68
1.4	Fertilizer consumption	0.50	1.00	0.68	0.50	0.68
1.5	Forest area	0.68	0.86	0.50	0.50	0.86
1.6	Livestock production index	0.50	0.50	1.00	0.86	0.86
1.7	Employment in agriculture, male	0.86	0.86	0.68	0.86	0.86
2	**Economy & Growth**					
2.1	Exports of goods and services	0.86	1.00	1.00	0.68	1.00
2.2	GDP per capita growth	1.00	1.00	0.86	1.00	1.00
2.3	Imports of goods and services	1.00	0.86	0.68	0.86	0.86
2.4	Inflation, consumer prices	1.00	1.00	0.86	0.68	0.86
2.5	Foreign direct investment, net inflows	0.68	1.00	0.68	1.00	0.86
2.6	Unemployment, total	0.68	1.00	0.68	0.68	1.00
2.7	Population growth	0.86	0.86	0.68	0.68	0.68
3	**Education**					
3.1	Government expenditure on education, total	0.68	0.50	0.50	0.68	0.68
3.2	Literacy rate, adult total	1.00	0.86	0.68	0.86	0.86
3.3	Literacy rate, youth total	0.50	0.31	0.50	0.68	0.68
3.4	School enrollment, primary (gross), gender parity index (GPI)	0.68	0.68	0.86	0.86	0.50
3.5	Research and development expenditure	0.86	0.86	0.68	0.86	0.68
4	**Health**					
4.1	Life expectancy at birth, total	0.86	0.50	0.68	1.00	0.68
4.2	Mortality rate, infant	0.68	0.68	0.68	0.50	0.68
4.3	Death rate, crude	0.31	0.68	0.31	0.50	0.13
4.4	Prevalence of undernourishment	0.31	0.68	0.50	0.50	0.68
4.5	Age dependency ratio	0.31	0.31	0.50	0.13	0.68
4.6	Fertility rate, total	0.68	0.50	0.31	0.68	0.68
5	**Private & Public Sector**					
5.1	Domestic credit to private sector	1.00	0.86	0.50	0.68	0.68
5.2	Fuel exports	0.50	0.86	0.50	0.86	0.86
5.3	High-technology exports	0.31	0.68	1.00	0.68	0.68
5.4	Net lending (+) / net borrowing (-)	0.86	0.50	0.68	1.00	1.00
5.5	Military expenditure	1.00	0.68	0.86	0.86	0.50

In this work, the values of Cronbach's apha are 0.807 which are acceptable. The threshold value is 0.6, any value above that is acceptable. These test outcomes show that there are consistency and dependability of the responses from the specialists.

Table 3.3. Reliability Statistics of Evaluation Criteria/Sub-criteria

		N	%	Cronbach's Alpha
Cases (Based on Experts)	Valid	5	100.0	.807
	Excluded	0	.0	
	Total	5	100.0	

3.3.4.4 Determination of the Normalized Weights

Collection of expert conclusions is vital irrespective of the technique for conglomeration i.e. arithmetic or geometric as midpoints being reliably superior to the assessments of individual specialists. While performing this research, it was considered that all the specialists are similarly skilled, qualified and experienced, and no noteworthy contrast could be seen regarding authenticity and significance, consequently all specialists are weighted similarly and mathematical averaging aggregation technique is embraced while performing an in-depth analysis. The average aggregation estimates are given in Table 3.4.

The weights of the development indicator/sub-indicator are evaluated by using simple mathematic operation. Likewise, the aggregate of the sub-indicators weights under each major factor is taken together. The global weights signify that when all the weights of the thirty criteria taken together is unity where as the local weights denote the individual sub-criteria of a particular indicator when taken together is unity. This compiled data is shown in Table 3.5.

Table 3.4. Aggregated Weights of Indicator/ Sub-Indicator

S. No.	Indicator / Sub –Indicator	Average
1	**Agricultural and Rural Development**	
1.1	Agriculture, forestry, and fishing, value added	0.888
1.2	Arable land	0.752
1.3	Crop production index	0.844
1.4	Fertilizer consumption	0.672
1.5	Forest area	0.680
1.6	Livestock production index	0.744
1.7	Employment in agriculture, male	0.824
2	**Economy & Growth**	
2.1	Exports of goods and services	0.908
2.2	GDP per capita growth	0.972
2.3	Imports of goods and services	0.852
2.4	Inflation, consumer prices	0.880
2.5	Foreign direct investment, net inflows	0.844
2.6	Unemployment, total	0.808
2.7	Population growth	0.788
3	**Education**	
3.1	Government expenditure on education, total	0.644
3.2	Literacy rate, adult total	0.852
3.3	Literacy rate, youth total	0.534
3.4	School enrollment, primary (gross), gender parity index (GPI)	0.716
3.5	Research and development expenditure	0.788
4	**Health**	
4.1	Life expectancy at birth, total	0.744
4.2	Mortality rate, infant	0.644
4.3	Death rate, crude	0.386
4.4	Prevalence of undernourishment	0.534
4.5	Age dependency ratio	0.386
4.6	Fertility rate, total	0.570
5	**Private & Public Sector**	
5.1	Domestic credit to private sector	0.744
5.2	Fuel exports	0.716
5.3	High-technology exports	0.670
5.4	Net lending (+) / net borrowing (-)	0.808
5.5	Military expenditure	0.780

Table 3.5. Global and Local Weights of Evaluation Criteria

S. No.	Indicator / Sub –Indicator	Local Weights	Global Weights
1	**Agricultural and Rural Development**	0.245954	0.245954
1.1	Agriculture, forestry, and fishing, value added	0.164323	0.040415
1.2	Arable land	0.139156	0.034225
1.3	Crop production index	0.156181	0.038413
1.4	Fertilizer consumption	0.124352	0.030584
1.5	Forest area	0.125833	0.030948
1.6	Livestock production index	0.137676	0.033867
1.7	Employment in agriculture, male	0.15248	0.037502
2	**Economy & Growth**	0.275444	0.275444
2.1	Exports of goods and services	0.150033	0.041325
2.2	GDP per capita growth	0.160608	0.044238
2.3	Imports of goods and services	0.14078	0.038777
2.4	Inflation, consumer prices	0.145406	0.040051
2.5	Foreign direct investment, net inflows	0.139458	0.038409
2.6	Unemployment, total	0.13351	0.036774
2.7	Population growth	0.130205	0.035870
3	**Education**	0.160840	0.160840
3.1	Government expenditure on education, total	0.18223	0.029313
3.2	Literacy rate, adult total	0.241087	0.038776
3.3	Literacy rate, youth total	0.151104	0.024305
3.4	School enrollment, primary (gross), gender parity index (GPI)	0.202603	0.032588
3.5	Research and development expenditure	0.222977	0.035858
4	**Health**	0.148543	0.148543
4.1	Life expectancy at birth, total	0.225414	0.033855
4.2	Mortality rate, infant	0.187845	0.029307
4.3	Death rate, crude	0.133702	0.017569
4.4	Prevalence of undernourishment	0.158011	0.024303
4.5	Age dependency ratio	0.117127	0.017567
4.6	Fertility rate, total	0.177901	0.025942
5	**Private & Public Sector**	0.169224	0.169224
5.1	Domestic credit to private sector	0.200108	0.033861
5.2	Fuel exports	0.192577	0.032586
5.3	High-technology exports	0.180204	0.030493
5.4	Net lending (+) / net borrowing (-)	0.217321	0.036771
5.5	Military expenditure	0.209790	0.035513

3.3.4.5 Ranking of Indicators/sub-indicators

In this research work, the next step after identifying and assigning weights to various indicators / sub-indicators is to rank the indicators in a descending manner. Table 3.6 depicts the ranking of the major indicators whereas Table 3.7 delineates the ranking of the sub-criteria.

Table 3.6: Ranking of Evaluation Criteria

S.No.	Evaluation Criteria	Global Weights	Rank
1.	Economy & Growth	0.275444	1
2.	Agricultural and Rural Development	0.245954	2
3.	Private & Public Sector	0.169224	3
4.	Education	0.160840	4
5.	Health	0.148543	5

Table 3.7: Ranking of Evaluation Sub-Criteria

S.No.	Evaluation Sub-Criteria	Global Weights	Rank
1.	GDP per capita growth	0.044238	1
2.	Exports of goods and services	0.041325	2
3.	Agriculture, forestry, and fishing, value added	0.040415	3
4.	Inflation, consumer prices	0.040051	4
5.	Imports of goods and services	0.038777	5
6.	Literacy rate, adult total	0.038776	6
7.	Crop production index	0.038413	7
8.	Foreign direct investment, net inflows	0.038409	8
9.	Employment in agriculture, male	0.037502	9
10.	Unemployment, total	0.036774	10
11.	Net lending (+) / net borrowing (-)	0.036771	11
12.	Population growth	0.035870	12
13.	Research and development expenditure	0.035864	13
14.	Military expenditure	0.035513	14
15.	Arable land	0.034225	15
16.	Livestock production index	0.033867	16
17.	Life expectancy at birth, total	0.033855	17

- - - - Table 3.7 Contd.

Table 3.7 (continued)

S.No.	Evaluation Sub-Criteria	Global Weights	Rank
18.	Domestic credit to private sector	0.033861	18
19.	School enrollment, primary (gross), gender parity index (GPI)	0.032588	19
20.	Fuel exports	0.032586	20
21.	Forest area	0.030948	21
22.	Fertilizer consumption	0.030584	22
23.	High-technology exports	0.030493	23
24.	Government expenditure on education, total	0.029313	24
25.	Mortality rate, infant	0.029307	25
26.	Fertility rate, total	0.025942	26
27.	Literacy rate, youth total	0.024305	27
28.	Prevalence of undernourishment	0.024303	28
29.	Death rate, crude	0.017569	29
30.	Age dependency ratio	0.017567	30

3.3.5 Ranking of Countries

Country ranks are dependent on numerous distinguished evaluation criteria/ sub-criteria, their weights assigned by the evaluators by utilizing the Modified Fuzzy Distance-Based Approach (MDFBA). Countries are positioned with respect to the ascending/descending order of scores obtained. There are a total of twenty-seven countries taken into account for ranking based on thirty indicators for 3 consecutive years i.e. 2014, 2015, and 2016.

The Distance-Based Approach has been utilized in many types of research as discussed in the literature review. The DBA technique is inadequate to adjust the consequences of weights of different indicators used to rank the countries. In the current exploration work, the DBA is modified with this impact and subsequently is made practical for the ranking of the countries. The Modified Distance-Based Approach (MDBA) is applied to decide the composite distance of the countries from the optima. The ranking of countries is done on the rising/descending order of the evaluations of the composite distances of the countries. The MDBA technique is explained below.

- The data of countries based on various indicators can be represented as:

$$[x_{ij}] = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1j} \\ x_{21} & x_{22} & \dots & x_{2j} \\ \vdots & \vdots & \vdots & \vdots \\ x_{i1} & x_{i2} & \dots & x_{ij} \\ x_{op1} & x_{op2} & \dots & x_{opj} \end{bmatrix} \quad (3.1)$$

Here i(i=1,2,3,4,…….,n), j(j=1,2,3,4,….m) delineates the Countries and the development indicators. Thus x_{ij} provides the data of of i^{th} country for the j^{th} indicator.

- The standardized matrix is obtained to remove the influence due to different dimensions as:

$$[k] = \begin{bmatrix} k_{11} & k_{12} & \dots & k_{1m} \\ k_{21} & k_{22} & \cdots & k_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ k_{n1} & k_{n2} & \cdots & k_{nm} \\ k_{OP1} & k_{OP2} & \cdots & k_{OPm} \end{bmatrix} \quad (3.2)$$

Where $k_{ij} = \frac{x_{ij} - \bar{x}_j}{S_j}$ (3.3)

$$\bar{x}_j = \frac{1}{n} \sum_{i=1}^{n} x_{ij} \quad (3.4)$$

$$S_j = \left[\frac{1}{n} \sum_{i=1}^{n} (x_{ij} - \bar{x}_j)^2\right]^{\frac{1}{2}} \quad (3.5)$$

- The weighted distance matrix id obtained and given by:

$$[W_{ij}] = \begin{bmatrix} W_{11} & W_{12} & \dots & W_{1j} \\ W_{21} & W_{22} & \dots & W_{2j} \\ \vdots & \vdots & \vdots & \vdots \\ W_{(i-1)1} & W_{(i-1)2} & \dots & W_{(i-1)j} \\ W_{i1} & W_{i2} & \dots & W_{ij} \end{bmatrix} \quad (3.6)$$

Where $W_{ij} = (k_{opj} - k_{ij}) w_j$;

W_j depicts the weight of j^{th} indicator.

- The composite distance value is given by:

$$c_i = \left[\sum_{i=1}^{m} (W_{ij})^2\right]^{\frac{1}{2}} \quad (3.7)$$

The Equations 3.8 represents an instance of the statistical data of agriculture indicator for year 2014 and is shown in Table 3.8. The optimal value i.e. the highest value among the given statistics of the Indicator for the corresponding country is provided in the recently added row in Equation 3.9 and same is shown using Table 3.9. Further, the adjusted and standardized matrixes are provided in the Equations 3.10 and 3.11 and the same is shown using Table 3.10 and Table 3.11. The average and standard deviations were obtained by utilizing the Equations 3.4 and 3.5. The arithmetic means are 17.8918433, 40.69164777, 27.11962963, 304.2309075, 40.8881372, 28.17407407 and 32.21574022. And the Standard deviations calculated were 5.710892142, 15.84003042, 18.06723309, 498.1822388, 18.36068524, 19.09471096 and 14.30588807.

$$\begin{bmatrix} 6.7127 & 14.3273 & 132.86 & 212.722 \\ 2.2163 & 6.11683 & 109.06 & 276.725 \\ 15.362 & 58.9265 & 142.45 & 469.669 \\ 4.3609 & 9.69187 & 142.82 & 484.868 \end{bmatrix} \quad (3.8) \qquad \begin{bmatrix} 6.7127 & 14.3273 & 132.86 & 212.722 \\ 2.2163 & 6.11683 & 109.06 & 276.725 \\ 15.362 & 58.9265 & 142.45 & 469.669 \\ 4.3609 & 9.69187 & 142.82 & 484.868 \\ 15.362 & 58.9265 & 142.82 & 484.868 \end{bmatrix} \quad (3.9)$$

Without Optimal Value — With Optimal Value

Data Matrix

$$\begin{bmatrix} 17.03184 & 44.59139 & 11.5 & 202.9093 \\ 21.52832 & 52.8029 & 35.3 & 266.9681 \\ 8.392919 & 0 & 1.91 & 459.5587 \\ 19.41893 & 49.22328 & 1.54 & 474.8112 \end{bmatrix} \quad (3.10) \qquad \begin{bmatrix} -0.15059 & 0.246195 & -0.86453 & -0.20338 \\ 0.636761 & 0.764598 & 0.452774 & -0.0748 \\ -1.6633 & -2.56891 & -1.39532 & 0.311789 \\ 0.267399 & 0.538612 & -1.4158 & 0.342405 \end{bmatrix} \quad (3.11)$$

Adjusted Matrix — **Standardized matrix**

The row that delineates the largest value is known as the optimal solution. The difference between the Optimal and each country's indicator statistics leads the formation of Distance Matrix. After this step, weighted distance is calculated using the Equation 3.12. The composite distance matrix is obtained by squaring each element of the weighted distance matrix to avoid negative values and is shown in Equation 3.13 and is shown in Table 3.12 and Table 3.13.

$$\begin{bmatrix} -2.98234 & -2.87703 & -0.63141 & -0.4072 \\ -3.76908 & -3.30168 & -1.95383 & -0.5358 \\ -1.43642 & 0 & -0.10516 & -0.92247 \\ -3.43218 & -3.10754 & -0.08523 & -0.95308 \end{bmatrix} \quad (3.12)$$

Weighted Distance Matrix

$$\begin{bmatrix} 8.894 & 7.924 & 0.4051 & 0.16589279 \\ 14.210 & 11.112 & 3.817 & 0.287 \\ 2.159 & 0.0110 & 2 & 0.8509 \\ -11.562 & 9.656 & 0.007 & 0.908 \end{bmatrix} \quad (3.13)$$

Composite Distance Matrix

The composite distances of the countries from the OPTIMAL are determined using Eq. 3.7. The ranking of countries is done using the CD value. The country with minimum CD value is ranked first, countries with next higher CD value as ranked second and so on. The country with maximum value of the composite distance is ranked last among all. This composite distance value is termed as 'Suitability Index (SI)' of the countries. The ranking of countries using the agriculture indicator for the year 2014 is depicted in Table 3.14. Similarly, all the twenty seven countries are ranked on the basis of the five indicators for the 3 consecutive years i.e. 2014, 2015 and 2016 using the FMDBA method as shown in Table 3.15, 3.16, 3.17.

Table 3.8: Statistical Data of twenty seven countries for Agriculture indicator (2014)

S.No.	Country	Agriculture, forestry and fishing value added(% of GDP)	Arable land (% of land area)	Crop production index (2004-2006 = 100)	Fertilizer consumption (% of fertilizer production)	Forest area (% of land area)	Livestock production index (2004-2006 = 100)	Employment in agriculture (% of total employment)
1.	**Argentina**	6.7127	14.323	132.86	212.7162	10.01	108.13	0.549
2.	**Australia**	2.21622	6.1123	109.06	276.7750	16.19	106.12	2.80
3.	**Bangladesh**	15.3516	58.915	142.45	469.3656	10.99	130.29	44.282
4.	**Brazil**	4.3256	9.6919	142.82	484.6181	59.16	128.25	10.335
5.	**Canada**	1.42479	4.7777	129.62	26.8909	38.17	85.7	1.713
6.	**China**	8.6742	11.258	136.31	95.2099	22.02	127.06	29.5
7.	**Colombia**	5.4469	1.5576	110.35	542.670	52.75	122.31	16.229
8.	**Egypt, Arab Rep.**	11.3377	2.6522	116.51	43.4735	0.072	129.76	27.552
9.	**France**	1.5563	33.481	103.55	228.707	30.82	103.27	2.845
10.	**Germany**	0.9045	34.024	111.9	58.8009	32.72	112.02	1.427
11.	**Hong Kong SAR, China**	0.0661	2.9523	102.31	1973.61	27.54	50.39	0.201
12.	**India**	16.7919	52.624	144.36	154.546	23.71	143.11	45.84
13.	**Iran, Islamic Rep.**	9.7822	9.0172	110.32	100.022	6.564	112.68	17.89
14.	**Kazakhstan**	4.3295	10.888	140.89	52.7467	1.226	116.82	20.951
15.	**Luxembourg**	0.2911	25.765	89.7	240.8	35.67	99.4	1.425
16.	**Malaysia**	8.8732	2.4471	116.3	286.2667	67.51	141.25	12.230
17.	**Mexico**	3.1348	11.987	123.33	228.89	34.01	113.84	13.772
18.	**Netherlands**	1.7383	31.018	112.19	13.003	11.14	116.59	2.292
19.	**New Zealand**	6.26861	2.2407	120.69	257.2861	38.55	115.53	6.247
20.	**Pakistan**	23.744	39.487	115.99	138.077	1.965	137.85	42.23
21.	**Russian Federation**	3.3598	7.5180	137.41	9.80693	49.76	122.69	6.723

----Table 3.8 (continued)

Table 3.8 (continued)

S.No.	Country	Agriculture, forestry and fishing value added(% of GDP)	Arable land (% of land area)	Crop production index (2004-2006 = 100)	Fertilizer consumption (% of fertilizer production)	Forest area (% of land area)	Livestock production index (2004-2006 = 100)	Employment in agriculture (% of total employment)
22.	**Saudi Arabia**	2.2269	1.5955	64.48	17.4514	0.454	131.69	5.261
23.	**Serbia**	7.0658	29.793	101.96	195.707	31.08	100.57	19.850
24.	**Spain**	2.5363	24.545	101.86	117.4949	36.75	101.63	4.240
25.	**Sri Lanka**	8.0066	20.730	121.02	1968.044	33.11	131	28.80
26.	**United Kingdom**	0.666	25.765	112.3	157.725	12.92	106.57	1.2549
27.	**United States**	1.1886	16.864	114.95	128.310	33.86	108.75	1.3470

Table 3.9: Statistical Data with optimal value of countries for Agriculture indicator

S.No.	Country	Agriculture, forestry and fishing value added(% of GDP)	Arable land (% of land area)	Crop production index (2004-2006 = 100)	Fertilizer consumption (% of fertilizer production)	Forest area (% of land area)	Livestock production index (2004-2006 = 100)	Employment in agriculture (% of total employment)
1.	Argentina	6.71270	14.323	132.86	212.716	10.0153	108.13	0.5490
2.	Australia	2.21622	6.11236	109.06	276.775	16.1986	106.12	2.8010
3.	Bangladesh	15.3516	58.9152	142.45	469.3656	10.9979	130.29	44.282
4.	Brazil	4.3259	9.6919	142.82	484.61	59.1665	128.25	10.335
5.	Canada	1.5747	4.77778	129.62	26.8909	38.1717	85.7	1.7139
6.	China	8.6737	11.2588	136.31	95.2099	22.0253	127.06	29.5
7.	Colombia	5.4469	1.5576	110.35	542.670	52.752	122.31	16.2290
8.	Egypt, Arab Rep.	11.3377	2.6522	116.51	43.4735	0.07273	129.76	27.5529
9.	France	1.5563	33.48	103.55	228.707	30.8205	103.27	2.84500
10.	Germany	0.90454	34.024	111.9	58.8009	32.7228	112.02	1.4279
11.	Hong Kong SAR, China	0.0661	2.9523	102.31	1973.61	27.54	50.39	0.2010
12.	India	16.791	52.6246	144.36	154.546	23.7131	143.11	45.8409
13.	Iran, Islamic Rep.	9.7822	9.01728	110.32	100.022	6.56449	112.68	17.893
14.	Kazakhstan	4.3295	10.888	140.89	52.7467	1.22569	116.82	20.9519
15.	Luxembourg	0.2911	25.765	89.7	240.8	35.6790	99.4	1.42599
16.	Malaysia	8.8732	2.4471	116.3	286.266	67.5111	141.25	12.2309
17.	Mexico	3.1348	11.987	123.33	228.894	34.0191	113.84	13.7720
18.	Netherlands	1.73834	31.018	112.19	13.0031	11.1427	116.59	2.29200
19.	New Zealand	6.26869	2.24070	120.69	257.286	38.5545	115.53	6.24700
20.	Pakistan	23.7445	39.4873	115.99	138.0770	1.96528	137.85	42.2330
21.	Russian Federation	3.35987	7.5180	137.41	9.8069	49.7635	122.69	6.72399

----Table 3.9 (continued)

Table 3.9 (continued)

S.No.	Country	Agriculture, forestry and fishing value added(% of GDP)	Arable land (% of land area)	Crop production index (2004-2006 = 100)	Fertilizer consumption (% of fertilizer production)	Forest area (% of land area)	Livestock production index (2004-2006 = 100)	Employment in agriculture (% of total employment)
22.	Saudi Arabia	2.2269	1.5955	64.48	17.4514	0.4544	131.69	5.26100
23.	Serbia	7.0658	29.7930	101.96	195.7078	31.083	100.57	19.8570
24.	Spain	2.5363	24.5456	101.86	117.494	36.7520	101.63	4.24300
25.	Sri Lanka	8.0066	20.7303	121.02	1968.04	33.1143	131	28.8700
26.	United Kingdom	0.66698	25.7657	112.3	157.7250	12.92	106.57	1.25499
27.	United States	1.18865	16.8643	114.95	128.3100	33.869	108.75	1.34700
28.	**Optimal Value**	**23.7445**	**58.915**	**144.36**	**9.806**	**67.511**	**143.11**	**45.841**

Table 3.10: Adjusted Data of countries for Agriculture indicator (2014)

S.No.	Country	Agriculture, forestry and fishing value added(% of GDP)	Arable land (% of land area)	Crop production index (2004-2006 = 100)	Fertilizer consumption (% of fertilizer production)	Forest area (% of land area)	Livestock production index (2004-2006 = 100)	Employment in agriculture (% of total employment)
1.	Argentina	17.03184	44.59139	11.5	202.9093	57.49588	34.98	45.292
2.	Australia	21.52832	52.8029	35.3	266.9681	51.31252	36.99	43.04
3.	Bangladesh	8.392919	0	1.91	459.5587	56.51326	12.82	1.558998
4.	Brazil	19.41893	49.22328	1.54	474.8112	8.344675	14.86	35.506
5.	Canada	22.31974	54.13748	14.74	17.08405	29.33939	57.41	44.127
6.	China	15.07029	47.65646	8.05	85.40297	45.48579	16.05	16.341
7.	Colombia	18.29758	57.35763	34.01	532.8631	14.75908	20.8	29.612
8.	Egypt, Arab Rep.	12.40683	56.26301	27.85	33.66662	67.43846	13.35	18.288
9.	France	22.18818	25.43364	40.81	218.9002	36.69065	39.84	42.996
10.	Germany	22.83999	24.89119	32.46	48.99399	34.78834	31.09	44.413
11.	Hong Kong SAR, China	23.67835	55.96288	42.05	1963.803	39.97119	92.72	45.64
12.	India	6.952606	6.290643	0	144.7392	43.79807	0	0
13.	Iran, Islamic Rep.	13.96228	49.89798	34.04	90.21547	60.9467	30.43	27.947
14.	Kazakhstan	19.41499	48.02702	3.47	42.9398	66.2855	26.29	24.889
15.	Luxembourg	23.45338	33.14983	54.66	230.9931	31.83218	43.71	44.415
16.	Malaysia	14.87133	56.46815	28.06	276.4598	0	1.86	33.61
17.	Mexico	20.60971	46.9273	21.03	219.0873	33.492	29.27	32.069
18.	Netherlands	22.0062	27.89716	32.17	3.196253	56.36842	26.52	43.549

----Table 3.10 (continued)

Table 3.10 (continued)

S.No.	Country	Agriculture, forestry and fishing value added(% of GDP)	Arable land (% of land area)	Crop production index (2004-2006 = 100)	Fertilizer consumption (% of fertilizer production)	Forest area (% of land area)	Livestock production index (2004-2006 = 100)	Employment in agriculture (% of total employment)
19.	New Zealand	17.47585	56.67456	23.67	247.4794	28.95663	27.58	39.594
20.	Pakistan	0	19.42793	28.37	128.2701	65.5459	5.26	3.607998
21.	Russian Federation	20.38466	51.39723	6.95	0	17.74762	20.42	39.117
22.	Saudi Arabia	21.51757	57.31969	79.88	7.644544	67.0567	11.42	40.58
23.	Serbia	16.67866	29.12222	42.4	185.9009	36.42726	42.54	25.984
24.	Spain	21.2082	34.36957	42.5	107.6881	30.75914	41.48	41.598
25.	Sri Lanka	15.73793	38.18492	23.34	1958.238	34.39685	12.11	16.971
26.	United Kingdom	23.07756	33.14955	32.06	147.9182	54.58596	36.54	44.586
27.	United States	22.55588	42.05089	29.41	118.5031	33.64153	34.36	44.494

Table 3.11: Standardized Data of twenty for Agriculture indicator (2014)

S.No.	Country	Agriculture, forestry and fishing value added(% of GDP)	Arable land (% of land area)	Crop production index (2004-2006 = 100)	Fertilizer consumption (% of fertilizer production)	Forest area (% of land area)	Livestock production index (2004-2006 = 100)	Employment in agriculture (% of total employment)
1.	Argentina	-0.15059	0.246195	-0.86453	-0.20338	0.904527	0.35643	0.914047
2.	Australia	0.636761	0.764598	0.452774	-0.0748	0.567756	0.461695	0.75663
3.	Bangladesh	-1.6633	-2.56891	-1.39532	0.311789	0.85101	-0.8041	-2.14295
4.	Brazil	0.267399	0.538612	-1.4158	0.342405	-1.77245	-0.69727	0.229993
5.	Canada	0.775343	0.848852	-0.6852	-0.57639	-0.62899	1.531101	0.832612
6.	China	-0.49407	0.439697	-1.05548	-0.43925	0.250407	-0.63494	-1.10966
7.	Colombia	0.071047	1.052143	0.381374	0.458933	-1.4231	-0.38618	-0.182
8.	Egypt, Arab Rep.	-0.96045	0.983038	0.040425	-0.5431	1.446042	-0.77634	-0.97357
9.	France	0.752306	-0.96326	0.757746	-0.17128	-0.22861	0.610951	0.753554
10.	Germany	0.866441	-0.9975	0.295583	-0.51234	-0.33222	0.152709	0.852604
11.	Hong Kong SAR, China	1.01324	0.964091	0.826378	3.331255	-0.04994	3.380304	0.938373
12.	India	-1.9155	-2.17178	-1.50104	-0.32015	0.158487	-1.47549	-2.25192
13.	Iran, Islamic Rep.	-0.68808	0.581206	0.383034	-0.42959	1.092473	0.118144	-0.29839
14.	Kazakhstan	0.266709	0.463091	-1.30898	-0.52449	1.383247	-0.09867	-0.51215
15.	Luxembourg	0.973847	-0.47612	1.524327	-0.14701	-0.49323	0.813625	0.852744
16.	Malaysia	-0.5289	0.995989	0.052048	-0.05574	-2.22694	-1.37808	0.097461
17.	Mexico	0.475909	0.393664	-0.33705	-0.17091	-0.40282	0.057394	-0.01026

----Table 3.11 (continued)

Table 3.11 (continued)

S.No.	Country	Agriculture, forestry and fishing value added(% of GDP)	Arable land (% of land area)	Crop production index (2004-2006 = 100)	Fertilizer consumption (% of fertilizer production)	Forest area (% of land area)	Livestock production index (2004-2006 = 100)	Employment in agriculture (% of total employment)
18.	Netherlands	0.72044	-0.80773	0.279532	-0.60427	0.843121	-0.08662	0.792209
19.	New Zealand	-0.07284	1.00902	-0.19093	-0.11392	-0.64984	-0.03111	0.51575
20.	Pakistan	-3.13293	-1.3424	0.069207	-0.35321	1.342965	-1.20002	-1.99972
21.	Russian Federation	0.436503	0.675856	-1.11637	-0.61068	-1.26033	-0.40608	0.482407
22.	Saudi Arabia	0.634878	1.049748	2.920224	-0.59534	1.42525	-0.87742	0.584672
23.	Serbia	-0.21243	-0.73039	0.84575	-0.23752	-0.24296	0.752351	-0.43561
24.	Spain	0.580708	-0.39912	0.851285	-0.39452	-0.55167	0.696838	0.655832
25.	Sri Lanka	-0.37716	-0.15825	-0.2092	3.320084	-0.35354	-0.84128	-1.06563
26.	United Kingdom	0.908039	-0.47614	0.273444	-0.31377	0.746041	0.438128	0.864697
27.	United States	0.816692	0.085811	0.126769	-0.37281	-0.39468	0.32396	0.858266
28.	**Optimal Value**	-3.13293	-2.56891	-1.50104	-0.61068	-2.22694	-1.47549	-2.25192

Table 3.12: Distance Information of countries for Agriculture indicator (2014)

S.No.	Country	Agriculture, forestry and fishing value added(% of GDP)	Arable land (% of land area)	Crop production index (2004-2006 = 100)	Fertilizer consumption (% of fertilizer production)	Forest area (% of land area)	Livestock production index (2004-2006 = 100)	Employment in agriculture (% of total employment)
1.	Argentina	-2.98234	-2.8151	-0.6365	-0.4072	-3.131	-1.8319	-3.16
2.	Australia	-3.7696	-3.333	-1.953	-0.5306	-2.794	-1.9371	-3.008
3.	Bangladesh	-1.4696	0	-0.105	-0.9224	-3.077	-0.6713	-0.1089
4.	Brazil	-3.4003	-3.1075	-0.0818	-0.95308	-0.454	-0.77822	-2.481
5.	Canada	-3.9082	-3.417	-0.8158	-0.03429	-1.597	-3.0065	-3.0845
6.	China	-2.63886	-3.0086	-0.445	-0.17147	-2.477	-0.8405	-1.1422
7.	Colombia	-3.203	-3.6210	-1.8824	-1.06961	-0.803	-1.0893	-2.0699
8.	Egypt, Arab Rep.	-2.1724	-3.5519	-1.5414	-0.0675	-3.672	-0.69914	-1.278
9.	France	-3.885	-1.605	-2.258	-0.4393	-1.992	-2.0864	-3.005
10.	Germany	-3.999	-1.5714	-1.7964	-0.09834	-1.947	-1.9561	-3.1045
11.	Hong Kong SAR, China	-4.14617	-3.53	-2.327	-3.94193	-2.176	-4.85579	-3.190
12.	India	-1.21742	-0.3971	0	-0.2905	-2.385	0	0
13.	Iran, Islamic Rep.	-2.44485	-3.1501	-1.884	-0.1810	-3.394	-1.593	-1.953
14.	Kazakhstan	-3.3996	-3.0320	-0.192	-0.0861	-3.101	-1.376	-1.739
15.	Luxembourg	-4.1067	-2.092	-3.0253	-0.4636	-1.771	-2.2891	-3.104
16.	Malaysia	-2.6040	-3.564	-1.553	-0.5549	0	-0.097	-2.349
17.	Mexico	-3.6088	-2.9625	-1.1639	-0.4397	-1.821	-1.532	-2.2416

----Table 3.12 (continued)

Table 3.12 (continued)

S.No.	Country	Agriculture, forestry and fishing value added(% of GDP)	Arable land (% of land area)	Crop production index (2004-2006 = 100)	Fertilizer consumption (% of fertilizer production)	Forest area (% of land area)	Livestock production index (2004-2006 = 100)	Employment in agriculture (% of total employment)
18.	Netherlands	-3.8533	-1.7611	-1.7805	-0.0064	-3.070	-1.388	-3.0441
19.	New Zealand	-3.060	-3.577	-1.3101	-0.4967	-1.577	-1.4443	-2.7676
20.	Pakistan	0	-1.2265	-1.570	-0.25747	-3.569	-0.2754	-0.252
21.	Russian Federation	-3.5694	-3.2447	-0.384	0	-0.966	-1.0694	-2.7343
22.	Saudi Arabia	-3.7678	-3.6186	-4.421	-0.015	-3.652	-0.5980	-2.836
23.	Serbia	-2.9204	-1.83	-2.3467	-0.3731	-1.989	-2.227	-1.8163
24.	Spain	-3.7136	-2.1697	-2.352	-0.2161	-1.677	-2.172	-2.9077
25.	Sri Lanka	-2.7557	-2.4106	-1.2918	-3.9307	-1.873	-0.6342	-1.186
26.	United Kingdom	-4.0409	-2.0927	-1.7744	-0.29691	-2.979	-1.9136	-3.116
27.	United States	-3.9496	-2.6547	-1.627	-0.2378	-1.832	-1.7994	-3.1101

Table 3.13: Composite Distance Data of countries for Agriculture indicator (2014)

S.No.	Country	Agriculture, forestry and fishing value added(% of GDP)	Arable land (% of land area)	Crop production index (2004-2006 = 100)	Fertilizer consumption (% of fertilizer production)	Forest area (% of land area)	Livestock production index (2004-2006 = 100)	Employment in agriculture (% of total employment)
1.	Argentina	8.894	7.924	0.405	0.1658	9.806	3.3559	10.023
2.	Australia	14.210	11.112	3.817	0.2871	7.8107	3.7526	9.0513
3.	Bangladesh	2.159	0	0.0111	0.8509	9.473	0.4507	0.0118
4.	Brazil	11.562	9.6567	0.007	0.9083	0.2065	0.6056	6.159
5.	Canada	15.274	11.681	0.6655	0.0011	2.5534	9.0395	9.514
6.	China	6.964	9.0517	0.1985	0.0293	6.1376	0.7065	1.304
7.	Colombia	10.265	13.1120	3.543	1.1440	0.6461	1.1865	4.284
8.	Egypt, Arab Rep.	4.7196	12.616	2.3760	0.0045	13.49	0.4888	1.6341
9.	France	15.0950	2.578	5.1025	0.1930	3.9933	4.353	9.0328
10.	Germany	15.994	2.469	3.227	0.0098	3.5899	2.6510	9.6380
11.	Hong Kong SAR, China	17.190	12.482	5.4168	15.538	4.7393	23.578	10.1779
12.	India	1.4821	0.1577	0	0.0844	5.6902	0	0
13.	Iran, Islamic Rep.	5.9772	9.923	3.5497	0.0327	11.018	2.5390	3.8162
14.	Kazakhstan	11.557	9.1930	0.036	0.007	13.033	1.8956	3.026
15.	Luxembourg	16.865	4.3797	9.1528	0.214	3.0057	5.24005	9.6389
16.	Malaysia	6.780	12.708	2.4120	0.307	0	0.0094	5.5195
17.	Mexico	13.023	8.7768	1.357	0.1934	3.3273	2.3497	5.0250
18.	Netherlands	14.848	3.1017	3.1704	4.1162	9.4252	1.9289	9.2667
19.	New Zealand	9.3641	12.8016	1.716	0.246	2.4874	2.0862	7.66000

----Table 3.13(continued)

Table 3.13 (continued)

S.No.	Country	Agriculture, forestry and fishing value added(% of GDP)	Arable land (% of land area)	Crop production index (2004-2006 = 100)	Fertilizer consumption (% of fertilizer production)	Forest area (% of land area)	Livestock production index (2004-2006 = 100)	Employment in agriculture (% of total employment)
20.	Pakistan	0	1.504	2.466	0.0662	12.744	0.0758	0.0636
21.	Russian Federation	12.740	10.5285	0.1479	0	0.934	1.1436	7.4765
22.	Saudi Arabia	14.19640	13.0947	19.52	0.0002	13.33	0.3576	8.046
23.	Serbia	8.5292	3.3801	5.507	0.1392	3.9369	4.9632	3.299
24.	Spain	13.7902	4.7079	5.533	0.04672	2.8065	4.7190	8.455
25.	Sri Lanka	7.5942	5.8112	1.6688	15.4509	3.5092	0.40221	1.4072
26.	United Kingdom	16.3299	4.3796	3.148	0.0881	8.838	3.6619	9.713
27.	United States	15.5995	7.0475	2.649	0.0565	3.3571	3.2380	9.6732

Table 3.14: Overall Country Ranking for Agriculture Indicator (2014)

S.No.	Country Name	Sum	Suitability Index	RANK
1.	**Argentina**	40.57561713	6.369899	19
2.	**Australia**	50.04183451	7.074025	25
3.	**Bangladesh**	12.9583656	3.599773	2
4.	**Brazil**	29.10670157	5.395063	6
5.	**Canada**	48.72988445	6.980679	24
6.	**China**	24.39177997	4.938803	4
7.	**Colombia**	34.18239033	5.846571	10
8.	**Egypt, Arab Rep.**	35.33051724	5.943948	11
9.	**France**	40.34783182	6.351994	18
10.	**Germany**	37.58092224	6.130328	15
11.	**Hong Kong SAR, China**	89.12465291	9.440585	27
12.	**India**	7.414521651	2.722962	1
13.	**Iran, Islamic Rep.**	36.85753305	6.071041	14
14.	**Kazakhstan**	38.75081491	6.225015	16
15.	**Luxembourg**	48.49799987	6.964051	23
16.	**Malaysia**	27.73861458	5.266746	5
17.	**Mexico**	34.05105302	5.835328	9
18.	**Netherlands**	41.74167597	6.46078	21
19.	**New Zealand**	36.36239191	6.030124	13
20.	**Pakistan**	16.91999989	4.113393	3
21.	**Russian Federation**	32.97188842	5.742115	8
22.	**Saudi Arabia**	68.58135662	8.281386	26
23.	**Serbia**	29.7546069	5.454778	7
24.	**Spain**	40.05986881	6.329287	17
25.	**Sri Lanka**	35.84447962	5.987026	12
26.	**United Kingdom**	46.15995734	6.794112	22
27.	**United States**	41.62190404	6.451504	20

Table 3.15: Overall Rankings of countries by FMDBA Method (2014)

S.No.	Country Name	Ranking of Countries Based on									
		Agriculture & Rural Development		Economy & Growth		Education		Health		Private& Public Sector	
		SI	Rank	SI	Rank	SI	Rank	SI	Rank	SI	Rank
1.	**Argentina**	6.36	19	10.3	27	3.13	13	4.34	20	8.99	25
2.	**Australia**	7.07	25	7.88	18	3.46	17	2.78	5	7.87	9
3.	**Bangladesh**	3.59	2	7.51	11	5.76	26	5.42	24	8.98	24
4.	**Brazil**	5.39	6	8.15	21	2.34	7	2.90	8	8.21	17
5.	**Canada**	6.98	24	7.41	8	2.13	5	2.45	3	8.48	20
6.	**China**	4.93	4	7.15	5	2.56	9	2.88	7	6.65	3
7.	**Colombia**	5.84	10	7.52	12	3.72	19	3.11	10	7.48	5
8.	**Egypt, Arab Rep.**	5.94	11	8.89	26	4.53	21	6.25	26	8.00	12
9.	**France**	6.35	18	7.83	17	1.78	1	4.15	19	7.48	6
10.	**Germany**	6.13	15	7.20	6	2.61	10	4.02	18	8.19	16
11.	**Hong Kong SAR, China**	9.44	27	2.71	1	3.88	20	1.19	1	8.29	18
12.	**India**	2.72	1	7.42	9	4.92	24	6.08	25	7.99	11
13.	**Iran, Islamic Rep.**	6.07	14	8.21	22	4.84	23	2.67	4	8.10	14
14.	**Kazakhstan**	6.22	16	7.53	13	4.67	22	4.56	21	9.29	27
15.	**Luxembourg**	6.96	23	4.76	2	3.02	12	2.07	2	9.23	26
16.	**Malaysia**	5.26	5	6.52	4	2.40	8	2.84	6	7.63	8
17.	**Mexico**	5.83	9	7.59	14	3.32	14	3.82	16	8.50	21
18.	**Netherlands**	6.46	21	5.97	3	1.93	3	3.37	13	7.90	10
19.	**New Zealand**	6.03	13	7.75	15	2.23	6	3.17	11	8.51	22
20.	**Pakistan**	4.11	3	8.30	23	9.11	27	9.51	27	8.80	23
21.	**Russian Federation**	5.74	8	8.06	19	3.46	16	5.15	22	7.60	7
22.	**Saudi Arabia**	8.28	26	8.50	24	3.33	15	3.26	12	6.50	2
23.	**Serbia**	5.45	7	8.11	20	3.56	18	5.37	23	8.46	19
24.	**Spain**	6.32	17	8.55	25	3.00	11	3.03	9	8.02	13
25.	**Sri Lanka**	5.98	12	7.40	7	5.15	25	3.86	17	8.17	15
26.	**United Kingdom**	6.79	22	7.47	10	1.96	4	3.76	15	7.26	4
27.	**United States**	6.45	20	7.81	16	1.84	2	3.41	14	6.35	1

Table 3.16: Overall Rankings of countries by FMDBA Method (2015)

S.No.	Country Name	Ranking of Countries Based on									
		Agriculture & Rural Development		Economy & Growth		Education		Health		Private& Public Sector	
		SI	Rank	SI	Rank	SI	Rank	SI	Rank	SI	Rank
1.	**Argentina**	6.61	19	9.25	27	3.16	13	4.28	20	9.16	26
2.	**Australia**	7.23	25	7.78	17	3.78	18	2.75	4	8.05	8
3.	**Bangladesh**	3.65	2	7.35	12	5.68	26	5.30	23	9.09	25
4.	**Brazil**	5.50	6	8.69	25	2.49	8	2.87	8	8.24	13
5.	**Canada**	7.19	24	7.35	13	2.20	5	2.43	3	8.69	21
6.	**China**	5.02	4	7.08	5	2.50	9	2.86	7	6.65	2
7.	**Colombia**	5.84	8	7.63	16	3.90	19	2.99	9	8.22	11
8.	**Egypt, Arab Rep.**	6.11	11	8.56	24	4.53	21	6.33	26	8.16	10
9.	**France**	6.56	18	7.41	14	1.85	2	4.24	19	7.84	6
10.	**Germany**	6.54	17	7.11	6	2.60	10	4.10	18	8.42	15
11.	**Hong Kong SAR, China**	9.66	27	2.90	1	3.99	20	1.18	1	8.59	19
12.	**India**	2.84	1	7.31	10	5.05	25	5.98	25	8.45	16
13.	**Iran, Islamic Rep.**	6.28	14	8.72	26	4.62	22	2.77	5	8.13	9
14.	**Kazakhstan**	6.36	15	7.83	18	4.62	23	4.61	21	8.57	18
15.	**Luxembourg**	7.10	23	5.27	3	3.01	11	1.94	2	9.30	27
16.	**Malaysia**	5.40	5	6.51	4	2.48	7	2.81	6	7.99	7
17.	**Mexico**	6.0	10	7.22	8	3.39	14	3.77	15	8.82	22
18.	**Netherlands**	6.66	20	4.76	2	1.98	3	3.41	13	8.32	14
19.	**New Zealand**	6.25	13	7.90	19	2.32	6	3.19	11	8.85	23
20.	**Pakistan**	4.20	3	8.17	22	9.15	27	9.52	27	9.00	24
21.	**Russian Federation**	5.82	7	8.17	23	3.54	15	5.04	22	7.61	4
22.	**Saudi Arabia**	8.05	26	8.14	21	3.55	16	3.22	12	5.73	1
23.	**Serbia**	5.92	9	7.17	7	3.64	17	5.38	24	8.66	20
24.	**Spain**	6.42	16	8.04	20	3.09	12	3.14	10	8.46	17
25.	**Sri Lanka**	6.21	12	7.25	9	5.02	24	3.87	17	8.23	12
26.	**United Kingdom**	7.03	22	7.32	11	2.09	4	3.82	16	7.82	5
27.	**United States**	6.68	21	7.49	15	1.74	1	3.42	14	7.01	3

Table 3.17: Overall Rankings of countries by FMDBA Method (2016)

S.No.	Country Name	Ranking of Countries Based on									
		Agriculture & Rural Development		Economy & Growth		Education		Health		Private& Public Sector	
		SI	Rank	SI	Rank	SI	Rank	SI	Rank	SI	Rank
1.	**Argentina**	6.64	17	10.1	27	2.33	8	4.21	19	8.74	22
2.	**Australia**	7.45	25	8.08	19	5.52	25	2.71	5	7.69	7
3.	**Bangladesh**	3.78	2	7.47	11	2.29	7	5.11	23	8.86	26
4.	**Brazil**	5.58	7	9.05	26	1.83	5	2.83	8	8.02	11
5.	**Canada**	7.26	22	7.87	16	2.34	9	2.42	3	8.47	21
6.	**China**	5.10	4	7.21	6	3.87	19	2.83	9	6.16	2
7.	**Colombia**	6.05	11	8.18	21	4.49	21	2.81	7	7.71	9
8.	**Egypt, Arab Rep.**	6.15	12	8.89	25	1.30	2	6.34	26	8.12	12
9.	**France**	6.97	21	7.68	13	1.51	4	4.24	20	7.45	5
10.	**Germany**	6.71	19	7.30	8	3.83	18	4.07	18	8.24	15
11.	**Hong Kong SAR, China**	10.2	27	3.83	1	5.13	24	1.25	1	8.41	19
12.	**India**	2.92	1	7.3	9	4.19	20	5.82	25	8.21	14
13.	**Iran, Islamic Rep.**	6.43	15	7.68	14	4.63	23	2.76	6	7.53	6
14.	**Kazakhstan**	6.38	14	7.92	17	2.95	11	4.64	21	8.33	17
15.	**Luxembourg**	7.44	24	4.96	2	2.48	10	1.76	2	9.29	27
16.	**Malaysia**	5.53	6	6.81	4	3.46	16	2.70	4	7.75	10
17.	**Mexico**	6.02	10	7.46	10	1.50	3	3.65	15	8.80	25
18.	**Netherlands**	6.78	20	5.55	3	2.19	6	3.41	13	8.36	18
19.	**New Zealand**	6.29	13	8.33	22	7.80	27	3.02	11	8.78	24
20.	**Pakistan**	4.38	3	8.38	23	3.30	15	9.45	27	8.75	23
21.	**Russian Federation**	5.82	9	7.75	15	2.96	13	5.05	22	7.23	4
22.	**Saudi Arabia**	7.96	26	8.63	24	3.59	17	3.13	12	5.67	1
23.	**Serbia**	5.77	8	6.98	5	2.95	12	5.33	24	8.45	20
24.	**Spain**	6.64	16	8.11	20	4.51	22	3.019634	10	8.29	16
25.	**Sri Lanka**	5.43	5	7.58	12	5.79	26	3.83	17	8.15	13
26.	**United Kingdom**	7.36	23	7.21	7	1.22	1	3.78	16	7.70	8
27.	**United States**	6.71	18	7.94	18	3.18	14	3.42	14	6.47	3

CHAPTER 4

SOFTWARE REQUIREMENT AND METHODOLOGY VALIDATION

4.1 SOFTWARE REQUIREMENT

For performing the evaluation, selection, and positioning of twenty-seven countries using thirty World Development Indicators (WDI), MATLAB software was utilized. It was developed with MATLAB 2013a for running in a Windows™ XP or higher environment.

4.1.1 MATLAB

MATLAB is one of the most well-established software used in many domains. In the late 1970s, Cleve Moler started designing this software to provide the working environment for LINPACK and EISPACK, thus avoiding the process of getting well versed with Fortran. Due to its usage in the statistical analysis, algebra and later on image processing this software has become a boon for the researchers.

It provides a multi-paradigm statistical computation environment and is a proprietary programming language that is developed further by Mathworks. It consists of many packages that are useful for the computations of the matrix, plotting of functions, creating an environment for implementing various data algorithms, image analysis, etc. Over the years, the application of this software has increased tremendously dues to easy computation and debugging power. MATLAB also consists of many external libraries, extensive visualization, and analysis of data, the ability to process the videos and images, etc.

4.1.2 Hardware/Software Requirements

The computers on which the following program will be executed must have the corresponding specifications:

1. Operating Environment: It can be implemented on any system having Windows 2000 or a higher version or any other platform with equivalent computation and processing power.
2. Central Processing Unit (CPU): Pentium-IV with a 60367, Dual core, or Quad core or higher microprocessor based system can be utilized.
3. Monitor - A 17" or greater VGA or better quality screen/TFT/LCD.
4. Memory - 1GB of RAM is recommended.
5. Disk space - The free space on hard disk drive to install optimal model selection tool needed is approximately 150 MB or more.
6. Printer – Windows supported printer is presumed to be present. A laser printer with 300dpi or higher resolution is strongly recommended.
7. Pointing device - Windows-compatible two-button mouse is assumed to be present. It will not run without a mouse or equivalent pointing device (e.g. Windows-compatible trackball, touch pad, or digitizing tablet).

4.2 METHODOLOGY VALIDATION

The fundamental goal of this methodology validation was to check the integration of the procedure for solving the problem statement. The technique used in any exploration must be assessed to guarantee the validity of the results. For this purpose, mostly the researchers adopt the formal and informal methods for the validation and verification of the methodology proposed. The informal method deals with either the expert's judgment or the numerical results on the final outcome.

In order to validate the proposed methodology, the TOPSIS method is used for comparison with FMDBA. The ranking results of the countries based on the major five indicators (Agriculture & Rural Development, Economy & Growth, Education, Health, and Public & Private Sector) are compared using TOPSIS [16], AHP, and FMDBA method for the year 2014. Similarly, the comparison was performed for the corresponding years 2015 and 2016. The differences in the rankings with respect to the other method are obtained in pair-wise comparisons. The compiled results are delineated in Table 4.1.

Table 4.1. Comparison of Rankings of countries by different 3-Methods

Countries	TOPSIS		AHP		FMDBA	
	Index Value	Rank	Index Value	Rank	Index Value	Rank
Argentina	0.271	26	0.168	25	16.01231136	26
Australia	0.574	16	0.471	16	13.93322973	16
Bangladesh	0.451	23	0.249	23	14.58679891	23
Brazil	0.686	7	0.551	8	13.30155486	8
Canada	0.583	13	0.48	13	13.65120882	13
China	0.783	1	0.68	1	11.60838726	1
Colombia	0.698	6	0.595	6	13.05186659	6
Egypt, Arab Rep.	0.478	22	0.236	26	15.43210339	25
France	0.645	9	0.542	9	13.34946588	9
Germany	0.639	10	0.536	10	13.40665896	10
Hong Kong SAR, China	0.624	11	0.521	11	13.48502966	11
India	0.590	12	0.487	14	13.70441545	14
Iran, Islamic Rep.	0.513	20	0.41	20	14.1620557	20
Kazakhstan	0.352	24	0.348	24	14.98830244	24
Luxembourg	0.701	5	0.598	5	13.03663422	5
Malaysia	0.736	2	0.633	2	11.93818465	2
Mexico	0.583	15	0.48	15	13.77579255	15
Netherlands	0.721	3	0.618	3	12.44791323	3
New Zealand	0.609	14	0.506	12	13.56931428	12
Pakistan	0.234	27	0.131	27	18.35830248	27
Russian Federation	0.568	18	0.465	19	13.9413149	17
Saudi Arabia	0.491	21	0.388	21	14.31889296	21
Serbia	0.339	25	0.375	22	14.45807983	22
Spain	0.568	17	0.444	18	13.99492969	18
Sri Lanka	0.522	19	0.419	17	14.10741068	19
United Kingdom	0.654	8	0.583	7	13.14790535	7
United States	0.718	4	0.615	4	12.57383152	4

There wasn’t any difference among the ranking using FMDBA and AHP method. Due to some differences between the rankings of countries using the TOPSIS method there emerges the necessity to demonstrate a analytical significant correlation between the ranking of the various countries.

Spearman's rank-correlation approach is used to provide a relatio between the two methodologies. Further, two hypotheses are formed and tested for the significance of (α=0.05). The hypotheses are:

H0: There is no positive relationship between $\{x_i\}$ and $\{y_i\}$.

H1: There is a positive relationship between $\{x_i\}$ and $\{y_i\}$

The test statistics for six sets of ranking pairs are provided in Table 4.2.

Table 4.2. Spearman's Rank – Correlation Coefficient

Set of Ranking Methods	**TOPSIS-FMDBA**	**AHP-FMDBA**
Squares Sum ($\sum(d^1)^2$)	30	10
Spearman's Rank - Correlation Coefficient (r_s) $r_s = 1 - 6\sum_{t=1}^{n}(d^1)^2/n(n^2-1)$	0.9908	0.996

The values of rank correlation are 0.9908 and 0.996. This means that the probability of the null hypothesis being true is 0.001. Therefore the alternative hypothesis must be accepted i.e. there is a very strong pragmatic correlation between FMDBA and TOPSIS.

CHAPTER 5

RESULTS, CONCLUSION and FUTURE SCOPE

5.1 INTRODUCTION

This highlights the major experimental results, conclusion, and the possible future work based on the country ranking system and selection of the world development indicators. The main aim of this chapter is to provide all the experimental findings of the research work and to conclude the research work. The methodologies for the country ranking and evaluations have been developed and illustrated for the twenty-seven countries using thirty world development indicators.

5.2 EXPERIMENT RESULTS

1. Fuzzy Modified Distance-Based Approach (FMDBA) is applied for assessment, ranking, and selection of countries. It is capable of solving and modeling the multi-criteria decision-making problem concerning the weights of indicators/sub-indicators.
2. Fuzzy Set Theory (FST) is considered to be an effective and useful approach for the efficient evaluation of the indicators (i.e. the weight of the indicators) to adjust with the uncertainties and ambiguity of human judgment. By using the linguistic terms it is easier to distinguish the indicators. This FST is then integrated with the MDBA method and thus combines the merits of both the techniques.
3. The proposed FMDBA is based on the matrix operations and FST which can be easily computed using the MATLAB. It has thus shown its efficiency in analyzing the countries and thus ranking them. The countries taken under this analysis were Argentina, Russian Federation, the United States, China , Canada, China, Spain , Egypt, Arab Rep., Saudi Arabia, Germany, Hong Kong SAR, Brazil, India, Iran, Islamic Rep., Kazakhstan, Luxembourg, Malaysia, Mexico, Netherlands, New Zealand, Pakistan, Australia, France, Serbia, Colombia, Sri Lanka, United Kingdom, and Bangladesh.

4. The first indicator based on which the countries were compared was Agriculture and Rural Development for the years 2014, 2015, and 2016. According to the data collected based on the 27 countries taken into account India was ranked first, Bangladesh was second, Pakistan was third and Hong Kong was ranked last. The same trend was observed for the years 2015 and 2016. This result is delineated in Figure 5.1, 5.2, and 5.3.

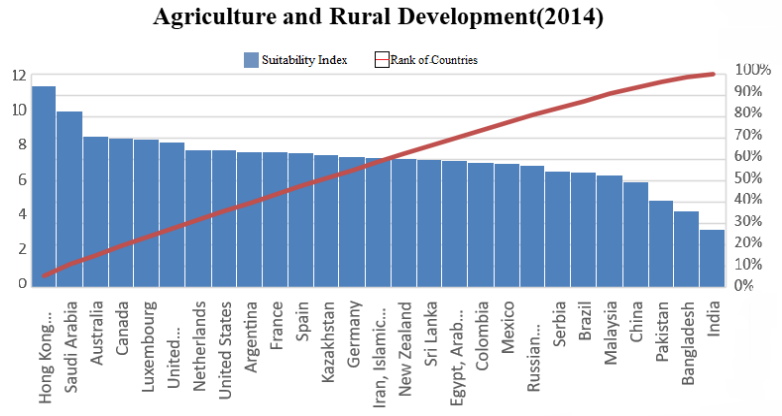

Figure 5.1: Ranking of Countries based on Agriculture and Rural Development Indicator (2014)

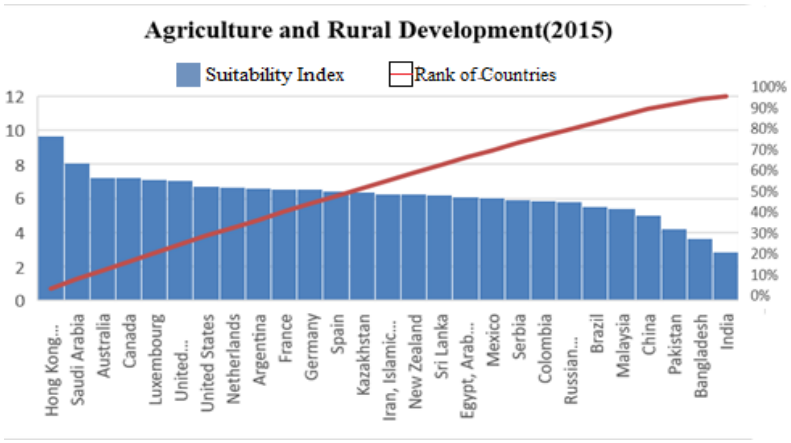

Figure 5.2: Ranking of Countries based on Agriculture and Rural Development Indicator (2015)

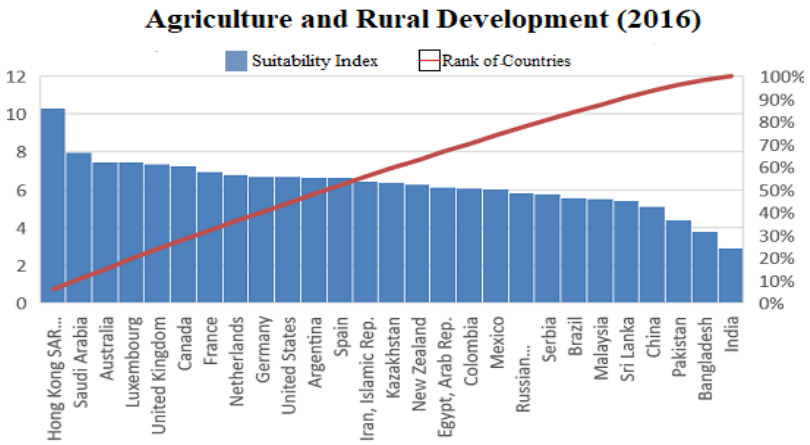

Figure 5.3: Ranking of Countries based on Agriculture and Rural Development Indicator (2016)

5. The second indicator based on which the countries were compared was Economy & Growth for the years 2014, 2015, and 2016. According to the data collected based on the 27 countries taken into account Hong Kong was ranked first, Luxembourg was second, Netherland was third and Argentina was ranked last for the years 2014 and 2016. Though for the year 2015 Netherland jumped to the second position whereas Luxembourg was ranked third. This result is delineated in Figure 5.4, 5.5, and 5.6.

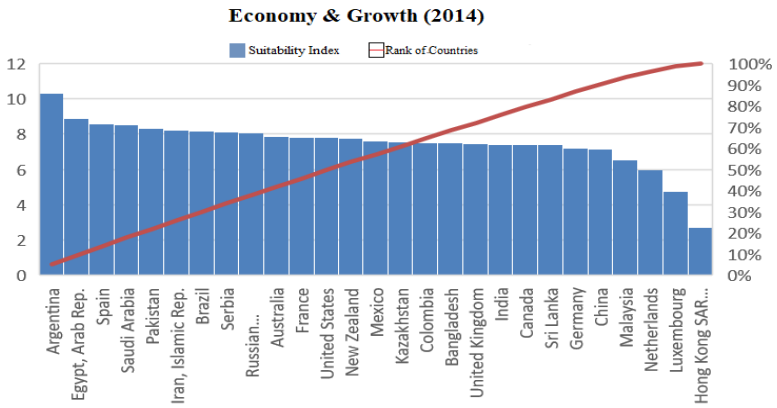

Figure 5.4: Ranking of Countries based on Economy & Growth Indicator (2014)

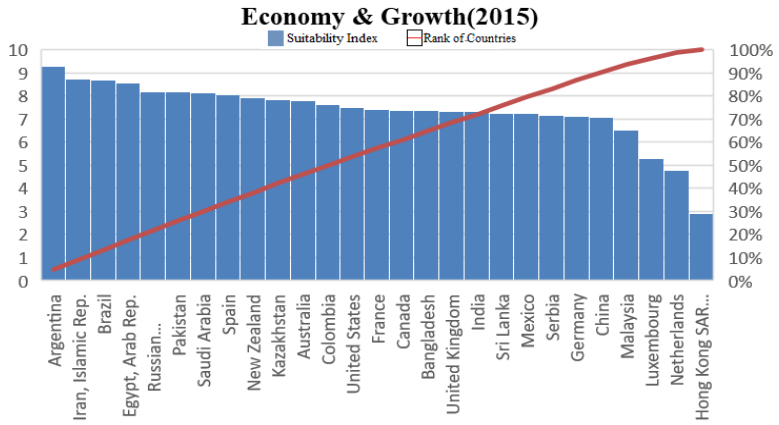

Figure 5.5: Ranking of Countries based on Economy & Growth Indicator (2015)

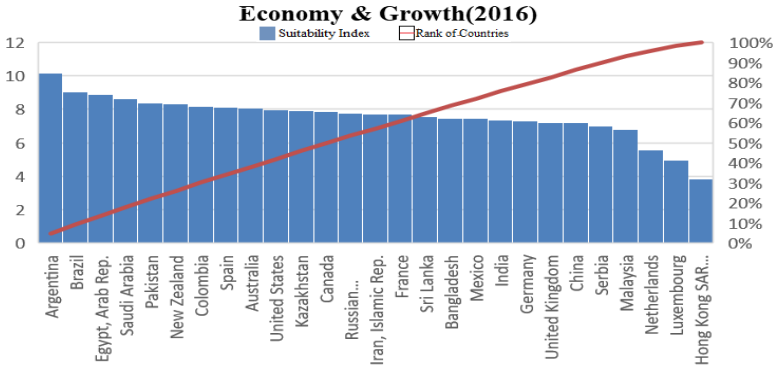

Figure 5.6: Ranking of Countries based on Economy & Growth Indicator (2016)

6. The third indicator based on which the countries were compared was Education for the years 2014, 2015 and 2016. According to the data collected based on the 27 countries taken into account France was ranked first, the United States was second, the Netherlands was third and Pakistan was ranked last for the year 2014. Though for the next consecutive years 2015 and 2016 the United States jumped to the first position whereas France was ranked second. This result is delineated in Figure 5.7, 5.8, and 5.9.

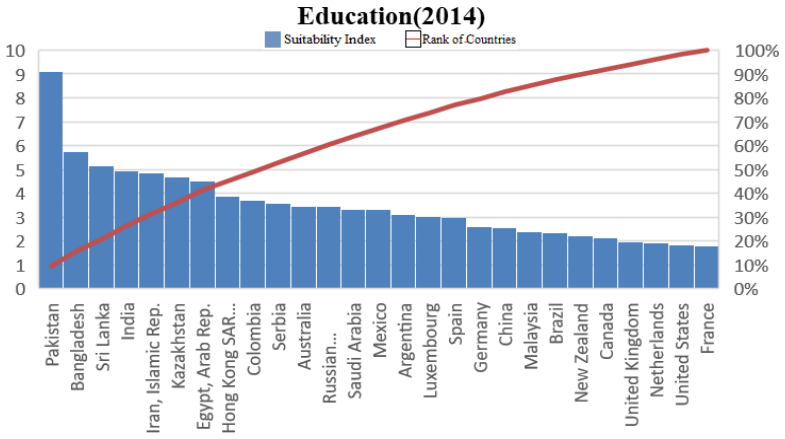

Figure 5.7: Ranking of Countries based on Education Indicator (2014)

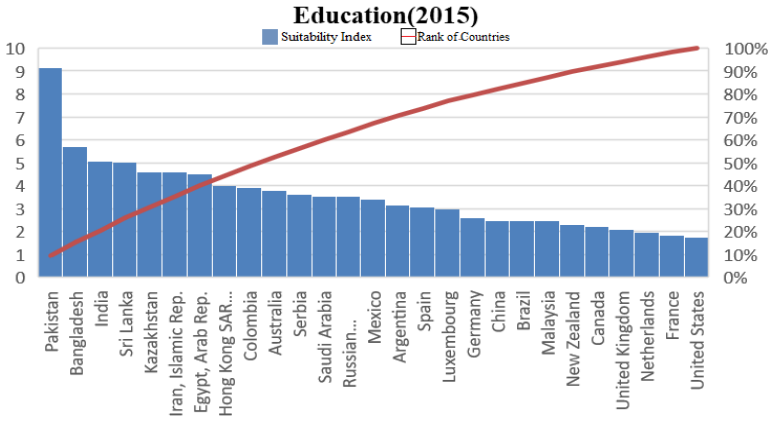

Figure 5.8: Ranking of Countries based on Education Indicator (2015)

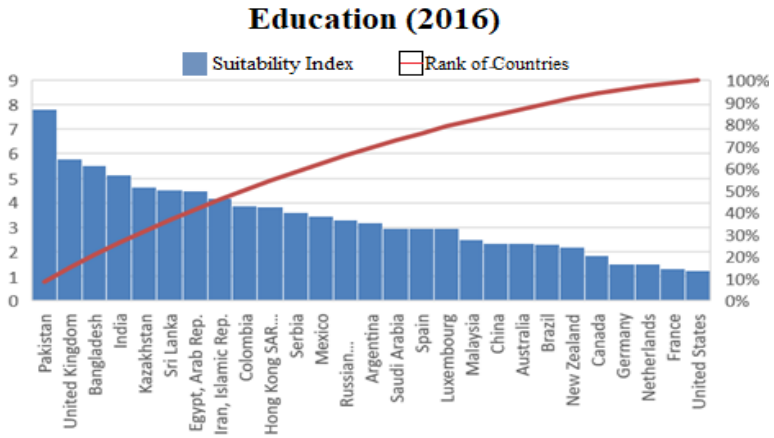

Figure 5.9: Ranking of Countries based on Education Indicator (2016)

7. The fourth indicator based on which the countries were compared was Health for the years 2014, 2015, and 2016. According to the data collected based on the 27 countries taken into account Hong Kong was ranked first, Luxembourg was second, Canada was third and Pakistan was ranked last for the years 2014, 2015, and 2016. This result is delineated in Figure 5.10, 5.11, and 5.12.

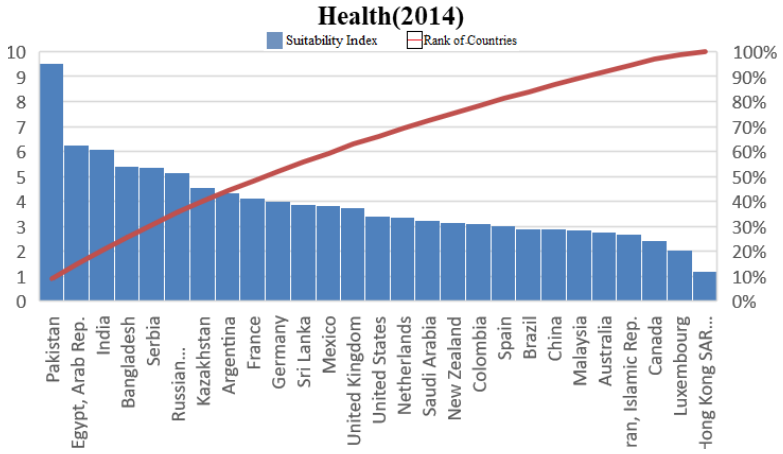

Figure 5.10: Ranking of Countries based on Health Indicator (2014)

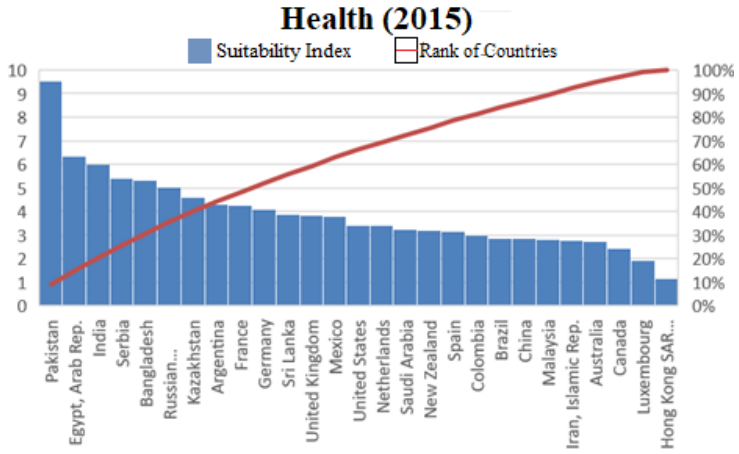

Figure 5.11: Ranking of Countries based on Health Indicator (2015)

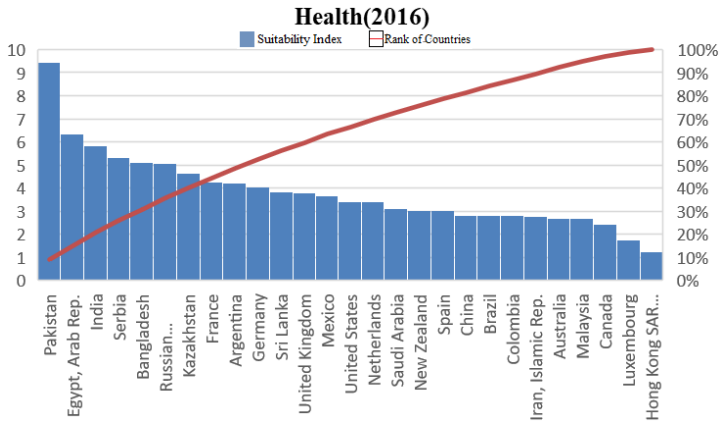

Figure 5.12: Ranking of Countries based on Health Indicator (2016)

8. The fifth indicator based on which the countries were compared was Private & Public Sector for the years 2014, 2015 and 2016. According to the data collected based on the 27 countries taken into account the United States was ranked first, Saudi Arabia was second, China was third and Kazakhstan was ranked last for the year 2014. However, the ranks changed in the years 2015 and 2016, Saudi Arabia was first, China was second, the United States was third and Luxembourg was last. This result is delineated in Figure 5.13, 5.14, and 5.15.

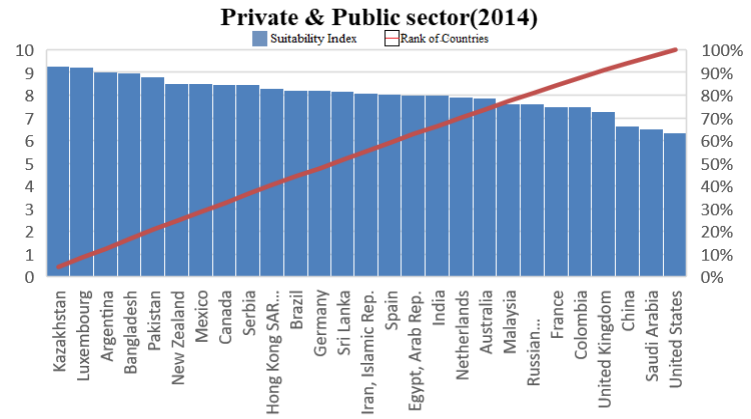

Figure 5.13: Ranking of Countries based on Public & Private Sector Indicator (2014)

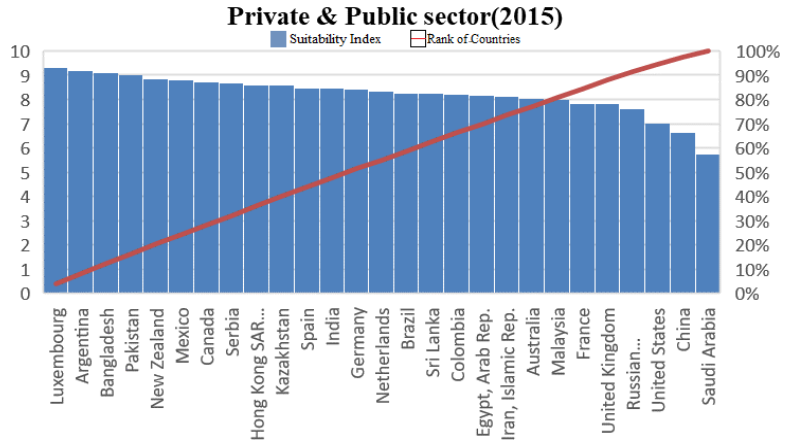

Figure 5.14: Ranking of Countries based on Public & Private Sector Indicator (2015)

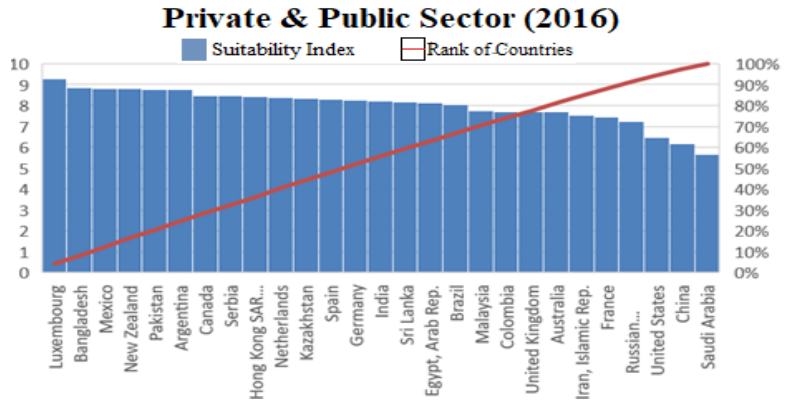

Figure 5.15: Ranking of Countries based on Public & Private Sector Indicator (2016)

9. Taking all the indicators into account the ranks obtained for the years 2014,2015 and 2016 were China was first, Malaysia was second, the Netherlands was third and the United States was forth. It was also observed that India was ranked fourteenth. This result is delineated in Figure 5.16, 5.17, and 5.18.

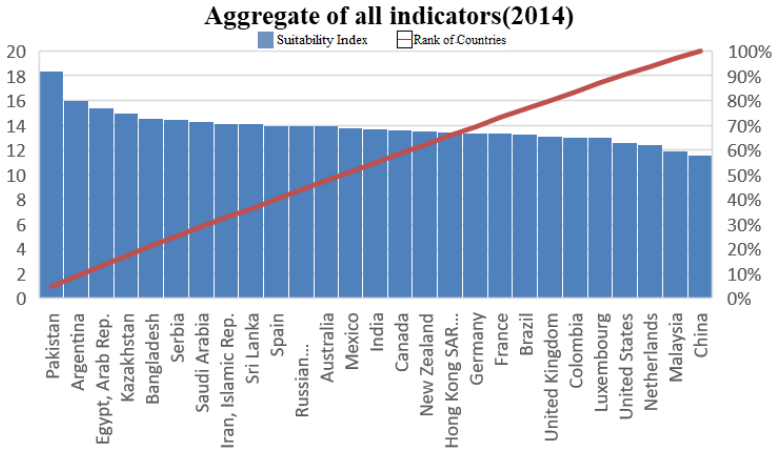

Figure 5.16: Overall Ranking of Countries (2014)

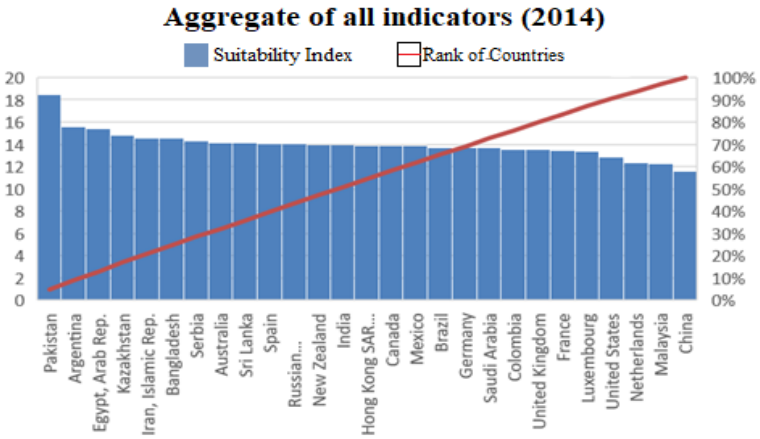

Figure 5.17: Overall Ranking of Countries (2015)

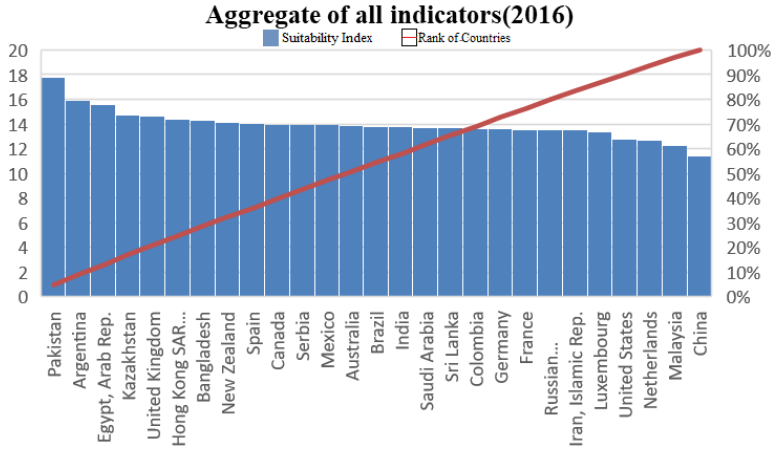

Figure 5.18: Overall Ranking of Countries (2016)

10. Further FMDBA is validated by comparing the results of existing methodologies i.e. AHP and TOPSIS. There isn't any major difference between the ranks and it was also observed that they have a strong correlation between the rankings of the countries using Spearman's Rank Correlation approach.

1.3 CONCLUSION

The development of countries has always been a point of debate for world development. Thus identifying a technique that can perform the ranking of countries is necessary. The world has been developing at a very fast rate but not all the countries need to develop at the same speed. Some countries might be developing at a tremendous speed whereas others might be at a standstill. This leads to a classification of low-income and high-income countries. Several reasons make the use of ranking countries much more significant. Intensifying the issue of missing or insufficient worldwide establishments are basic highlights of the world economy that restrain "stream down" procedures of human advancement.

The method used in this research is simpler for comparing the countries based on different parameters. Modified Fuzz DBA method was applied for the process of ranking the countries and evaluating the parameters of their development. This model is well defined and capable of solving various MCMD problems by considering the credence allotted to a range of criteria. FST is said to be one of the most efficient and valuable technique for the evaluation of the attributes (weights) to adjust according to ambiguous situations. Further, it also helps in drawing the line between the larger and smaller values of the developmental indicators. Hence this technique can be thought of as a hybrid that incorporates the advantages of a fuzzy set with MDBA. As a consequence, this technique also helps the countries to analyze their index in the overall ranking and accordingly can take effective measures for the same. This research work has several conclusions:

1. While evaluating countries there are a multiple number of indicators that can be considered. Evaluation indicators are generally disregarded as the majority of the indicators present are either founded on straight forward estimations. In the current examination, a compiled list of thirty indicators which are significant and complex

for the further evaluation of the countries. Further to facilitate, these indicators were separated into 5 major sets of progression. These indicators are then presented in a comprehensive format.

2. Using the fuzzy set theory and expert judgment all the indicators were then quantified and normalized weights. This was done to depict the uncertainties and ambiguous circumstances due to human perception.
3. It has become a necessity to identify the ideal country standards for world development. Not all countries developed some under-developed and the rest are developing. In this research work, a decision-making tool using the FMDBA method is developed for performing the ranking of the countries. Developing such a MCMD tool enhances the authenticity and confidence for solving such research problems.
4. In the current research work, the proposed methodology used is that of FMDBA which is demonstrated for solving the problem of country ranking for effective analysis by the economist and statisticians for world development.
5. The computed tool is effortless for utilization and user-friendly for analysis. The number of indicators for performing the evaluation has no limit. Thus any number of indicators can be selected for ranking and comparison. There are inbuilt decisions for the decision-makers whether to provide weights of their own or to use the computed normalized weights or to provide equal weights to all the indicators without any constraint. This helps us to save time wasted during the computation.

1.4 FUTURE SCOPE

There is always a scope of improvement in the field of research. The quantity of indicators can be expanded which will further improve the ranking of the countries. Likewise, the portrayal of different development factors based on the charts can be demonstrated which makes it progressively justifiable for the one utilizing it. . The prescient examination can be additionally improved by building a model. Different grouping methods can likewise help in further examination. Further, the client experience can be upgraded which makes it all the more simple for the clients to discover the arrangement.This methodology can be utilised with increased set of indicators and countries for further analysis. The existing technique

deals with the challenge of uncertainities while solving this problem. While assigning the weights based on the expert judgment and ranking the countries based on these indicators more research analysis can be performed.

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[1] Ranking of Countries using World Development Indicators: A Computational Approach has been accepted in the The 11th International Conference On Computing, Communication And Networking Technologies (ICCCNT) to be held at IIT Kharagpur.

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