Facility Location with Optimal Supply Chain Performance Measures in Developing Countries – Issues and Challenges

A THESIS SUBMITTED IN PARTIAL FULFILLMENT for THE DEGREE of

DOCTOR OF PHILOSOPHY

IN THE Faculty of Engineering

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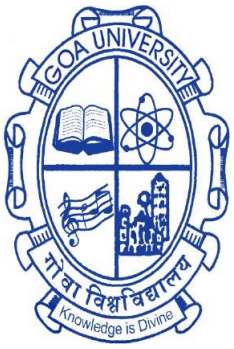

By

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JULY *2021*

DECLARATION

I, **Milind Jaiwant Sakhardande,** hereby declare that this thesis represents work which has been carried out by me and that it has not been submitted, either in part or full, to any other University or Institution for the award of any research degree.

Place: Taleigao Plateau.
Date: 23-07-2021 **Milind Jaiwant Sakhardande**

CERTIFICATE

I hereby certify that the above Declaration of the candidate, **Milind Jaiwant Sakhardande**, is true and the work was carried out under my supervision.

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Dedicated to

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ABSTRACT

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Keywords: Facility Location, Supply Chain Performance Measures, Ranking by Paired Comparison, Fuzzy AHP, Make in India, Renewable energy, Multi Criteria Decision Making, Fuzzy TOPSIS

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Contents

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List of Abbreviations, Notations and Nomenclature

Abbreviations

DC	: Distribution Center / Distribution Centre
UFLP	: Un-capacitated Facility Location Problem
AHP	: Analytical Hierarchical Process
MCDM	: Multi Criteria Decision Making
TFN	: Triangular Fuzzy Number
TOPSIS	: Technique of Order Preference Similarity to the Ideal Solution
FAHP	: Fuzzy Analytical Hierarchical Process
ROI	: Return on Investments
UN	: United Nations
PESTLE	: Political Economic Social Technological Legal Environmental
DEMATEL	: Decision Making Trial and Evaluation Laboratory
SWOT	: Strengths Weaknesses Opportunities Threats
CPSU	: Central Public Sector Undertaking
ANP	: Analytical Network Process
QFD	: Quality Function Deployment
SEZ	: Special Economic Zone
FTZ	: Free Trade Zone
USD	: United States Dollar
FDI	: Foreign Direct Investment
GDP	: Gross Domestic Product
ESP	: Economic Stimulus Payment
CE	: Consumer Expenditure
OHS	: Occupational Health and Safety
KAM	: Knowledge Assessment Model
IT	: Information Technology
R&D	: Research & Development
SME	: Small & Medium Scale Enterprise

ELECTRE : ELimination Et Choix Traduisant la REalité / ELimination Et Choice Translating Reality

KLEM : Keystroke Level Energy Model

ICT : Information & Communication Technology

ERP : Enterprise Resources Planning

IRC : Iran Railways Corporation

CSR : Corporate Social Responsibility

VIKOR : Vlse Kriterijumska Optimizacija I Kompromisno Resenje

DEA : Data Envelopment Analysis

RES : Renewable Energy Systems

PEST : Political Economic Sociological Technological

PESTEL : Political, Economic, Sociological, Technological, Environmental, Labour related

PESTLIED : Political, Economic, Social, Technological, Legal, International, Environmental, Demographic

STEEPLE : Social/Demographic, Technological, Economic, Environmental, Political, Legal, Ethical

STEPE : Social, Technical, Economic, Political, and Ecological

SLEPT : Social, Legal, Economic, Political, Technological

ETPS : Economic, Technical, Political and Social

SRM : Supplier Relationship Management

CRM : Customer Relationship Management

ISCM : Internal Supply Chain Management

RPN : Risk Priority Number

FMECA : Failure Mode Effect and Criticality Analysis

NGO : Non-Government Organisation

VHI : Very High Influence

HI : High Influence

LI : Low Influence

VLI : Very Low Influence

NI : No Influence

EI : Equally Important

WI : Weakly Important

SI : Essential or Strongly Important

VSI : Very Strongly Important

EP : Extremely Preferred

SCM : Supply Chain Management

RI : Random Index

CI : Consistency Index

CR : Consistency Ratio

BPM : Business Process Management

GEDA : Goa Energy Development Agency

DM : Decision Maker

GHI : Global Horizontal Irradiation

HVDC : High Voltage Direct Current

HVAC : High Voltage Alternating Current

PVPS : Photo Voltaic Power Systems

AOL :Availability of Land

ECI : Environmental Clearance Issues

LONS : Location of Nearest Substation

SS : Surface Slope

ATPS : Access to Potential Site

DFLC : Distance from Load Centres

IOL : Interference of Locals

DA : Dust Accumulation

DFRA : Distance from Residential Areas

FPIS : Fuzzy Positive Ideal Solution

FNIS : Fuzzy Negative Ideal Solution

CC : Closeness Coefficient

VV : Valpoi Vagheri

PT : Pernem, Terekhol

CG : Canacona, Gaondongri

PKB : Ponda, Keri Bhootkhamb

Notations

Σ : Summation

$\forall$: For all

Nomenclature

$\mu_A(x)$	: Membership function of fuzzy set A
$\tilde{a}$	: Triangular fuzzy number
(a^L, a^M, a^U)	: Triangular fuzzy number as a triplet with lower, middle and upper value
sump (i)	: Sum of positive centroids along rows (i)
sumn (j)	: Sum of negative centroids along columns (j)
λ	: Constant
r_i	: Fuzzy geometric value
w_i	: Fuzzy weights
$\overline{\lambda}_{max}$	: Largest principal eigen value
ρ	: Spearman rank correlation coefficient
d_i	: Difference between ranks of corresponding variables
W	: kendall's coefficient of concordance
m	: Number of raters (experts)
n	: Number of subjects (criteria)
r_{ij}	: The rating rater j gives to subject i
R_i	: Summation of the ratings given by rater to the subject
$\overline{R}$	: Mean of R_i
R	: Squared deviation
O	: Occurrence of a failure mode
S	: Severity of a failure effect
D	: Probability of detection
Var	: Variance
K	: Number of criteria
$\propto$	: Cronbach's Alfa
k	: Number of decision makers
$\tilde{\omega}_j$	: Weight of the criteria
$\tilde{x}_j$	: Rating of alternative given by k^{th} decision maker
D	: Matrix of the alternatives
$\tilde{v}_{ij}$	: Weighted normalized decision matrix
$\tilde{r}_{ij}$	: Elements of the normalized fuzzy decision matrix
S^+	: Separation from the positive ideal solution
S^-	: Separation from the negative ideal solution

d_v : Distance between two fuzzy numbers

C_i^* : Closeness coefficient

Chapter 1

Introduction

1.1 General

In today's world, considering the worldwide market competition and soaring levels of customer expectations, the supply chains have to be designed very cautiously. With businesses spreading all across globe, the countries worldwide are opening their boundaries inviting others for setting up industries. In recent years, many developing countries including India are flaunting a moderately enduring development rate. Today, many developing countries, particularly in Asia, are looked upon for development of business supply chains [1]. Many developing countries are trying to lure investors by creating free trade and special economic zones with tax exemptions. However, there are lots of issues and challenges that need to be addressed while locating facilities in such countries. The research is aimed at identifying such issues and challenges in facility location decisions in developing countries in general and India in particular.

1.2 Facility Location

Supply chain decisions are strategic decisions that impact the entire chain consisting of elements performing various functions like planning, purchasing, manufacturing, distribution and marketing. Manufacturing forms the heart of any business. In simple terms, what to manufacture can be addressed by product design, How to manufacture can be addressed through the manufacturing process, when to manufacture can be addressed by the market demand, why to manufacture can be addressed by market requirement and needs and where to manufacture can be addressed by facility location decisions. The facility location decision making has to be a long-term strategic decision. Facility location is one of the major business strategies as the entire prospects of business depends on facility location decisions [2]. A strategic view by the management for investments on procurement, development, configuration, resource utilization leads to a value driven supply chain [3].

1.2.1 Historical overview

The traditional methods of facility location mainly dealt with factors like distance, market demand [4, 5]. Many researchers have initially worked on principle of minimizing the costs

and maximising the desirables based on the finalised location[6]. However, In the present scenario, facility location problem has become an extensive strategic decision problem that should be carefully addressed for efficient long-term supply chain operation[2, 7, 8]. The optimal facility forms the basis to determine the further supply chain links like distribution centres (DCs), warehouses, pick up points etc. to be used and also decides on the distribution channel and the associated inventories ranging from suppliers to end customer. Location decision making includes investment decisions with constraints on the quantity of production and distribution of goods. Location decision making is an intricate problem and depends on a number of known and unknown factors that are of unique nature that influence the behaviour of entire supply chain. These factors are of quantitative and qualitative nature and have a major impact on location choices. While deciding on location choices, it is an extremely difficult task to achieve optimal trade-offs among those factors. Moreover, managing global supply chains is a herculean task due to the numerous uncertainty sources and intricate interrelationships at different echelons amidst the diverse elements. Such situations make it very difficult to decide the supply chain configuration and associated total cost simultaneously. Some of the supply chain parameters that are difficult to predict include dynamic transportation and facilities costs, capacity, and consumer demand due to market vagueness [9]. Considering developing countries like India, locating a facility has been a challenging concern. From the cases in India like the Tata Nano plant shift to Gujarat from Singur [10], West Bengal or the Goa Nylon 66 plant agitation, it is obvious that developing countries still have socio economic issues.

1.2.2 Factors affecting facility location

The factors affecting facility location decisions are quantitative and qualitative in nature. In past, factors like proximity to markets and supply sources, availability of transportation, labour characteristics, education system, energy alternatives, water availability, infrastructure availability, tax system, exchange rate, Gross Domestic Product, per capita income, standard of living , healthcare, climate, competition, political stability, market size, Government policies, customer characteristics are considered to a great extent [11, 12, 13]. However, in recent years, we have seen that a lot of the dormant qualitative factors like maturity of political leadership, blind belief in leadership, bureaucratic hurdles, internal turbulence, internal threats, role of parallel economy, that are vague in nature, and predominantly seen in developing countries, have not been considered in facility location decisions. Such dormant qualitative factors come to surface when location of the plant is already decided and can eventually turn out to be vital adversely affecting the decisions made and thus forcing

relocation of plant. This has been evident from the past cases like Tata Singur plant shifting to Gujarat, India [10] and Nylon 66 plant moving out of Goa, India. Hence these factors have been considered for facility location decisions in present research.

1.2.3 Facility location methods

Facility location decisions have been analysed through the p-median problem, the un-capacitated facility location problem (UFLP), multi-period location problem in past research. One of the primitive methods of facility location is a simple gravity location model which helps the firm locate a facility which is close to supply sources as well as markets based on minimum transportation costs [14]. The uncertainty associated with demands and costs is reviewed through the inclusion of stochastic components in some facility location models. In recent times, location models involving supply chain network design decisions like transportation modes, distribution design, material flow in the process, single and multi-sourcing relations, are analysed in research problems. In recent research, qualitative factors have also been combined with quantitative factors for a multi-objective capacitated multi-facility location problem. The problem is analysed using a combination of possibilistic linear programming and fuzzy AHP (Analytical Hierarchical Process) for cost minimization and benefit maximization in a multi stage supply chain network considering vagueness [9].

1.3 Supply Chain Performance Measures

Through the extensive literature review in facility location carried out by Melo et al. (2008) it is revealed that seventy-five percent of researchers have worked on cost minimization, sixteen percent of researchers have worked on profit maximization and nine percent have worked on multiple objectives of supply chain performance measures in the domain of Facility location. It is observed that many researchers are working in the area of integrating the strategic and operational decisions in supply chain planning. Hence there is a strong need to include supply chain performance measures in facility location decisions. Supply chain performance measures can be categorized largely as qualitative and quantitative measures. Enhancement of supply chain performance needs a multi-dimensional approach that addresses how the organization will serve various customer needs. The specific performance goals of each measurement may be different, though performance measurements may be similar. Quantitative measures of supply chain performance are classified in two widespread classifications: Non-financial and financial [15]. The non-financial in supply chain performance measures are as follows:

Cycle time: The time taken to produce an item or complete a task.

Lead time: The time between order and delivery.

Customer service level: This depends on the order fill rate, stock-out rate, backorder level and the probability of delivery on-time.

Inventory levels: Various inventory levels i.e. raw materials, work-in-process, finished goods inventory and spare parts should be measured from time to time and should be kept at optimum levels as the inventory costs contribute to the total supply chain costs in a major way.

Resource utilization: The manufacturing, storage, logistics and human resources should be utilised efficiently for maximum customer service levels, minimum lead time and optimal inventory levels.

Quality is also to be accounted as a major non-financial performance measure along with performability.

The financial performance measures are discussed as follows. The fixed and operating costs associated with supply chain such as inventory costs, transportation costs, facilities costs, material costs, technology costs, IT costs, labour costs affect the financial performance of a supply chain and need to be assessed from time to time. This assessment can be done by looking into the cost of raw material, sale revenue, activity-based costs, cost of expired perishable goods, penalties and credits for incorrectly filled or late deliveries from suppliers etc.

In the best scenario, the performance measures need to be at optimal levels. It is seen that the factors that affect facility location decisions have a direct or indirect effect on the performance measures. For example, non-availability of the required transportation facility affects the on time delivery. Similarly, the inventory levels can be managed optimally with proper use of information technology. Such dependency proves that supply chain performance has a strong connect to the factors considered for facility location.

1.4 Fuzzy Sets Theory

Lotfi A. Zadeh introduced the Fuzzy set theory in 1965 [16]. Over the past decades, many enhanced fuzzy methods have been developed in various areas like multi-objective optimization and multi criteria decision making (MCDM) [17, 18, 19].

1.4.1 Fuzzy sets

Assume that X is a collection of objects represented by x ,a fuzzy set α in X is a set of

ordered pairs defined as shown in Equation 1.1,and the bigger the value of the membership function, it will be more certain that *x* belongs to A [20].

$$A = \{(x, \mu_A(x)) | x \epsilon X\} \quad (1.1)$$

Where $\mu_A(x)$ is a membership function of *x* in A.

1.4.2 Triangular fuzzy numbers

The triangular Fuzzy number (TFN), $\tilde{a}$, is usually used in fuzzy study, and $\tilde{a}$can be defined by a triplet (a^L, a^M, a^U)[21]. Its mathematical and graphic concepts are shown in Equation 1.2 and Figure 1.2, respectively.

$$\mu_{\tilde{a}}(x) = \begin{cases} 0 & x \leq a^L \\ \frac{x-a^L}{a^M-a^L} a^L < x \leq a^M \\ \frac{x-a^U}{a^M-a^U} a^M < x \leq a^U \\ 0 & x \geq a^U \end{cases} \quad (1.2)$$

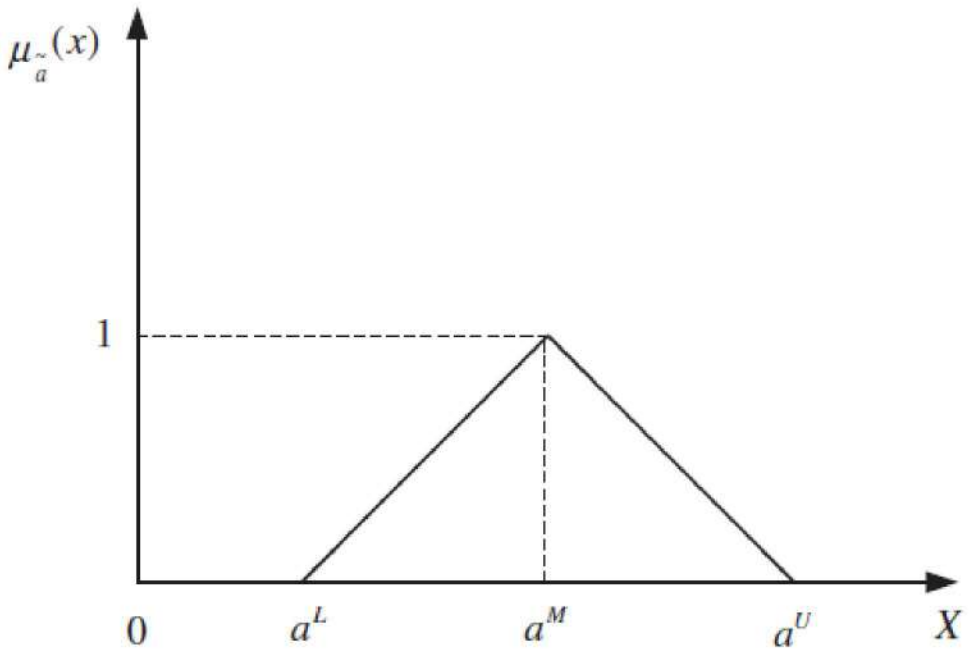

Figure 1.1 Triangular fuzzy number (TFN) (a^L, a^M, a^U) [21]

1.4.3 Arithmetic operations

The basic arithmetic operations between the triangular fuzzy numbers represented as $\tilde{A} = (a^1, a^2, a^3)$ and $\tilde{B} = (b^1, b^2, b^3)$are presented shown as follows [22]:

- **Addition**

$$\tilde{A} + \tilde{B} = (a^1, a^2, a^3) + (b^1, b^2, b^3) = (a^1 + b^1, a^2 + b^2, a^3 + b^3) \quad (1.3)$$

- **Subtraction**

$$\tilde{A} - \tilde{B} = (a^1, a^2, a^3) - (b^1, b^2, b^3) = (a^1 - b^3, a^2 - b^2, a^3 - b^1) \quad (1.4)$$

- **Multiplication**

$$\tilde{A} \times \tilde{B} = (a^1, a^2, a^3) \times (b^1, b^2, b^3) = (a^1 \times b^1, a^2 \times b^2, a^3 \times b^3) \quad (1.5)$$

- **Division**

$$\tilde{A} \div \tilde{B} = (a^1, a^2, a^3) \div (b^1, b^2, b^3) = (a^1 \div b^3, a^2 \div b^2, a^3 \div b^1) \quad (1.6)$$

- **Reciprocal**

$$1/\tilde{A} = 1/(a^1, a^2, a^3) = \left(1/a^3, 1/a^2, 1/a^1\right) \quad (1.7)$$

- **Scalar**

$$\widetilde{\lambda A} = \lambda(a^1, a^2, a^3) = (\lambda a^1, \lambda a^2, \lambda a^3) \quad (1.8)$$

- **Euclidean distance**

$$d(\tilde{A}, \tilde{B}) = [(a^1 - b^1)^2 + (a^2 - b^2)^2 + (a^3 - b^3)^2]^{\frac{1}{2}} \quad (1.9)$$

Where $0 < a^1 \leq a^2 \leq a^3$ and $0 < b^1 \leq b^2 \leq b^3$

1.4.4 Decision making in fuzzy environment

In mathematical programming research problems, over the past decades, the fuzzy set theory has gained numerous applications. The decision-making model in a fuzzy environment [20] is the kick-start to research in fuzzy decision theory. In the model, the objective function and constraints are considered to be fuzzy and are represented by a membership function. A decision in a fuzzy environment is analogous to a non-fuzzy environment as the aim is to satisfy the objective function or optimize the objective function under some constraints. Therefore, the decision in a fuzzy environment can be viewed as the intersection of a fuzzy objective function and the fuzzy constraints.

The term fuzzy programming is used differently in different situations. The mathematically formulated problem can be considered as a fuzzy problem as a part or as a whole and fuzziness can be represented in different ways. The objective function can be expressed as a fuzzy set / a fuzzy function & constraints can be fuzzy sets instead of crisp inequalities. The coefficient elements can be represented as fuzzy elements instead of crisp numbers. The decision can be depicted in terms of either a fuzzy set or a crisp solution.

1.5 Fuzziness in Facility Location Decision Making

Majority of facility location decision making problems in recent times consider both qualitative and quantitative factors. Hence an approach to represent qualitative data is a must in the analysis. The best way of analysing the qualitative data is to represent the qualitative data in terms of linguistic variables and then convert the data to fuzzy numbers. Hence fuzzy sets are used in the analysis to represent the qualitative data. Further, when decision making on quantitative factors is done, many a times it is seen that the factors vary as the locations differ. The costs can be considered as one of the prominent examples to discuss this issue. The costs at different locations will be different and also may vary with time during decision making process. Secondly, many a times the costs are not known. In such conditions, for this research work, the quantitative factors are also assumed as fuzzy numbers and the data is collected in terms of linguistic variables similar to qualitative variables.

1.6 Aims and Objectives

There are many qualitative factors that have been addressed in literature as shown in section 1.2.2. In developing countries, it is mostly seen that the policies are not firm hence there are many loopholes which can work towards benefits of those who like to play with system. In developing countries, a major stakeholder is the political system of the country in its industrial growth. Underlying factors like maturity of political leadership, blind belief in leadership, bureaucratic hurdles, internal turbulence, internal threats, role of parallel economy have not been considered yet in facility location decision making and can cause a lot of issues and pose lot of challenges during location tracking for a facility. The integration of location decisions should happen with supply chain network design decisions for better results [2]. Hence the supply chain performance measures affecting the strategic and operational decisions making need to be integrated in facility location decisions. The factors that have not been considered in decision making may directly or indirectly affect the supply chain performance. The research aims at locating a facility that will ensure all such deliverables at optimum levels. Many a times, even after the location is finalized and structure is built, some of these factors may lead to closure of work in such advanced stages that might cause a huge loss to the investors i. e. the business houses. This research aims at identifying such factors and ranking them based on their importance. The major objectives of this research are:

1. Identifying and analyzing various dormant qualitative factors that can surface at the time of finalization of facility location.
2. Identifying and ranking different sectors of business considering potential.

3. Identifying optimal location for a particular business sector.

1.7 Organisation of Report

The report is organised in the form of nine chapters. The First chapter introduces the facility location problem with factors affecting facility location decision in general, gives an historical review of facility location problem, addresses the supply chain performance measures and fuzzy set theory and presents the aim and objectives of the research work. The second chapter presents detailed literature review in all the concerned areas of research. The third chapter deals with problem identification & scope and the proposed methodologies to address the research problem. Fifty-seven factors that affect the facility location decisions are identified in the fourth chapter and are discussed in brief. Chapter five includes two case studies carried out for ranking of the factors using proposed method of ranking. Further, for validation of the proposed method, a well-known fuzzy AHP method is modified to take care of higher order matrix comparisons and both methods are compared for correlation. For further validation, one hundred randomly generated data sets are used and results of correlation are presented as a support for validation. A thorough analysis of consistency ratio is also presented in detail and new research directions in large matrix paired comparison problem solving are identified. The sixth chapter addresses the dynamic behaviour of factors through risk-based ranking using proposed method with an extension to address the risk. Chapter seven deals with ranking of sectors identified through Make in India using proposed method and fuzzy AHP with validation. The academicians and industry professionals' perspective in decision making is also addressed in chapter seven. Chapter eight presents two case studies for finding out the optimum location for a solar power plant in Goa, India. The first case study uses the proposed method and the results are compared with existing fuzzy AHP approach for MCDM. The second case study uses the proposed method- fuzzy TOPSIS (Technique of Order Preference Similarity to the Ideal Solution) combination and the results are compared against the existing combined fuzzy AHP- fuzzy TOPSIS approach. The conclusions and future research directions are presented in chapter nine.

Chapter 2

Literature Review

2.1 General Discussions

Over the years, facility location has been one of the prime subjects of research interest and many papers have been written and published in the subject area. Many of the research contributions have identified quantitative and qualitative factors that affect facility location decisions. Researchers have combined the above factors in facility location selection for optimal decisions. The factors affecting facility location are linked to the Supply chain performance in facility location decision making process. Multi Criteria Decision Making models have been applied in the domain for optimal choice of facility location amongst given location alternatives with the factors affecting facility location decisions as the main criteria. It is seen that in most of the research, Fuzzy Analytical Hierarchical Process (FAHP/ fuzzy AHP) is used for ranking of factors affecting facility location. In many research papers, methods like FAHP and fuzzy TOPSIS are combined for finding the best alternative. In the recent past, some of the researchers have identified India as the potential country for investments with its Make in India initiative and have tried to study the Indian manufacturing scenario by comparing it with other global leaders in manufacturing sectors. The role of academicians and industry professionals in decision making also has been keenly observed through some literature. In this section a thorough literature review is carried out on the factors that are not considered so far in facility location decisions and have been envisaged through brain storming by Academicians and industry professionals. Some literature review on the factors identified through brainstorming has been included with a mere reason of understanding the meaning of the factors though the available literature which does not have direct link in context with facility location decision making. A focussed review on Fuzzy AHP research papers is carried out to understand the number of criteria, levels and expert details used in various applications. All such aspects that support the present research are taken into consideration in the literature review.

2.2 Facility Location

Melo et al. [2] have carried out a widespread literature review of facility location decision models with emphasis on supply chain management. The authors have identified basic

features by reviewing models that support the decision making involved in the planning stage of the supply chain. The paper discusses the integration of location decisions with supply chain network design decisions. Supply chain network features with reverse supply chain features are addressed. The paper reviews supply chain performance measures and optimization techniques related to the supply chain and highlights the issues related to further research. Review of the p-median problem and its extension like the un-capacitated facility location problem (UFLP) is carried out in this paper. Further multi-period location problem is reviewed. The uncertainty associated with demands and costs is reviewed through the stochastic components included vide facility location models. Based on the literature review carried out on UFLP and its extensions, the authors conclude that facility location research has evolved without a supply chain management context. Hence the authors have also reviewed some essential papers relevant to facility location decisions with regards to decision-making phases like strategy, planning, and operations in supply chain management. Further, location models involving supply chain network design decisions like transportation modes, distribution design, material flow in the process, single and multi-sourcing relations, are reviewed. Papers with objectives of maximum ROI, equipment choice for installation, multi-stage production, capacity issues, procurement, multi-stage production, routing, etc. are addressed. Research papers on inventory models for supply chain management are reviewed by authors as inventory is one of the major drivers of the supply chain. The authors have provided a synthesis of the reviewed literature in support of decision-making process in supply chain management in terms of network structure and design. The authors have presented an analysis of the different supply chain performance measures and the method used for solving problems in supply chain network design. Some papers that address the applicative case studies and real-life issues of facility location strategic decisions with respect to supply chain planning are reviewed. The reviewed literature reveals that seventy-five percent of researchers have worked on cost minimization, sixteen percent of researchers have worked on profit maximization and nine percent have worked on multiple objectives of supply chain performance measures. The authors conclude that there is an increasing research happening in the area looking into the strategic and operational decisions integration in supply chain planning.

Melnyk et al.[3] have proposed a framework of supply chain design to understand the three major levels of critical factors in the design phase of supply chain. Life cycle, desired outcome, business model and the environment are considered as the influencers. Physical designs, social network design, behavioural design, sourcing strategy, relationship governance are considered under design decisions and Inventory, capacity, transportation and technology

are considered as the building blocks. Re Velle and Church [4] have proposed an extension to the urban facility location model proposed by Teitz. The extension looks for maximum facility utilization. Chentnik [5] have discussed the plant location methods that have proved computationally feasible for moderately sized problems, minimising the total distance between the interconnected points, and selection of only one site. The paper summarises properties of various analytical techniques that have been developed, as well as the types of problems each is best suited for and points out some of the deficiencies in the literature for solving the realistic general problem. The ramifications and repercussions as well as the applicability of existing location theory techniques to the practical site selection problem faced by the physical distribution manager are also discussed in the paper. Munasinghe et al. [8] have developed a simulation based approach for evaluation of facility influence and product differentiation over supply chain network design. The approach provides a basis for strategic decisions making in retail industry to reduce the overall distribution network cost. Ozgen and Gulsun [9] have proposed a combined two-phase possibilistic linear programming approach and FAHP approach to for cost minimization and qualitative factors benefit maximization in a supply chain network with ambiguity. Quantitative factors are combined with qualitative factors and are jointly evaluated in this paper. The approach provides many interactive solutions for decision makers for taking decisions in varying conditions.

Kalantari [11] has found that a majority are of the opinion that a facility location problem has to be addressed on regular basis. Once the plant is built, relocation would require re-consideration only when it is nearing an economical end. A clustering technique is used to address the problem. A classification model is created based on decision making factors found in the literature. Bhutta [12] has reviewed the literature on factors affecting the international business and has categorized the analytical models. The factors are categorised into market, manufacturing and economic risk/Government policy factors. Burciu et al. [13] have developed a model having various applications in economic sectors considering elements like maximum distance, closeness to resources and infrastructure availability. The model is developed for locating a cement factory with three levels of production i.e. quarries, cement factories and concrete plants. The authors conclude that the reduced transport costs could make up for a new facility in ten to fifteen years period. Nguyen and Olapiriyakul [23] have conducted a study for cost and human healthy impact minimization in facility location decisions. It is observed that the population density on various transportation routes acts as a major influence on the optimal solutions. Considering the cost and human health impact tradeoffs, it is observed that there is a significant human health impact reduction with minor cost.

Florez et al. [24] have proposed an artificial intelligence model to support decision making and have developed robust solutions for a humanitarian supply chain location. A case study is carried out to emphasize the advantages and limitations of the proposed model. Bespamtyatnikh [25] has proposed two approaches for facility location decision problems. The aim is to identify best location amongst given alternative sites in both the problems. The first problem deals with identification of best location by maximizing the weighted distance function between the facility and the sites. The second problem aims at identifying a location by minimizing the sum or sum of the squares of the distances of the sites from the facility. Owen and Daskin [26] have carried out a thorough literature review on research work on strategic facility location problems with stochastic or dynamic characteristics. Many industrial applications using various models and approaches are addressed in this paper.

Daskin et al. [27] have presented a summary on the significance of facility location decision making in the supply chain design phase. The authors have reviewed the classical models and also the research that is aimed to include other features in a supply chain like inventory management, vehicle routing, reliability etc. in facility location decisions. Farahani et al. [28] have reviewed the models, solutions and applications in covering problems in facility location. The work is classified in set covering and maximal covering categories. The authors have reviewed less explored areas in covering problems and have also considered objective functions other than costs.

Chen et al. [29] have identified the economic social and environmental perspectives and factors that affect location decisions. The review explicitly includes sustainability in the decision-making process. Sarkis and Sundarraj [30] have used Analytical Network Process model combined with an optimization model to analyse the issues in locating a repair-parts warehouse for a leading electronics and computer manufacturer in the world taking into consideration qualitative and quantitative factors. Strategic issues like Geopolitical, fiscal and trade uncertainties are considered for evaluation. The research aims at providing solutions for international facility location that is not seen much in literature.

2.3 Supply Chain Performance Measures

The performance measures of any supply chain have to be considered in majority of supply chain strategic and operational decisions. Though facility location is a strategic decision but as seen in recent past, the operational factors also contribute in major form if considered during initial phase of decisions. Re Velle and Church [4] have proposed that the supply chain performance is affected by facility location decision making in an organisation. The authors

conclude that the location decision should be based on the factors that affect location decision making.

Bhatnagar and Sohal [7] confirmed that supply chain performance is influenced by location decisions. The quantitative factors like transportation costs, labour rate, exchange rate, tax are identified through literature. There is a significant connection between qualitative location factors like Infrastructure, Main Competitor's location, market and supplier proximity, labour, political stability, and environment for business, uncertainties in supply chain and the operational competitiveness like flexibility, quality, responsiveness and inventory turnover of supply chains as per the results seen. Ravet [31] carried out research to identify link that exists between the global & local supply chain performance and distribution location with key performance indicators. The research aims at providing an insight to the management for selecting a facility location set with optimum inventory, transportation costs, and service level requirements. Production costs, productivity, time, flexibility, and quality at global and local levels are identified as key performance indicators.

2.4 Developing V/S Developed Countries

As the research aims at facility location decisions in developing countries, review of UN industrial report is carried out as follows. UN Industrial report [32] states that the developing nations compete in short term periods to sustain their positions, whereas the developed countries have kept their positions in the long term by maintaining their resource and energy efficient high-tech industries. The report suggests that developing countries should focus on technology enhancement and building a robust knowledge base for sustainable industrial development. Azmat [33] has discussed the role of social entrepreneurs in sustainable development of developing countries with a case study from Bangladesh. The findings suggest that the entrepreneurs should be supported by academicians and policy makers to come up with novel methods for the development.

2.5 PESTLE Analysis

The factors affecting facility location are identified and classified using a PESTLE tool. This tool helps in classification of various factors at global level i.e. Political, Economic, Social, Technological, Legal and Environmental. This section throws light on existing literature review on PESTLE (Also referred as PESTEL) applications in various contexts. Yuksel [34] has recommended a method and presented a model to discuss issues in PESTEL analysis. Analytic Hierarchy Process is used for modelling the factors and sub factors of PESTLE and

Analytic Network Process is used to calculate the global weights of the sub-factors. Decision Making Trial and Evaluation Laboratory is used to identify relationships between the factors. The sub-factor relationships are not considered. In the present study, the data has been used as crisp numbers for AHP analysis. The author suggests use of fuzzy numbers for further studies as most of the factors and sub-factors are not quantifiable.

Kolios and Read [35] have used PESTLE for a thorough renewable energy analysis in general and tidal energy in particular in the United Kingdom. The analysis is carried out to identify the different stakeholders associated with all stages and the risks associated with the tidal energy projects. The authors have inferred that several risks can be reduced early by involving particular stakeholders at the right stage of a project.

Rastogi and Trivedi [36] have used PESTLE in the domain of risk management. The authors have identified external risks connected with a construction project using PESTLE and tried to minimize the impact of external risks. This article discusses PESTLE in detail and proposes a step by step method to identify the risks with advantages and disadvantages. Pourmohammadi et al. [37] have conducted a study to present a strategic direction to Iranian public hospitals and to determine influential environmental factors using PESTLE. The issues that are pointed out at the micro-environmental level are over-prescription, distribution inequality of healthcare services and luxurious health service demands. Zalengera et al. [38] have presented the existing energy situation in Malawi and addressed the renewable energy potential to counter the situation. The authors have proposed a PESTLE analysis to identify and manage the constraints for renewable energy technology development. Srdjevic et al. [39] propose a method to determine the criteria for multi-criteria decision making of a specific category of water management problems. The approach is used in a real-life situation for the selection of the optimal water intake remodelling of the existing structure for a regional hydro system in a Serbian province. The factors are identified by an expert using the SWOT/PESTLE analysis and ranked using the AHP. There is a total correlation among a list of factors provided by the elimination algorithm and the prime factors identified through AHP thus conferring satisfying results.

Sridhar et al. [40] present a broad analysis of coastal zone management practice using the PESTLE approach. The study highlights various geomorphologic features, coastal resources, major threats on coastal areas, coastal zone management policies of India and the impact of the policies on the coastal area and ecosystems. The study also discusses the strengths and challenges of the existing framework and presents recommendations for efficient coastal zone management in India. Fosher [41] has conducted a study on the management of trails to learn public use sustainability. Officials and other stakeholders from two counties in a North-

eastern state are interviewed on trail maintenance. The results are analysed using PESTEL. Potential trail benefits for town communities are identified as a result of this study.

Kara [42] has carried out a study to estimate the significance of PESTEL in Mugla, Turkey tourism sector. For the tourism sector development, legal factors are estimated as the most important whereas social factors are least important, based on the analysis done on the data provided from one hundred and fifty business top managers. As seen, the highly qualified participants gave high priority to all these factors in this study than others.

2.5.1 Political factors

The literature review carried out in order to understand the political factors that are considered for facility location decisions is as follows.

Hager [43] discusses about bureaucratic corruption and its various forms in India. He also shows the effect of corruption on development, the causes and further suggests cures and the role of law. The author suggests that besides codes and rules, a freedom of media, ministerial integrity and political process maturity also play key roles in solving the corruption problem.

Kumar and Thacker kumar [44] have discussed about the bureaucratic hurdles faced by foreign investors in India. The study compares the hurdles at the state and central level. The authors state that all states are not equal and can face hindrances due to varying environmental conditions, power connections and labour laws. The authors suggest right choices of three factors namely location, joint venture partner, and personnel to handle the bureaucratic hurdles.

Pattanaik and Nayak [45] tests the hypothesis that less government control leads to higher economic growth in federal system like India. The results indicate that, three dimensions of economic freedom, government size, strong law, and open regulations governing credit, labour, and product markets can benefit the income growth.

Rana [46] examines the transformation pattern in the Indian political parties. The study shows that the country along with its culture, governing norms and other political dimensions keeps on changing thus affecting the political system of the country. The study has identified the key factors that have directly facilitated the country to safeguard their democratic government in the last decades. Borkakoti [47] has identified the democratic shortfalls of Indian political system. The author has proposed six major deficiencies i.e. immoral and ineffective representation in democratic institutions, unproductive media, poor governance and corruption, top-down approach of governance, lack of public participation and lack of strong leadership and morality of majority of politicians. The author suggests that a robust leadership with a clear vision is needed for a well-organised democracy of a country.

Feng [48] has studied the connection between democracy, political stability and economic growth. The author concludes that the democracy is favorable for growth indirectly. Altun [49] has studied the effect of political stability and governance on economic development through literature review, analysis and experiments. The estimation is done based on one hundred and fifty-seven countries over a decade from 2002 to 2011. The results prove the noteworthy effect of political stability on economic development for short term as well as long term.

Akshat [50] studies various challenges to internal security in India. The study also suggests the possible policy responses that have been put forth to drive out the feeling of invulnerable insecurity amongst Indian citizens. Manoharan [51] discusses the importance of internal security to achieve the political, social and economic objectives of nation. The study highlights various challenges to internal security and its causing factors in India. The author concludes that citizens, government and private sectors together play a vital role in fighting these challenges.

Doldor [52] has observed that the recent investigations of leaders' political involvement neglects awareness of knowledge & development and has presented a developmental perception to overcome the weaknesses. The author states that the political maturity involves a change in visible skills and behaviour of the leaders and also the mindset and cognitive scenario change during their involvement in organizational politics. The paper also discusses the practical and theoretical indications of the perception. Haq and Anwar [53] have observed that the concept of agreement between leaders and followers is reasonably new, based on literature. Over the years, there is not much literature is available on the agreement concept in developing countries. The study is carried out to review and synthesize major leadership theories, models, and relationships with varying outcomes. During the studies on various theories, maturity in leadership is considered as one of the strong factors influencing the leadership style.

Scott [54] discusses the concept of extended neighborhood which India endorses, along with the aims and objectives it has set for itself. It further entails the practicality of the steps from a multidimensional mirror reflecting upon as to how much of the concerns have been addressed to, and as to what extent this extended neighborhood policy has been successfully implemented in the face of challenges and restraints. Pattanaik [55] has observed that the security is a key factor in India's neighborhood policy. The author has attempted to study the neighboring country Bangladesh's reaction to India's sympathies with democratic countries and its faith in a stable neighborhood with favorable relationships, reciprocally. The author claims that some people with vested interests have created different opinion in the people of

Bangladesh, promoting India as a country with different ideology. The author concludes that India needs to frame policies that blend with the residents of Bangladesh and are beyond biased politics.

2.5.2 Economic factors

The literature review on eighteen economic factors that are considered for facility location decisions is as follows.

Manjari Singh et al. [56] have carried out a study to present a comparative analysis of salaries in the government sector, central public sector undertakings (CPSUs) and private sector in India. The objectives of the study are to develop the framework for identifying job families in the said sectors, conduct a comparative study of salary patterns, study the factors affecting pay levels across the sectors and create a conceptual map of the pay levels and factors interrelationship.

Kalantari [11] considers construction costs as an important decision-making factor in the international location decision.

Bist [57] has investigated the long term relationship in financial development and economic growth in sixteen low-income countries. The study is done on available data of two decades. The results show a cross sectional dependence of the selected countries. The important policy inference of the study is policies should favor the growth of the private sector. Mukherji [58] has discussed the economic policies that favour India's growth. Inclusive growth has been a challenge for the development of the country. The author states that the middle and richer segments have always gained more than the poorer sections of society. This is obvious from the fact that reforms in areas such as infrastructure have not been matched by human and agricultural development. Sluggish progress in education and health is a biggest barrier to the growth of the country in long run. The author concludes that the major challenge for India's growth and development is to get an increase the middle-class segment that is well served by markets and competition.

Das & Raut [59] in their research state that service production needs less resource capital than human capital when compared to industrial or agricultural goods. The rise in export services has caused the service sector to provide opportunities in employment growth. It is observed that the service sectors like banking, communications, community services, hotels and restaurants, trade and business services demonstrated faster growths.

Conceicao et al. [60] have conducted a case study on a multinational steel company to identify the number and location of distribution centers. Through literature, the authors have identified financial incentives as one of the performance metrics in strategic decision making

of facility location. Eterovic and Ozgul [61] have administered a study to select the best country location for a new packaging facility amongst alternatives. The problem is analysed using fuzzy AHP and TOPSIS. The authors feel that the company should plan to locate their business in the states or countries that provide incentives. MacCarthy and Atthirawong [62] have described thirteen general factors and sub factors that affect the global location decision. One of the sub factors identified by the authors is financial incentives.

Ashtiani [63] has reviewed recent works in competitive facility location models based on seven classes. Type of competition is studied on the basis of existing competition and competition that can be foreseen. Various models based on existing and foreseen competition are reviewed. Kalantri [11] has surveyed the literature and identified inflation as one of the economic factor. The study suggests that countries with lower inflation rate are more suitable for locating a facility. MacCarthy & Atthirawong [62] have identified a set of factors that can potentially influence the global location decisions. The results are based on a Delphi study that utilizes international group of experts to examine factors influencing global location decisions. Inflation is considered to be a major economic factor.

Kowalski and Paraskevopolous [64] re-examine the connection between location and the industrial land price. The paper designs a model that includes the location factors in a hedonic pricing model. The authors have adopted econometrically reinforced assessment that the market for industrial land is divided into submarkets and that location is suitably measured in reference to the submarket. Qiu et al [65] have designed a innovative method to simulate transformation process of urban industrial spatial distribution in Shanghai, China. The results indicate a shift of industries way from city centre with an increase in urban land price. The study suggests introduction of new government policies and competitive advantages when the land price crosses a certain threshold, so as to retain industries within the city boundary.

Partovi [66] incorporates external and internal criteria in the decision making process to give a strategic solution to the facility location problem using AHP, Analytical network Process (ANP) and quality function deployment(QFD). A proper location can provide encouraging support to the market competitiveness for the company. Organisations have been capitalising on the variations in the cost, labour quality, talent, energy, facilities and capital, and shifting sections of manufacturing processes on a national level. The analytic model discussed in the paper adds quantitative precision to the decision-making process which otherwise would be abrupt in nature proving its worth. Reddy & Holak [67] study the influence of market structure characteristics and external market interventions on the intensity of timely competitive reaction. It is observed that moderate behaviour in both concentration and growth rate stimulates greater competitive activity. The of the competitive goals, on the basis of

which these companies operate, keeps changing due to influence of factors such as the global economic slowdown, technological advancement, deregulation, and market globalization. The aim of the study is to see the competitive behaviour among companies by integrating the effects of market structure factors.

Sarkar [68] has made an attempt to gauge the parallel economy in India with emphasis on causes, impacts and government initiatives. It is evident from the study that Indian government has formed various committees to control the parallel economy but results are disheartening. The results indicate that parallel economy has been growing swiftly in India and other developing countries. Gujrati [69] has studied the cause and effect of parallel economy in India. A hidden economy in its wide interpretation consist of illegal economy, such as money laundering, smuggling, etc; unreported economy including tax evasion & unregulated economy, that is economic activities outside law and regulations. The present study is based on secondary data collected through journals, books, magazines, internet, Newspaper etc. It is evident that the rate of growth of black money in India depends on the economical state of universal business. Menon [70] has thrown some light on the effect of black money on economy in India. The Indian economy is divided into a large informal sector comprising of 90% and a small formal sector supporting only 10% of the economy. The informal sector is the major contributor to black money as most of the activities are informal. The paper presents the impact of black wealth and black money on the economy and the difference between the two.

Mulky [71] has identified the issues and challenges faced by business houses in distribution channels across India. The authors propose that the channels should be designed optimally with right inputs on thinking, efforts, and funds to be invested. The author feels that the margins associated with distribution channel and the sales expense in channel management form a significant proportion of total marketing costs. Ciari et al. [72] have developed a location decision module of retailers for use in an agent based microscopic transport model. The visualized retailer module focuses on location choice of retailers and related strategies. Promotional media is considered as a cost factor.

Kumar and Srivastava [73] have worked to identify opportunities and challenges for Biotechnology industry in India. The authors suggest that considerable opportunities are available for the growth of biotechnology industry, especially in the health and agricultural area due to the large markets for food products and pharmaceutical needs for the growing population. Agrawal [74] has highlighted the strategies and initiatives taken by the Information Technology industry to mitigate the opportunities and challenges. The author

states that the developed markets like Japan, Germany, Switzerland and Austria are offering new expansion opportunities to Indian information technology industry.

Sagar and Singh [75] have identified criteria for supplier selection process of automobile sector in India. In total eighty-five criteria that access the characteristics of the suppliers are listed by the authors. The findings can be used as a baseline for a business house to support supplier selection process and for better buyer supplier coordination. The most important findings are compared with findings from the previous literature at the end. Wheeler and Mody [76] have suggested that the countries with superior infrastructure development, expert input suppliers and growing domestic market need not compete for foreign investments by offering incentives.

Izadi et al. [77] have compared cost models and cost factors in freight transportation through literature review. The authors have proposed road freight transportation costs model and cost estimating methods and data gathering model that help in identifying inconsistencies like the gaps between the types of costs etc. Potluri and Tejaswi [78] have identified the various challenges faced by the carriers and shippers for chosen modes of transportation in India. In case of roadway transportation, traffic congestion and parking together form the major problem whereas cleanliness and safety are some major issues in railway transportation. The high-ticket prices and lack of skilled employees are the prime challenges encountered by air transportation industry, as per the authors. Fulton &Hoch [79] reviews transportation factors affecting facility location decision-making problems. Authors state that cost and quality of transportation are inter-dependent factors in the framework of production and marketing objectives. Nature of this study is qualitative and hence has a general appeal to it rather than specific.

Singh et al. [80] have conducted a case study of an Indian auto components manufacturing company with business expansion plans in Iran to take advantage of the incentives announced by Iran Government in free trade and special economic zones (FTZs / SEZs). Nine major criteria including taxation policies are identified through literature review. The selection of most suitable location for a warehouse amongst four alternatives in different FTZs and SEZs is done using fuzzy AHP method. Boujelben and Boulaksila [81] have carried out extensive literature review on global facility location models and have proposed a stochastic dynamic model for global location selection. The authors have identified tax rate as an international factor that influences strategic location decisions. Ko [82] has proposed an integrated decision model for the distribution facilities location decision. The model is used to reveal the practical application of the research finding. Tax structure is taken as a cost related decision factor in the analysis. Dixit et al. [83] have studied the effect of economic and non-economic

factors on business location decisions. Tax structure is identified as one of the regulatory factors in paper.

Kalantari [11] has reviewed the literature on recent research on international facility location problem and states that US dollar forms the basis for evaluating the strength of the currency of different countries. The author further states that it is important for the organisations to locate in a economically robust country to avoid capital devaluation problems while deciding on international locations. Daya Shankar [84] in his study states that the financial globalization and power transfer has helped the internationalization of the USD to generate money and credit to multinational firms. The author states that FDI strategies of multinational firms can be better understood because of the dominance of the US dollar in international market.

Ketokivi [85] inspects thirty five assembly location choices to identify best location amongst the choices from strategic and financial viewpoints. The study concentrates largely on the choice to locate explicitly in a high GDP for each capita condition. Jain et al. [86] examine the effect of various economic elements on GDP components. In the examination the authors identified a huge effect of FDI, Net FII value and import on GDP components. However, there was no noteworthy effect of Net FII obligation on GDP components. The examination suggests that there was a negligible effect of export on GDP parts yet service had a critical effect. Neog [87] examines the shifts of Indian GDP. The monetary change of 1991 has opened up the Indian economy to the world. The paper investigates whether this monetary change is likewise advantageous for all the segments of GDP or not. The dummy variable regression model is utilized in this examination and information were gathered from the economic survey of India 2015-16. Results showed that the area like community, social and services indicates no adjustment in development rate in the post change period.

Fornahl et al. [88] have examined the role of three location based production factors namely; transportation, human, and social capital for identifying the per capita income. It is concluded that the three factors connect positively with poor people and rich region's financial performance. Per capita income etc. has been considered while as an important economic factor for global location decisions by MacCarthy and Atthirawong [62] .

2.5.3 Social factors

As seen in the past research, consideration of social factors in facility location selection is of prime importance. Twenty important social factors are considered in the present research and the literature is reviewed on individual basis as follows.

Rizwan, Nongkynrih and Gupta [89] have studied the status and effect of air pollution in Delhi. The paper also discusses the vehicular and industrial policy initiated by the government in order to curb the level of air pollution. The authors conclude that further measures in addition to existing and community participation are the need of the hour to further control the air pollution. Pascal et al. [90] reviews epidemiological studies that are used to evaluate the health concerns of those living around industries. The survey included various papers that studied effects of air pollution, cancer, morbidity, mortality and birth outcome.

Richard Starley [91] has expressed his views on the blind belief in leadership quoting the Iraq attack and the associated war. Modh [92] presents various leaderships styles in literature and draws a comparison in leadership style of Narendra Modi and Manmohan Singh. The author proposes a framework for comparison based on seven categories of leadership styles. The author suggests that the study can help in self-awareness of leadership capabilities. Besides, the author also claims that knowing a leader's genuine style is beneficial to his organization's accomplishment.

Fan and Abdel Ghany [93] utilize a model coordinating the lasting salary and relative pay speculations to clarify shopper use conduct in the U.S. The model was observationally tried utilizing information from the meeting study part of the 1996 and 1997 Consumer Expenditure Survey. Parker et al. [94] gauges the adjustment in family spending straightforwardly brought about by the receipt of the economic stimulus payments (ESPs) by utilizing a characteristic examination given by the structure of the tax break. The investigation depended on inquiries regarding the instalments to the progressing Consumer Expenditure (CE) Survey, which contains thorough proportions of family level uses. It is discovered that on normal family units spent around 12 to 30 percent of their boost instalments, contingent upon the particular, nondurable consumptions during the three-month time frame in which the instalments were acquired.

Sheikh [95] has studied the higher education system in India and presented the possible challenges and opportunities. The author suggests that there is need to boost the quality and quantity of the institutes in India to sustain the development. There is a serious need to re-consider the financial resources, access and equity, quality standards, relevance, to reach and accomplish the future requirements. Boruah [96] has presented a case on the infrastructure facilities provided to teachers and students in government primary school in a district in Assam. The author states that primary education is the base of formal education and acts as gateway to higher education. The study concludes that a majority of the schools lack physical end educational facilities which might be contribute to the dropout rate. The author also points

out that certain government policies are leading towards improvement in the schooling system.

Blom and Saeki [97] have conducted an employer's survey to highlight the gap between expectation of an employer and the necessary skills possessed by an engineering graduate. The survey indicates that employer consider soft skills to be very noteworthy. The study suggests that the engineering institute should incorporate the importance of soft skills, change the teaching learning process and assessments to concentrate on analysing and solving engineering problems and interact with the employer to understand their expectations. Khare [98] investigates the development and changing structure of the Indian advanced education framework in the light of the training profile of the Indian jobseekers, work showcase requests and the employability list for India's high development areas based on existing skill gaps and proposes a wide pathway to connect the gaps and missing connections. The author concludes that planning for both horizontal and vertical extension of Higher Education is the interest present day.

Sani et al. [99] investigate approaches to improve work execution through integrity. The examination, which is a subjective report, has utilized semi-organised interviews to investigate the proficiency of the respectability of open library pioneers with the Method Framework analysis. The discoveries of this investigation have suggestions for the model, arrangement and practice on trustworthiness that can be received by libraries and other government offices. This model can along these lines be viewed as a guide that will manage associations with proper estimates when attempting to improve execution through trustworthiness. Vig and Sati [100] focus on the role of professional ethics. The authors have stated that the Make in India initiation would lead to appealing global businesses into India which in turn will boost development of economy, health and standard of living. The paper suggests that practise of professional ethics which includes the behaviour a professional at personal, organizational and corporate level can ensure that Make in India to be a complete and inclusive approach for development.

Aghera [101] has studied the viewpoint of Occupational Health and Safety (OHS) in six textile businesses in Gujarat territory of India. The idea of word related Health and Safety in creating nations is constrained and illnesses and mishaps at work stay one of the most shocking misfortunes of the contemporary industrial age. No adequate information about OHS are accessible in India in light of the fact that most of mishaps are not answered to the Labour Department. The author stresses that India additionally has poor occupational safety and health legislation and infrastructure. Sethi, Khandelwal and Sethi [102] present a hazardous case due to exposure to cadmium fumes in silver cottage industry. Many a times

continuous exposures to poisonous metals are not detected in developing nations since individuals are unaware of the dangers. The authors point out that no principles and guidelines have been created for family run cottage industries. The paper suggests critical steps for example, anticipation programs, preparing instruction about the risks of cadmium presentation, appropriate precautionary measures, and the advancement of more secure substitutes. Animashaun and Odeku [103] have studied the physical work environment in Nigeria. The authors have identified unemployment, lifestyle value, prevalent corruption, as major causes for badly designed working environment leading to labour exploitation and fostering workplace hazards. Use of unsafe chemicals, working without protective equipment, ill arranged workplace design are common and need to be looked into as a serious affair leading to reduction in accidents and to aid evacuation in accidental situations. Tripathy and Ala [104] identify the safety hazards present in Indian underground coal mineshafts and to fabricate a fundamental database of the recognized risks. Mishap information gathered from the Directorate General of Mines Safety in India and an open part coal mining organization was concentrated to recognize security dangers that may most likely prompt mishaps. The database could assist the mine administration with improving dynamic in the wake of breaking down and assessing the dangers of recognized risks.

Staniland [105] analyses both counter insurgent clashes and the murkier domain of private armed forces and armed political groups that mix legislative issues with violence. The author gives a review of the settings of common war and political brutality, variation in strategies in tackling rebel challenges, bunches that work in "militarized politics" conditions and examines future exploration and strategy suggestions.

Pillai [106] inspects the key information based areas in India and possible benefits it has in pushing forward its information based ventures. The paper contrasts India and other information-based nations. The author likewise features the difficulties confronting India in this regard. He concludes that India has advanced well since it started its progression drive in the mid-1990s. However, the difficulties faced would require an immediate and more proactive methodology from the Indian government and the huge Indian multinationals. Bhattacharya [107] studies the difficulties and prospects on the pathway to India's excursion towards turning into a worldwide pioneer in information economy with reference to the four pillars as characterized by the Knowledge Assessment Model (KAM) of the World Bank. The author states that, to be a worldwide pioneer in the information economy, India needs to build up a coordinated system for the improvement of instruction, advancement and business and the data and correspondence arrange. There ought to be combination in the sharing of

information between pioneers working at the grassroots and researchers at research associations.

MacCarthy [62] identifies labour characteristics as one of the factor influencing location decision. Verick [108] analyses the Indian labour market, a task which is intrinsically challenging, given the nation's size and assorted variety. Author contends that as opposed to concentrating on quantitative numbers dependent on net changes in all out work or the work constrain, it is ingenious to take a more disaggregated perspective on India's labour market, which yields a superior image of the nature of work in India. Three key factors, namely, low and declining female work power cooperation, familiarity and sectoral nature of business pattern are identified.

Bhar et al. [109] takes a gander at the language hindrances looked by representatives working in different fields identified with Information Technology (IT) in Malaysia. A poll was disseminated to IT representatives working in different worldwide and national organizations in Malaysia, wherein representatives needed to rate the impacts of every language boundary on them with regards to the working environment. The study concludes that future exploration should all the more expressly consider the various setups of language aptitudes that are required by IT staff. Jones [110] questions 2000 US workers with a list of seventeen benefits and ask them to rate the options when choosing between jobs with higher salaries and those paying lower salaries with higher incentives. The study reveals that 88% of respondents wished to choose better health and dental benefits, with 34% wanting to give “some consideration” and 54% opted for “heavy consideration” for health benefits.

Dobre [111] has analysed the employee motivation drivers. The author feels that every individual should to be encouraged using different procedures as every individual is different. Ali et al. [112] discovers the effect of motivation on performance of employees and employment fulfilment in IT Park area of Peshawar, Pakistan. The study indicates that motivation is the key instrument for enhanced work execution and occupation fulfilment and hence can enhance the degree of individual and organizational capability. Moreover, the authors claim that, if an organization needs to build their profitability and income it must think all viewpoints to build the persuasive degree of workforces. Robescu and Iancu [113] have also researched on the impact of motivation on employee performance. The findings reveal two opinions on the addressed issue. First indicate that there is solid support for addressing in which the money is priority and financial factor inspiring human. Second line of opinion shows the significance of initiative style and language utilized by pioneers in expanding the exhibition of subordinates.

Dehejia and Dehejia [114] assess the case that there exist profound interrelationship between religious beliefs and financial movement in India. This case is assessed, first with regards to ancient India where confidence was pushed, both monetarily and religiously. With regards to medieval India, the hardening of the once adaptable caste framework had significant financial ramifications. In light of this recorded point of view, it is battled any endeavour to comprehend the monetary real factors of contemporary India should likewise assess its religious real factors.

Mathur [115] points that according to the accepted development model of India , development is seen in restricted terms of financial turn of events and, all the more especially, GDP development. This is western way of thinking, which depends on materialistic qualities, and has brought forth current decision monetary philosophy of free markets and rivalry, where gaining cash and gathering riches is viewed as essential objective of life. The author states that there is a need to grasp a more human-driven model of advancement, in light of social and civilizational ethos, which is ethico-spiritual and is profoundly concerned about the issue of human, social welfare and prosperity of individuals.

Kalantari [11] has identified standard of living as one of the factors affecting facility location and is included by many researchers in facility location research.

Sundar [116] in his paper covers the story of trade unions in India with verifiable and relevant issues, distinguishing association types and structures and their relationship with the state, considering the jobs of association and clarifies the turn of events, elucidating structure and techniques of unions in going up against the difficulties that have emerged because of changes in the framework. Dhal [117] observes the decrease in worker's guild participation is a worldwide wonder, especially in the time which is affected by the free development of creation, capital and work. Be that as it may, unions have revived themselves by concealing their developmental job of encounter among capital and work and receiving different systems to endure and grow. The author evaluates the significant workers' union of India and their reaction to the adjustments in the trade structure in India.

Saran and Shirodkar [118] studies and compares Vastu Shastra and Feng Shui with respect the Indian architecture. The findings of the study are that both the sciences depend on five essential components and their rules are as per their geographic and climatic condition. Although the objective of Feng shui and Vastu Shatra are equivalent, the strategy is unique. However, use of both is fit for halting the debilitated structure condition. Nandy [119] defines Vaastu Shastra as Indian antiquated science that gives rules to plan and keep up an agreeable day to day environment in the structures and hence gets basic to comprehend and acclimatize

the Vaastu thoughts into present day engineering. With the assistance of the case studies, the article comprehends and accentuates the job of Vaastu Shastra and its reasonable applications.

2.5.4 Technological factors

Owusu and Asimadusarkodie [120] have carried out a study to review the opportunities linked with renewable energy sources. The study suggests measures and policy recommendations for emission reduction, climate change mitigation and clean environment & clean energy provision for years to come.

MacCarthy & Atthirawong [62] have identified infrastructure as one of the top five major factors influencing decision making of location choice. Turhan et al. [121] have studied the factors influencing location choices using personal surveys. Questionnaire and personal interviews were conducted to collect the data using four-point Likert Scale. Infrastructure was considered among six important factors influencing business. Survey findings conclude that infrastructure, raw material and market are the driving factors for plant location choices. Richardson et al. [122] have identified the factors that are critical for humanitarian organizations for identifying locations during emergencies through a Delphi study with opinions of the experts. The infrastructure quality and availability is among the top five factors discussed in the outcome of this study.

Sahin & Topal [123] have determined the relation between cost and financial performance of information technologies used in businesses. The overall aim is to investigate which technologies contribute to which performance criteria, to what extent and in which direction. Authors have concluded that IT used in the form of forecasting demand, electronic data interchange and enterprise resource planning systems have contributed positively to the financial performance. Bessen [124] discusses the relationship between technology adoption costs, i.e. in this case, the information technology and productivity growth. Author finds through the data that the capital adjustment cost in the period 1974-1983 rose sharply in favour of adoption of information technology. Author concludes that information technology investments have increased the productivity at about 0.4% per annum. Mitra & Chaya [125] investigate the cost factors that are affected by information technology (IT) investments. Data set comprises of over four hundred large and medium sized U.S. corporations. Authors conclude that high information technology investments are linked directly with lower production costs, lower total costs, and higher overhead costs on an average.

Kalantari [11] has identified a new labour related factors including skill as one of the factors that plays a vital role in location decision. MacCarthy & Atthirawong [62] have identified factors influencing global location decisions through literature analysis and Delphi study.

Labour characteristics is one of the top five factors identified through the analysis. In the study, majority of the experts suggest that major motivation for international manufacturing decisions is to get cheaper labour with finer labour skills with the main purpose of reduction in production costs. Thumawongchai & Huang [126] have reviewed the literature on factors affecting manufacturing location decision. Labour characteristics have been considered under the group of human resource management. From a factor's perspective, authors have shown that the availability and reliability of labour is among the main factors to consider in production location decisions. Kathawala & Gholamnezhad [127] have introduced a novel method and presented a framework for decision making in facility location problem considering qualitative and quantitative factors. Availability of labour and their skill set was considered one among seven factors so chosen for analysis. Authors have used AHP decision model for ranking of the factors.

MacCarthy & Atthirawong [62] have considered power supply as a sub-factor in this study.

Kumar [128] addresses the relationship between technology and health-care costs. The author suggests that use of efficient simple and inexpensive quality measures have the potential of enhancing the output before accepting high end technology. Fagerberg [129] investigates co-relation between the technological progress and the growth of countries internationally Author takes a critical approach to the economic growth models enlisting the pros and the cons via theoretical review of existing literature. Study summarizes that growth factors such as investment, education, R&D have to be viewed a complementary to each other rather than substitutes.

Kalantari [11] has covered Availability of transportation as a sub-factor under infrastructure. MacCarthy & Atthirawong [62] have concluded that the countries with reliable and good condition facilities and utilities are preferred choice for locating firms. Rahman & Kabir [130] have attempted to find the cluster pattern of production SMEs in Khulna city, Bangladesh and the cause behind the same. The authors have shown that although sufficient utility access is considered as a main factor, however, in Khulna city, it proved to have less impact in a facility location decision as per the data collection. This is because utility services factor is taken as granted by the entrepreneurs, as they are easily accessible in the city. Vlachou & Iakovidou [131] have attempted to summarize existing research on facility location factors and their development through time as this could be a valuable tool for policy makers, entrepreneurs and researchers. As per the literature studied, utility has been considered in decision making process under the module of external factors after 1970.

2.5.5 Legal factors

The legal factors considered for choice of facility location are Government laws & regulations for industries and Government policies for industry. The literature with respect to the legal factors considered is carried out as follows.

Laws and Regulations have been considered under the umbrella of Legal Factors by Thumawongchai & Huang [126]. Badri [132] through objective programming shows how global quality factors could be effortlessly consolidated in location allocation problem. The study examines the sensitivity of location allocation choice that involves global location factors. Global location factors incorporate factors identified with political situation, international competition and survival, government regulations and economic factors.

Luo [133] presents the case of China's automotive industry to reveal the complicated relationship between policies and development in industries, and present the relations between government and industry. Author states that Government industrial policies largely affect the industrial performance and development. Eterovic & Ozgul [61] have conducted a study to identify the best country location for a new packaging facility. Fuzzy AHP and TOPSIS are used for analysis. Government policy has been taken as one of the sub factors affecting location decision choice. Elderjy et al. [134] present a report on study of Sarir Gas turbine industrial management for economical sustainable process. It is found that the Government policies have a major influence on plant location decision in planned economies.

2.5.6 Environmental factors

Some literature on environmental factors considered for the research work is as follows.

Chen et al. [29] have studied the inclusion of sustainability aspects in manufacturing facility location decision-making. Social, economic and environmental factors influencing location decisions are identified in the study. The authors have reviewed the literature to support the sustainability factors selection for climate change performance.

Abe & Ye [135] discuss the effect of natural disasters on international supply chains and the risks associated. The Authors conclude that investors show concerns on investing in developing countries that are prone to natural disaster damage. Chari &Ngcamu [136] have addressed the effect of disaster risks on the dairy supply chain performance in Zimbabwe. A mixed method involving questionnaires, interviews and observations is employed for the purpose of study. It is inferred that there is a negative effect of disaster risks on the performance of dairy supply chains.

Ahuti [137] has identified and quantified effect of industrial growth on the environment. The paper provides suggestions for policy improvements like the use of clean technology and environment friendly manufacturing methods. Gundogdu [138] have analysed seven regions of turkey on the basis of environmental issues caused by industrialization. Ecosystem, basin characteristics and land type form the basis for identifying the criteria and alternatives. The ELECTRE method is used to identify best location for industries in the country with minimal harm to environment Rasmi Patnaik [139] has conducted a study on the existing industrial pollution issues and environmental effect in Puducherry. A causal chain analysis carried out shows harsh impacts of industrialization on the environment. The instant and root causes are detailed based on the data analysis.

Dupont and Renzetti [140] has discussed the role of intake and re circulated water in production. Using an econometric KLEM model of manufacturing, the authors state that the relationship between water intake and water recirculation is strong when water intake is process related. The authors conclude that the increased water intake and decreased water recirculation in industries is mainly because of the technological changes biased in that direction. Kummu et al. [141] discuss the 20^{th} century water shortage and the roadmap towards sustainability. With respect to the population growth since 1900, the water scarcity is four-fold over time period as per the study. It is seen that there is a small increase in per capita water consumption during the past century. However, the rise in water scarcity is largely due to the effect of geographical population growth distribution with respect to the water resources as mentioned in this paper.

2.6 Fuzzy AHP

Balusa and Gorai [142] have applied fuzzy AHP in the area of mining. They have solved a two-level problem with seven main criteria and sixteen sub-criteria. However, the authors have not mentioned any details on the number of decision-makers, their field of work, and experience. Besikci et al. [143] have worked in the application of ship operational efficiency measures. They have used fuzzy AHP in a two-level problem with six main criteria and nine sub-criteria. The study is conducted with the help of twenty decision-makers. Bian [144] has worked with six main criteria considering a single level fuzzy AHP problem for dry port location selection. Eight experts have analysed the problem in the research paper. Bozbura et al. [145] have applied fuzzy AHP in human capital applications with three main criteria and twenty sub-criteria considering a two-level problem. There is no mention of the number of experts in the paper. Bozbura and Beskese [146] have applied fuzzy AHP in organizational

capital application with three main criteria and twenty sub-criteria considering a two-level problem. The number of experts is not specified in the research paper. Butdee and Fungsalee [147] have worked in the area of risk assessment in bus body manufacturing. They have carried out the analysis as a two-level problem using fuzzy AHP with five main criteria and fifteen sub-criteria. Six decision makers have participated in the analysis. Buyukozkan and Cifci [148] have applied fuzzy AHP in electronic service in healthcare with six main criteria and twenty sub-criteria considering a two-level problem. The number of experts is not specified in the research paper. Buyukozkan et al. [149] have applied fuzzy AHP in analyzing service quality in healthcare with six main criteria and nineteen sub-criteria considering a two-level problem. They have collected data from five Hospitals for decision making. Calabrese et al. [150] have worked with two main criteria and six sub-criteria considering a two-level Fuzzy AHP problem in ICT service industry application. The number of decision-makers is not specified in the research paper. Calabrese et al. [151] have worked with two main criteria, two sub-criteria and thirteen sub-sub criteria considering a three-level fuzzy AHP problem in strategic decision making application. The number of decision-makers is not specified in the research paper. Cebeci [152] has applied fuzzy AHP in the application of ERP systems in the textile industry. He has analysed the problem using two levels with three main criteria and thirteen sub-criteria. There is no mention of the number of decision-makers in the paper. Chamodrakas and Martakos [153] have utilized fuzzy AHP for electronic marketplace supplier selection. They have analysed the problem as two-level with three criteria and five sub-criteria without mentioning the number of decision-makers. Chang et al. [17] have applied fuzzy AHP for wafer slicing quality application. They have analysed the problem as two-level with four criteria and eleven sub-criteria. Decision-makers from thirteen factories have taken part in the study. Cheng [154] has used fuzzy AHP in the area of naval tactile missile systems. He has analysed the problem as two-level with five criteria and twenty-three sub-criteria. Three decision-makers have taken part in the investigation. Cho and Lee [155] have implemented concepts of fuzzy AHP for new technology product development. They have investigated the problem as two-level with four criteria and sixteen sub-criteria. One hundred and eleven decision-makers have taken part in the analysis. Dagdeviren and Yuksel[156] used fuzzy AHP in the area of behaviour based safety management. The authors have examined the problem as two-level with four criteria and fourteen sub-criteria. The authors' along with three industry managers have taken part in the investigation as decision-makers. Dozic et al. [157] have applied fuzzy AHP in the application of passenger aircraft type selection. They have investigated the problem using two levels with three main criteria and ten sub-criteria. Decision-makers are taken from airlines and technical universities.

However, there is no mention of the exact number of decision-makers in the paper. Duran [158] used fuzzy AHP in the field of computer-aided maintenance management systems. The authors have analysed the problem as two-level with seven criteria and twenty sub-criteria. However, there is no mention of the number of decision-makers in the paper. Fu et al. [159] have applied fuzzy AHP in the domain of electronic marketplaces adoption decisions. The authors have analysed the problem as three-level with two criteria, six sub-criteria, and nineteen sub-sub criteria. Three Scholars' along with eight industry experts have taken part in the investigation as decision-makers. Gold and Awasthi [160] have used fuzzy AHP in the area of international supplier selection. The authors have analysed the problem as two-level with five criteria and twenty-five sub-criteria. A focal committee of experts has taken part in the investigation as decision-makers. Four members have conducted sensitivity analysis. Gungor et al. [161] have worked with three main criteria and seventeen sub-criteria considering a two-level fuzzy AHP problem in personal selection application. The number of experts is not specified in the research paper. Gupta et al. [162] used fuzzy AHP for green supplier selection in the automotive industry. The authors have analysed the single level problem with nine main criteria. The decision-makers are industry experts. However, there is no mention of the exact number of decision-makers in the paper. Heo et al. [163] have made use of fuzzy AHP in the area of renewable energy. The authors have analysed the problem as two-level with five criteria and seventeen sub-criteria. Ho et al. [164] have worked with six main criteria and twenty sub-criteria considering a two-level fuzzy AHP problem for selecting third-party logistics service providers. The company officials' team carried out decision making as mentioned in the paper. Ilbahar et al. [165] have worked with five main criteria and thirty-two sub-criteria considering a two-level fuzzy AHP problem for occupational safety and health application. The experts carried out decision making as mentioned in the paper but no exact number was specified. Isaai et al. [166] have worked with three main criteria considering a single level fuzzy AHP problem for railways time table application. Three-time tables are compared. The managers and experts from IRC carried out decision making as mentioned in the paper but no exact number was specified. Ishizhaka and Nguyen [167] have worked with three main criteria and eight sub-criteria considering a two-level fuzzy AHP problem for current bank account selection. The experts carried out decision making as mentioned in the paper but no exact number was specified. Jaskowski et al. [168] have worked with five main criteria considering a single level fuzzy AHP problem for contractor selection. Fifteen decision-makers have analysed the problem in the research paper. Jayawikrama et al. [169] have applied fuzzy AHP in the area of manufacturing plant sustainability. The authors have analysed the problem as three-level with three criteria, nine

sub-criteria, and thirty-one sub-sub criteria. The number of experts is not mentioned in this paper. Kaganski et al. [170] have worked with seven main criteria and thirteen sub-criteria considering a two-level fuzzy AHP problem for performance measurement. Ten experts carried out decision making as mentioned in the paper. Kamvysi et al.[171] have worked with four main criteria considering a single level fuzzy AHP problem in the field of education. The number of experts is not mentioned in the research paper. Kang and Lee [172] have applied fuzzy AHP in the domain of priority mix planning for semiconductor fabrication decisions. The authors have analysed the problem as two-level with three criteria and sixteen sub-criteria. Two Scholars' along with four senior managers have taken part in the investigation as decision-makers. Keprate and Ratnayake [173] have worked with three main criteria and five sub-criteria considering a two-level fuzzy AHP problem for application in fatigue critical piping locations. The number of decision-makers is not specified in the research paper. Khan et al.[174] have applied fuzzy AHP in the domain of software development. The authors have analysed the problem as two-level with five criteria and twenty-one sub-criteria. Twenty-seven experts have taken part in the investigation as decision-makers. Kim et al. [175] have applied fuzzy AHP for raw material criticality assessment. The authors have analysed the problem as three-level with two criteria, three sub-criteria, and eleven sub-sub criteria. The number of experts is not mentioned in this paper. Kreng and Wu [176] have applied fuzzy AHP in the domain of knowledge portal development. The authors have analysed the problem as two-level with four criteria and sixteen sub-criteria. Five experts have taken part in the investigation as decision-makers. Kuo et al. [177] have applied fuzzy AHP for convenient store location. The authors have analysed the problem as two-level with six criteria and forty-three sub-criteria. Sixteen experts have taken part in the investigation as decision-makers. Lee [178] has worked with six main criteria considering a single level fuzzy AHP problem in the field of performance evaluation. The number of experts is not mentioned in the research paper. Lee et al. [179] have worked with four main criteria considering a single level fuzzy AHP problem in the field of hydrogen energy technology development. Five out of eight experts responded for decision making as mentioned in the research paper. Li [180] has applied fuzzy AHP for energy performance contracting. The author has analysed the problem as two-level with three criteria and ten sub-criteria. Questionnaires were designed for analysis. However, the number of experts is not mentioned in the research paper. Ligus and Peternek [181] have applied fuzzy AHP in the area of sustainable development. The authors have analysed the problem as two-level with three criteria and sixteen sub-criteria. Fifteen experts have taken part in the investigation as decision-makers. TOPSIS is combined with fuzzy AHP for analysis. Lima Junior et al. [182] have worked with five main criteria

considering a single level fuzzy AHP for supplier selection. Three experts responded for decision making as mentioned in the research paper. Fuzzy AHP is compared with fuzzy TOPSIS in this analysis. Lin [183] has applied fuzzy AHP for course website quality evaluation. The author has analysed the problem as two-level with four criteria and sixteen sub-criteria. Twenty experts responded for decision making as mentioned in the research paper whereas three experts carried out the pilot study. Lo and Wen [184] have applied fuzzy AHP for massively multiplayer online role-playing games. The authors have analysed the problem as three-level with two criteria, nine sub-criteria, and thirty-six sub-sub criteria. The number of experts is not mentioned in this paper. Ly et al. [185] has applied fuzzy AHP in the area of internet of things. The authors have analysed the problem as two-level with five criteria and fifteen sub-criteria. Twenty- four out of twenty-six experts responded for decision making as mentioned in the research paper. Mandic et al. [186] have worked with eight main criteria considering a single level fuzzy AHP for financial performance domain. Experts have carried out the decision making as mentioned in the research paper; however, the exact number is not mentioned. The analysis is carried out using fuzzy AHP and TOPSIS in the paper. Mangla et al. [187] have applied Fuzzy AHP for analyzing risks in green supply chain. The authors have analysed the problem as two-level problem with six main criteria and twenty-five sub-criteria. A team of sixteen decision makers have participated in the analysis. Moktadir et al. [188] has applied fuzzy AHP for CSR drivers in footwear industry. The authors have analysed the problem as two-level with four criteria and twenty sub-criteria. Sixteen experts have participated in decision-making as mentioned in the research paper. Nepal et al. [189] have applied fuzzy AHP in the area of customer satisfaction attributes in automotive product development. The authors have analysed the problem as three-level with three criteria, eight sub-criteria, and sixteen sub-sub criteria. The number of experts is not mentioned in this paper. Onut and Soner [190] have worked with five main criteria considering a single level fuzzy AHP problem in the field of transshipment site selection. The number of experts is not mentioned in this paper. TOPSIS is combined with fuzzy AHP for analysis. Ozyol and Albayrak [191] have applied fuzzy AHP for knowledge based management styles. The authors have analysed the problem as two-level with three criteria and seven sub-criteria. Five experts have participated in decision-making as mentioned in the research paper. Pan [192] has applied fuzzy AHP for bridge construction. The author has analysed the problem as two-level with five criteria and eleven sub-criteria. Eight experts i.e. four from engineering bureau and four project contractors /senior bridge engineers have participated in decision-making as mentioned in the research paper. Patil and Ravi Kant [193] have applied fuzzy AHP for knowledge management application. The authors have analysed

the problem as two-level with five criteria and twenty-eight sub-criteria. Five Experts have done the analysis. Pourebrahim et al. [194] have applied fuzzy AHP for conservation priority assessment in coastal areas. The authors have analysed the problem as single level with seventeen criteria. Thirty experts have participated in decision-making as mentioned in the research paper. Extent analysis method is used in this paper. VIKOR is combined with fuzzy AHP for analysis. Rajak and Shaw [195] have applied fuzzy AHP in mobile health applications. The authors have analysed the problem as two-level with nine criteria and thirty-two sub-criteria. Three experts from academia and healthcare have participated in decision-making as mentioned in the research paper. TOPSIS is combined with fuzzy AHP for analysis. Rezaei et al. [196] have applied fuzzy AHP for supplier selection in airline industry. The authors have analysed the problem as two-level with twelve criteria and thirty-six sub-criteria. There is no mention about experts in the research paper. Conjunctive screening is used for analysis. Rostamzadeh and Sofian [197] have applied fuzzy AHP in effective 7Ms for production system performance. The authors have analysed the problem as two-level with seven criteria and thirty two sub-criteria. Three experts have participated in decision-making as mentioned in the research paper. TOPSIS is combined with fuzzy AHP for analysis. Sharma et al. [198] have applied fuzzy AHP for sustainable food supply chain management. The authors have analysed the problem as single level with nine criteria. There is no mention about experts in the research paper. Extent analysis method is used in this paper. Shaverdi et al. [199] have used fuzzy AHP in the application of sustainable supply chain management in publishing industry. The authors have analysed the problem as two-level with five criteria and twenty-three sub-criteria. Fifteen experts have participated in decision-making as mentioned in the research paper. Extent analysis method is used in this paper. Shaverdi et al. [200] have applied fuzzy AHP in the application financial performance evaluation. The authors have analysed the problem as two-level with five criteria and seventeen sub-criteria. There is no mention about experts in the research paper. Shaw et al. [201] have made use of fuzzy AHP for supplier selection for low carbon supply chain. The authors have analysed the problem as single level with four criteria. There is no mention about experts in the research paper. Fuzzy multi objective linear programming is used with fuzzy AHP in this paper. Sirisawat and Kiatcharoenpol[202] have applied fuzzy AHP in the area of reverse logistics. The authors have analysed the problem as two-level with eight criteria and twenty-nine sub-criteria. Ten experts have participated in decision-making as mentioned in the research paper. TOPSIS is combined with fuzzy AHP for analysis. Song et al.[203] have applied fuzzy AHP in the area of coal pile safety. The authors have analysed the problem as two-level with three criteria and eleven sub-criteria. Experts' details and numbers are not mentioned in the research paper.

Suganthi[204] have applied fuzzy AHP for sectoral investments application. The authors have analysed the problem as two-level with seven criteria and twenty-five sub-criteria. Ten experts i.e. two from the government, three from service industry, three from manufacturing industry and two consultants have participated in decision-making as mentioned in the research paper. Fuzzy AHP, VIKOR and DEA are used for analysis. Sun [205] has applied fuzzy AHP in performance evaluation. The author has analysed the problem as single level with six criteria. Ten experts have participated in decision-making as mentioned in the research paper. TOPSIS is combined with fuzzy AHP for analysis. Tan et al. [206] have applied fuzzy AHP in three case studies for process safety in wastewater treatment. The authors have analysed the problem as single level problem with four criteria in first case study, three criteria in second case study and four criteria in the third case study. Domain experts have participated in the decision-making. The exact number of experts is not mentioned in the research paper. Taylan et al. [207] has applied fuzzy AHP in construction project management. The authors have analysed the problem as single level with five criteria. Construction experts have participated in decision-making as mentioned in the research paper. There is no mention about number of experts in the research paper. TOPSIS is combined with fuzzy AHP for analysis. Thengane et al. [208] has applied fuzzy AHP in cost benefit analysis. The authors have analysed the problem as single level with five criteria. There is no mention about experts in the research paper. AHP is combined with fuzzy AHP for analysis. Tseng et al. [209]has applied fuzzy AHP in cleaner production implementation. The authors have analysed the problem as single level with four criteria. Anonymous industrial experts by national science council have done the analysis. There is no mention about number of experts in the research paper. Van Laarhoven and Pedrycz [210] proposed the fuzzy AHP method as an extension to Satty's fuzzy theory, in which the linguistic terms are represented by the triangular fuzzy numbers for the pair-wise comparison. Vinodh et al. [211] have applied fuzzy AHP in plastic recycling. The authors have analysed the problem as single level with twenty criteria. Industrial experts have done the analysis. There is no mention about number of experts in the research paper. Wang et al.[212] have applied fuzzy AHP for selection of best catering form. The authors have analysed the problem as two-level with three criteria and eleven sub-criteria. Five experts and customers of catering firms have participated in decision-making as mentioned in the research paper. Extent analysis method is used in this paper. Yan et al. [213] have applied fuzzy AHP for safety early warning in coal mining. The authors have analysed the problem as two-level with five criteria and thirty-three sub-criteria. Experts have done the analysis. There is no mention about number of experts in the research paper. Yucesan and kahraman [214] have applied fuzzy AHP for risk evaluation in hydroelectric

power plants. The authors have analysed the problem as single level with twenty criteria. Five experts from operations and maintenance area have done the analysis. Pythagorean fuzzy AHP approach is used in the paper. Zhang et al. [215] have applied fuzzy AHP for mineral prospectivity mapping. The authors have analysed the problem as single level with three criteria. Thirteen alternatives are compared. Three Experts have done the analysis. Zhu and Lei [216] have applied fuzzy AHP for independent innovation capability evaluation. The authors have analysed the problem as two-level with four criteria and eleven sub-criteria. Five Experts have done the analysis.

2.7 Indian Manufacturing Scenario and 'Make in India'

Singha and Gayatri [217] have identified two breakthroughs in the Indian industrial policies, the first being in 1965-66 which emphasized heavy industries and the second in 1984-85 for major changes concerning liberalization. Athreye and Kapur [218] state that there was no proper product-wise categorization in various parts of the country after the 1984-85 deregulations despite the expected growth of industries concerning the products. Kanda [219] has proposed that the Indian manufacturing sectors have to overcome major hurdles like poor policy decisions, lack of protection from foreign competition, absence of competitive domestic industries, and several other regional factors for growth and productivity improvements. Mehta and Rajan [220] have found out that in recent years, new land and labour laws along with infrastructure improvement have given a boost to the Indian manufacturing sector. Sharma and Kodali [221] have proposed different frameworks that include elements like leadership, manufacturing strategy, supply chain management, world class maintenance systems etc. to support the positive changes taking place in manufacturing sector. Further, initiatives in the areas of knowledge management, flexible processes and innovative product planning are also proposed to account for the changing manufacturing scenario. Luthra et al. [222] have proposed that the manufacturing sector has the potential to enhance its share in the economic development of the country. Dhyani and Saxena [223] state that Indian industry authorities have emphasized the need of implementing technology and digitalization to the manufacturing domain rather than depend entirely on cheap labour to make the initiative successful.

Lees and Khatri [224] have found out that India has cross-cultural issues which need to be sorted.

2.8 Research Perspectives of Academicians and Industry Professionals

Wowk et al. [225] feel that academicians should work hand in hand with government and industry professionals for innovative solutions. The Collective research will lead to resilient societal outcomes that will benefit mankind as per the authors. Carbone and Armstrong [226] have identified that many researchers have proved using forecasting methods case study that there is a similarity in the responses given by academicians and industry professionals. They further state that although the general outcome of this survey is that the same criteria are used by both groups, a certain lack of agreement still exists within each group. Wright et al. [227] have conducted an apparel industry case study that represents the disparity of thought in the decision making of academicians and industry professionals. Bartunek and Rynes [228] have discussed the gap in decision making between members of Industry and academia that has been addressed on several occasions. The authors state that while some think it is expanding, others consider it important for insightful research and speculations.

2.9 Fuzzy TOPSIS

Chu [18] has presented a case study with a purpose of plant location amongst three alternatives using four criteria. Fuzzy TOPSIS is used for analysis. A team of three experts is made for decision making. The previous work in this area is carried out with crisp numbers for linguistic variables whereas in the present work, linguistic variables are addressed using fuzzy numbers. Deng Yong [229] have used a new fuzzy TOPSIS approach for identifying best location amongst three alternatives using four criteria. The uniqueness of this paper is that the difficulty in ranking of fuzzy numbers is overcome by multiplication of ratings and weights by canonical representation of multiplication operation of TFNs.

2.10 Renewable Energy

Raghuvanshi and Arya [230] have carried out an extensive literature review for finding the potential of Renewable Energy Systems (RESs) and region wise installed capacity of India. The potentials of renewable energy systems in the country are covered in detail in this paper. The authors have proposed future research on reliability assessment and improvement & associated costs. Kumar and Majid [231] have carried out literature review to identify the challenges and opportunities due to renewable energy systems in India. Through the literature, obstacles faced in RES in the country are identified. Technology, regulation and market

identification are major obstacles and can be incorporated as criteria in selection of solar energy systems. Akkas et al. [232] have worked on PVPS site selection problem using three criteria and five alternatives. The authors have used AHP, ELECTRE, TOPSIS and VIKOR methods for analysis. The methods used are with crisp numbers and no fuzzy numbers are taken. Raina and Sinha [233] have carried out extensive literature review on Policies for solar energy and barriers in India. The Through literature suggestions and discussions, authors feel that India can be a leader in energy market with the conditions and potentials in the country. Gupta and Anand [234] have identified various schemes, incentives, packages and promotion for photo voltaic through literature review. India's potential in solar Energy is discussed.

2.11 Summary

In this chapter, literature concerning all relevant areas of research problem has been reviewed. Research and review papers in the area of facility location are reviewed in the beginning to identify the literature gap. Majority research papers indicate that there is no weightage given to supply chain performance measure in location decisions. Few papers addressing facility location decision along with supply chain performance measures are identified and reviewed. The factors that directly or indirectly affect supply chain performance are identified and are incorporated along with the existing factors in this research. A small brief review on developed v/s developing countries is carried out. A PESTLE tool has been used to identify such factors and papers are reviewed in the area of PESTLE approach and applications. Further, research work concerned with fifty-seven factors has been reviewed in detail. A summary of the factors identified and classified using PESTLE tool is presented in Table 2.1. A major review to identify the number of criteria, experts and multilevel applications of Fuzzy AHP has been carried out to support the research. A brief literature review on academicians' and industry professionals' decision making is carried out for identifying the decision-making gap. Some literature has been reviewed on the Indian manufacturing scenario as ranking of sectors identified in Make in India initiative is done in this research work. At the end, a brief review on Fuzzy TOPSIS and renewable energy is done. The next chapter deals with problem and methodology.

Table 2.1: PESTLE classification of factors based on literature survey

PESTLE	FACTORS
Political	Bureaucratic Hurdles [43, 44]
	Government Intervention [45]
	Political System [46, 47]
	Political Stability [48, 49]
	Internal Threats [50, 51]
	Maturity of Political Leadership [52, 53]
	Neighbourhood Stability [54, 55]
Economic	Average salaries paid in location of choice [56]
	Construction cost in location of choice [11]
	Economic standing of the country of location choice [57, 58]
	Impact of present industry status [59]
	Financial incentives [60 - 62]
	Industry competitive scenario [63]
	Inflation trend [11, 62]
	Land price [64, 65]
	Market characteristics (customer proximity/purchasing power) [66, 67]
	Role of parallel economy [68 - 70]
	Sales & marketing costs [71, 72]
	Scope for expansion opportunities for industries [73, 74]
	Supplier characteristics (quality/reliability) [75, 76]
	Transportation costs [77 - 79]
	Tax structure [80 - 83]
	Trend of currency strength against U. S. dollar of the country of location choice [11, 84]
	Gross Domestic Product (GDP) [85 - 87]
	Per capita income in location of choice [62, 88]
Social	Affect on health of people due to industries [89, 90]
	Blind belief in leadership [91, 92]
	Consumer spending characteristics (demography/culture) [93, 94]
	Education system and avenues [95, 96]
	Employability [97, 98]
	Employee integrity & ethics [99, 100]
	Health hazards due to industrialization [101, 104]
	Internal turbulence [105]
	Knowledge base [106, 107]
	Labour characteristics (education/training facilities) [62, 108]
	Linguistic barriers [109]
	Medical facilities [110]

	Motivation & enthusiasm of employees [111 - 113]
	Religious beliefs [114]
	Social ethos (pride in work of any type in the location of choice) [115]
	Standard of living of people in location choice [11]
	Union flexibility [116, 117]
	Use of vastu shastra [118, 119]
Technological	Alternate energy sources and backup [120]
	Infrastructure availability [62, 121, 122]
	IT costs [123 - 125]
	Availability of skilled labour [11, 62, 126, 127]
	Power supply [62]
	Technology costs [128, 129]
	Availability of transportation facility (road/rail/ports/air) [11]
	Availability of utility services (assistance to main services) [62, 130, 131]
Legal	Government laws and regulations for industries [126, 132]
	Government policies for industry [61, 133, 134]
Environmental	Climatic conditions [29]
	Disaster risks [135, 136]
	Impact of industrialization on environment [137 - 139]
	Water availability [140, 141]

Chapter 3

Problem Description and Solution Methodologies

3.1 Introduction

Business houses have to design the supply chains very carefully amidst fierce competition and high level of customer expectations. Every element in the supply chain is influenced by strategic decisions as the elements need to function together as an integral part of supply chain. One of the important strategic decision is facility location decision. Over the years, many models have been proposed for optimal facility location decisions in different contexts [24, 25, 30]. Attempts have been made to integrate location decisions with the supply chain network design decisions [2, 26]. Facility location highly contributes to the Supply chain performance of an organization [4, 7]. As facility location is a strategic decision, there is a need of identifying the factors affecting facility location in terms of their direct or indirect effect on supply chain performance. Addressing various issues of facility location decision making with optimal supply chain performance measures especially in developing countries is the need of the hour.

3.2 Motivation of the Research Work

Sustainable growth is crucial in developing countries [33]. The decision making thus should include environmental, social and economic factors in context of sustainability [29]. The research is aimed at taking such factors into account to support the facility location decisions. Though the facility location decision is a part of supply chain design phase, there are some factors affecting the location decision that can be of dynamic nature [26] and these factors can cause issues in the operational stage. In developing countries, it is seen that lot of dormant qualitative factors prevail and can surface when optimal location of the plant is already decided. Such factors can eventually turn out to be vital adversely affecting the decision-making process. Maturity of political leadership, blind belief in leadership, bureaucratic hurdles, internal turbulence, internal threats, roll of parallel economy, that are vague in nature, predominantly seen in developing countries, have not been considered in the facility location decision making. This has been evident from the past cases like Tata singur plant shifting to

Gujarat [10] and Nylon 66 plant moving out of Goa in India and this forms the motivational basis for the research. The research aims at identifying such dormant qualitative factors, combining them with other qualitative and quantitative factors, ranking them, identifying and ranking different business sectors and using fuzzy multi-criteria decision making method for identifying best location with a case study.

3.3 Problem Statement

The research problem is to identify various factors that affect facility location decisions based on their direct or indirect impact on supply chain performance in developing countries and issues and challenges associated with it. The research problem has been designed with following objectives in mind:

1. Identifying and analyzing various dormant qualitative factors that can surface at the time of finalization of facility location.
2. Identifying and ranking different sectors of business considering potential.
3. Identifying optimal location for a particular business sector.

The research is designed in the direction of achieving the above objectives.

3.4 General Assumptions

3.4.1 Considering supply chain performance measures as factors affecting facility location decisions

Facility location decision is considered to be a strategic decision as per research. Hence most of the factors need to be identified in line with strategic decisions. However, in this research, the factors considered have been identified to be related to supply chain performance measures directly or indirectly. As the supply chain performance measures take care of strategic as well as operational decisions, the factors considered for decision making include both strategic as well as operational performance measures. This is for considering the dynamic aspects of factors. Though bureaucracy is considered as a strategic decision, majority of the times it is the bureaucratic hurdles that are addressed in research. Many a times, while in operational phase, the organisations land in such complexities that directly influence the supply chain performance. This is the strong motive behind considering such complexities in location decisions.

3.4.2 Quantitative factors as linguistic variables

In this research, the quantitative factors have been considered as linguistic variables in problem solving in general. This is supported with the fact that when alternatives are not identified for location decisions and only factors have to be ranked, then we do not get the actual field values of some of the variables especially the costs (land cost, transportation cost, IT costs). While solving real life problems with known alternatives and existing costs, the problem can be redefined and actual costs can be taken for comparative analysis.

3.4.3 Research directed in context of India

Though the title of the research suggests identification of factors in developing countries, the case studies have been carried out in India. This is due to the fact that in initial phase, though data for analysis was tried to be sourced from other developing countries, the efforts were in vain. Hence India has been assumed to represent developing countries in general. However, for identification of factors, some case studies in developing countries like Zimbabwe, Kenya, Pakistan etc. have been referred [112, 136, 235]. A small brief on developing versus developed countries is presented further.

3.4.3.1 Developing V/S developed countries

Consistent and sound policies are needed for speedy and sustainable industrial growth. Due to globalisation, international markets often witness production fragmentation, on the economic front. Innovation is the key to industrial development. On a social front, automation in technology has decreased labour requirement while generating new markets and opportunities. These markets absorb those workers who have lost their jobs to machines. From an environmental perspective, the industrialists use resources efficiently. Modern entrepreneurs thrive for enhanced productivity through innovations leading to medium to high-tech industry transition and facilitating lower pollution levels [32]. The annual growth rate by development group, region and income is shown in Table 3.1 and Table 3.2 shows various countries and economies by industrial level. India is placed as an emerging economy as per Table 3.2.

Table 3.1: Annual growth rate by development group, region and income [32]

	1990-2000	2000-2007	2007-2013
By industrialization level			
World	9.2	11.2	3.7

Industrialized countries	7.8	9.5	1.6
Developing and emerging industrial economies	21.4	17.7	8.7
By development group			
Emerging industrial Countries	20.8	18.4	8.9
Least developed countries	19.1	14.1	- 0.9
Other developing countries	28.1	11.9	7.0
By region (world)			
Africa	23.8	19.7	6.0
Asia and Pacific	22.7	18.6	8.7
Europe	17.8	13.1	10.0
Latin America	13.8	13.7	- 2.2
By income			
High income	24.5	13.0	6.5
Upper middle income	10.6	12.7	6.3
Lower middle income	8.2	12.3	1.8
Low income	19.1	9.3	5.6

Table 3.2: Various countries and economies by industrial level [32]

Industrialized countries and economies	
Andorra, Taiwan Province of China, Iceland, Monaco, Slovenia, Aruba, Czech Rep., Ireland, Netherlands, Spain, Australia, Denmark, Israel, New Caledonia, Sweden, Austria, Estonia, Italy, New Zealand, Switzerland, Bahrain, Finland, Japan, Norway, United Arab Emirates, Belgium, France, Korea, Rep. of Portugal, United Kingdom, Bermuda, French Guiana, Kuwait, Puerto Rico, United States, British Virgin Islands, French Polynesia, Liechtenstein, Qatar, Virgin Islands (United States), Canada, Germany, Lithuania, Russian Federation, Cayman Islands, Greenland, Luxembourg, San Marino, Hong Kong SAR China, Guam, Malaysia, Singapore, Macao SAR China, Hungary, Malta, Slovakia	
Industrializing countries and economies (or developing and emerging industrial economies)	
Emerging industrial	Argentina, Colombia, Kazakhstan, Saudi Arabia, Turkey, Belarus, Costa Rica, Latvia, Serbia, Ukraine, Brazil, Croatia,

countries and economies	Mauritius, South Africa, Uruguay, Brunei, Darussalam, Cyprus, Mexico, Suriname, Bolivarian Rep. of Venezuela, Bulgaria, Greece, Oman, Thailand, Chile, India, Poland, Former Yugoslav Rep. of Macedonia, China, Indonesia, Romania, Tunisia
Other developing countries and economies	Albania, Cook Islands, Guyana, Mongolia, Saint Lucia, Algeria, Cuba, Honduras, Montenegro, Saint Vincent and the Grenadines, Angola, Côte d'Ivoire, Islamic Rep. of Iran, Montserrat, Seychelles, Anguilla, Dominica, Iraq, Morocco, Sri Lanka, Antigua and Barbuda, Dominican Rep., Jamaica, Namibia, State of Palestine, Armenia, Ecuador, Jordan, Nicaragua, Swaziland, Azerbaijan, Egypt, Kenya, Nigeria, Syrian Arab Rep., Bahamas, El Salvador, Dem. People's Rep. of Korea, Pakistan, Tajikistan, Barbados, Equatorial Guinea, Kyrgyzstan, Palau, Tonga, Belize, Fiji, Lebanon, Panama, Trinidad and Tobago, Plurinational State of Bolivia, Gabon, Libya, Papua New Guinea, Turkmenistan, Bosnia and Herzegovina, Georgia, Maldives, Paraguay, Uzbekistan, Botswana, Ghana, Marshall Islands, Peru, Viet Nam, Cameroon, Grenada, Martinique, Philippines, Zimbabwe, Cape Verde, Guadeloupe, Federated States of Micronesia, Réunion, Rep. of the Congo, Guatemala, Moldova, Rep. of Saint Kitts and Nevis
Least developed countries and economies	Afghanistan, Congo, Dem. Rep. of the Lesotho, Rwanda, Timor-Leste, Bangladesh, Djibouti, Liberia, Samoa, Togo, Benin, Eritrea, Madagascar, Sao Tome and Principe, Tuvalu, Bhutan, Ethiopia, Malawi, Senegal, Uganda, Burkina Faso, Gambia, Mali, Sierra Leone, Vanuatu, Burundi, Guinea, Mauritania, Solomon Islands, Yemen, Cambodia, Guinea-Bissau, Mozambique, Somalia, Zambia, Central African Rep., Haiti, Myanmar, South Sudan, Chad, Kiribati, Nepal, Sudan, Comoros, Lao People's Dem. Rep., Niger, United Rep. of Tanzania,

Developing nations compete to sustain their positions in the short term. Developed countries have kept their positions in the long term by maintaining their resources and energy efficient high-tech industries. Such sustainable competitiveness consists of focusing on foundation and infrastructural investments for long term benefits while forgoing the short-term ones. This suggests that developing countries should focus on technology enhancement and building a robust knowledge base for sustainable industrial development.

3.5 Scope of the Problem

Facility location decision making has a wide scope for research as seen in literature. However, the existing research has been mostly happening in developed countries wherein most of the government procedures are well set, the economy is strong and the countries enjoy strong knowledge base and technology leading to continuous industrial development. On the other hand, the developing countries still thrive for development on all fronts including the industrial sectors and get into the loop of varying policies with changing government, social and economic issues and unorganised industrial sectors. The supply chains in such countries lack strength and majority of the players in markets tend to move in the directions of high profit-making business backed up by illegalities with a tendency to avoid taxes. This leads to rise of parallel economy which is a major factor hampering the overall economic growth of the country and further giving rise to unethical ways of working, corruption etc. Majority of the world players do not invest in such countries due to lack of infrastructure; poor government support and the skill sets of the local employee base. An optimal location taking care of all such irregularities supported by strong government backing will always be a blessing to such world players for investments, especially in developing countries. Hence identification of the factors which are directly or indirectly linked to supply chain performance measures that affect facility location in developing countries has a wide scope. The ranking of such factors will always be an added advantage. The framework for identified factors in strategic and operational context will be an added advantage for investors. Further, ranking potential sectors of business identified through Make in India campaign is also a need of the day as investors will be in a position to identify scope for investments in the sectors that provide maximum opportunities. So far, in literature, a large number of factors are never compared on same levels when ranking is done by paired comparison. The paired comparison is done using multi-level methods used for ranking of factors. Creating a novel decision-making technique to take care of high number of identified factors for ranking on a common level with advantages over existing methods is the major scope of the research. The scope of

the research expands further, with choice of the best alternative amongst given alternatives based on various criteria done by the newly designed method.

3.6 Solution Methodologies

The research problem has three major objectives. It aims at identifying factors that affect facility location decisions, rank the identified factors, identifying various business sectors and selecting best location for business in broader sense. In order to satisfy the first objective that is identification of factors, PESTLE tool is used. Further the factors are ranked using an innovative mapping approach for existing method of fuzzy AHP and a proposed method that has many advantages over existing fuzzy AHP method. Risk based ranking is done to address the dynamic nature of dormant factors. The proposed method is used to satisfy the second and third objective along with existing method for comparison. This section presents the existing methodologies that are used. The existing ranking approaches and multi criteria decision making problems have some disadvantages when the number of factors to be ranked go beyond a particular number. Such cases are solved in literature as multi-level cases. The research is aimed at proposing a new method that will take of factor ranking on a single level so that disadvantages of multi-level ranking can be taken care off. The various solution methodologies proposed in this research are as follows.

3.6.1 PESTLE

PESTLE is a tactical business plan tool used to for analyzing and evaluating the effect of political, economic, social, technological, legal and environmental factors on the project in consideration [36]. PESTLE is a mnemonic for Political, Economic, Sociological, Technological, Legal, and Environmental. PESTLE has been regularly used in the last two decades though it's difficult to confirm history. PESTLE has been used regularly for making decisions and planning for future events. It captures all risks, issues, opportunities and threats. It shows the direction of change and gives an objective view of the environment to make conscious and sound project decisions accordingly. PESTLE analysis has been used in past research in various domains like renewable energy analysis [35, 38], risk management [36], health services [37], water management [39], coastal zone management [40], management of trails [41] , tourism [42] etc. Table 3.3 presents variations of PESTLE.

Table 3.3: Variations of PESTLE

Mnemonic	What it stands for
PESTLE (Also known as PESTEL analysis)	Political, Economic, Sociological, Technological, Legal, Environmental
PEST analysis (Also known as STEP analysis)	Political, Economic, Sociological, Technological
PESTLIED analysis	Political, Economic, Social, Technological, Legal, International, Environmental, Demographic
PESTEL analysis	Political, Economic, Sociological, Technological, Environmental, Labour related
STEEPLE analysis	Social/Demographic, Technological, Economic, Environmental, Political, Legal, Ethical
STEPE analysis	Social, Technical, Economic, Political, and Ecological
SLEPT analysis	Social, Legal, Economic, Political, Technological
ETPS analysis	Economic, Technical, Political and Social

These factors can neither be affected by the organisation alone nor can they affect the profitability of the organisation openly. However, studying them helps to make sound project decisions to maximize opportunities and minimize threats. In this research, use of PESTLE is proposed to identify and classify the factors affecting facility location. In one of the studies carried out by Yuksel (2012) on various issues in PESTEL analysis, the author has suggests use of fuzzy numbers for further studies as most of the factors and sub-factors are not quantifiable [34]. Hence in this research, Fuzzy numbers have been used for analysis.

3.6.2 Multi Criteria Decision Making (MCDM)

Industry decision makers often face the issue of selecting the best from a set of alternatives based on conflicting criteria. MCDM methods help in making a rational choice between such alternatives and are gaining importance these days. Farahani et al (2009) have presented a review on MCDM methods in facility location considering bi-objective, multi-objective and multi-attribute problems and their solution methods [236]. Methods like fuzzy AHP and fuzzy TOPSIS are considered for locating facilities with various factors affecting the choice of location as criteria. For problems analysed in this research, a novel ranking method is proposed. The factors are ranked using the proposed method and the results are validated against an existing fuzzy AHP method modified to incorporate the large data matrix issue on a

single level. The proposed method is further used for selecting the ideal solar power plant location amongst given alternatives directly and in combination with fuzzy TOPSIS and is validated against existing fuzzy AHP and fuzzy AHP – fuzzy TOPSIS combination respectively. A short note on fuzzy AHP is as follows:

The vague nature of linguistic assessment cannot be dealt by the conventional AHP method effectively. To address this limitation, Van Laarhoven and Pedrycz (1983) proposed the fuzzy AHP method in which linguistic terms are represented by the triangular fuzzy numbers for the pair-wise comparison [210]. The fuzzy AHP algorithm for calculating weights using geometric mean is as follows [237]:

Step 1: Create fuzzified pair-wise comparison matrix

Step 2: Calculate fuzzy geometric value r_i for each row

$$A_1 \times A_2 = (l_1, m_1, u_1) \times (l_2, m_2, u_2) = (l_1 \times l_2, m_1 \times m_2, u_1 \times u_2) \quad (3.1)$$

$$r_i = (l_1 \times l_2 \times l_3 \dots l_n)^{\frac{1}{n}} \times (m_1 \times m_2 \times m_3 \dots m_n)^{\frac{1}{n}} \times (n_1 \times n_2 \times n_3 \dots n_n)^{\frac{1}{n}} \quad (3.2)$$

Step 3: Calculate Fuzzy Weights w_i

In the method proposed by Buckley (1985), geometric mean is used to calculate fuzzy weights

$$w_i = r_i \times (r_1 + r_2 + r_3 + \cdots r_n)^{-1} \quad (3.3)$$

Where

$$A^{-1} = (l, m, u)^{-1} = \left(\frac{1}{u}, \frac{1}{m}, \frac{1}{l}\right) \quad (3.4)$$

Step 4: Defuzzify w_i using centroid method to get defuzzified weights

$$w_i = \frac{(l+m+u)}{3} \quad (3.5)$$

Step 5: Normalize to make $\sum w_i = 1$

$$w_i = \frac{w_i}{\Sigma w_i} \quad (3.6)$$

3.6.3 Risk based MCDM

In real world situations happening in dynamic environment, many a times some of the factors affecting the situation behave dynamically. The dormant qualitative factors that can suddenly crop up have such a dynamic nature. To address the dynamic and dormant nature of the factors, risk based ranking analysis using the concept of Risk Priority Number (RPN) in Failure Modes and Effects Analysis (FMEA) has been proposed.

3.6.4 Mapping approach

In most of the applications in literature, wherein ranking of factors is required to be done, fuzzy AHP has been dominantly used. In fuzzy AHP, the factors or criteria need to be

compared in pairs by experts. As the number of factors increase beyond the processing capacity of human brain, this becomes a tedious job. Hence, for higher number of factors, multi-level factor method has been used to take care of the size of the factor matrix. This method has a distinct disadvantage as the weights for global factors and local factors are multiplied and the dominance of local factor may reduce if the global factor is weighted less on global comparison. Secondly finding the experts for paired comparisons and the experts devoting time for such causes is a difficult preposition. Hence this research aims at providing an alternate solution that takes care of all such disadvantages while solving large matrix problems and proposes a mapping approach in fuzzy AHP that allows the factors to be compared on one level, whatever the number of factors may be. The mapping approach takes care of paired comparisons within the method and experts only need to give their inputs in simple format, thus saving time.

3.6.5 Proposed method

The Fuzzy AHP approach has some distinct disadvantages. Firstly, the number of paired comparisons to be done is by each expert if the experts are approached as individuals and not as a team which is the case in most of the decision-making process. This gives rise to space complexity as more data is generated. Secondly the huge time investment for paired comparisons leads to time complexity. The proposed mapping approach takes care of the time complexity but the number of paired comparisons remains same as per the number of experts and as mapping approach provides a freehand on choosing a greater number of experts, the paired comparisons in the method will increase thus creating space complexity. To overcome this, a novel method has been proposed in this research for ranking of criteria. The proposed method is further extended for risk-based ranking to address the dynamic behaviour of unforeseen factors that can create harm if not properly accounted for. The proposed method is also used for ranking of sectors identified in 'Make in India' and further in a case study for identifying the best location for a solar power plant in Goa, India as an MCDM approach.

3.7 Summary

The research is aimed at identifying and ranking factors affecting facility location decision making in developing countries. During the course of work, the research has culminated into four innovative methods, the mapping method for fuzzy AHP, the proposed method for ranking of factors, extension of proposed method for risk-based ranking and as MCDM approach for selection of best alternative amongst given alternative. The innovative methods

along with case studies are discussed in further chapters. The potential based ranking is done for sectors identified through 'Make in India' initiative with a decision making gap analysis of academicians and industry professional's. Further a case study on locating an optimal location for a renewable energy project in Goa, India amongst given alternatives has been carried out to authenticate the proposed method. The next chapter deals with creating a framework for identifying the factors that affect facility location decisions in developing countries with special emphasis on India.

Chapter 4

Framework for Identifying Factors Affecting Facility Location

4.1 General

The first step towards moving ahead in this research work is identification of factors that affect the choice of facility location in developing countries. These factors are directly or indirectly linked to the supply chain performance in particular. Though Facility location is a strategic decision, there are many factors that surface during the initial stages after finalization of the location. Such factors can create a total disruption of the business forcing organizations to change their locations. These factors have to be identified and taken into consideration during location decision, especially in developing countries. A brainstorming session involving a group of members from industry and academia was conducted to identify such dormant qualitative factors that can create issues after finalizing the location as seen in some of the cases in recent past. Political system existing in the country has a major role to play in industrialization. This has been considered as one of the factors that can affect location decisions. Whenever a political system arises, leaders rise. The decision making towards industrial growth depends on the maturity of leadership hence 'maturity of political leadership' has been considered as one of the factors. In developing countries, especially in most of the backward areas, people blindly follow their leaders. Hence 'blind belief in leadership' also happens to be one of the major factors that can affect location decisions. Bureaucracy is one more major issue that was considered during brainstorming as many a times the investor goes through bureaucratic hurdles in business and hence 'bureaucratic hurdles' is considered as a factor. For any industry to progress, the area in which it is supposed to be located should have stable neighbourhood, and hence 'neighbourhood stability' has been considered as one of the factor affecting facility location decisions. In recent past, some of the countries have been facing a lot of internal turbulence and threats, and hence these factors have also been considered. Parallel economy plays a major role in many countries. In some countries entire business may run on parallel economy and it badly affects the economic growth of the country. 'Role of parallel economy' is also enlisted as a probable factor to be looked upon during facility location. In countries like India, Vastu Shastra is gaining importance in recent times and has been considered as one of the factors in

this research. Supply chains can be disrupted during disasters having a tremendous financial and operational impact on firms. Disaster prone sites will never be the first choice for facility location as the entire business can be doomed. Hence disaster risks also have to be considered while locating a facility. All such factors can create issues even after finalizing the location as seen in some of the cases in recent past. The various factors affecting facility location are classified in terms of Strategic and Operational factors using PESTLE tool.

4.2 PESTLE Analysis

PESTLE is an acronym for Political, Economic, Sociological, Technological, Legal, and Environmental. The term PESTLE has been used regularly in the last two decades. Organizations need to understand the complete environment in which they function in detail for maximizing the opportunities and minimizing the threats while taking facility location decisions. A strategic analysis of these economic environments needs to be carried out for realizing the long-term directions. This analysis can be best done with the PESTLE tool. In this research, the factors affecting facility location are identified through literature review and brainstorming in terms of their meaning, status, effect on location decisions and the best possible connection with respect to industries using PESTLE.

The various factors affecting facility location are classified in terms of strategic and operational factors. The factors considered are further sub divided as qualitative and quantitative factors with static and dynamic nature. The factors which do not show much variations w. r. t. time are considered as static in the present research. The various factors affecting facility location are classified in terms of strategic and operational factors using PESTLE tool. The various factors affecting facility location are classified into qualitative and quantitative of static and dynamic nature using PESTLE tool.

The Classification of factors for facility location is as follows:

- Strategic
    - Static Quantitative (SSQ)
    - Dynamic Quantitative (SDQ)
    - Static Qualitative (SSQl)
    - Dynamic Qualitative (SDQl)
- Operational
    - Static Quantitative (OSQ)
    - Dynamic Quantitative (ODQ)
    - Static Qualitative (OSQl)

- Dynamic Qualitative (ODQl)

The factors that face sudden changes are included in the dynamic category whereas those factors which change with a very slow rate over a period of time are considered to be static in the present context. All the identified factors are discussed in details in further sections.

4.2.1 Political factors

One of the major contributors of development in countries is the political scenario. Political inputs contribute to decision making in all major fields in the country. The Political factors contributing to facility location decision making are identified from previous research and brainstorming and are discussed in brief'. All these factors are of qualitative nature. Out of all these factors the political system is considered as static but rest all are considered having dynamic nature.

- **Bureaucratic hurdles**

During the brainstorming session, one major factor influencing facility location decision was figured out to be bureaucracy especially in context to developing countries like India. The red tape mechanism promotes decision delays indirectly leading to corruption as seen in literature. Corruption affects the development of the country [43]. Bureaucratic hurdles, is one of the factor the foreign investors have to look into for location choice, especially in India [44].

- **Government intervention**

It is seen that in locating bigger sized facilities, Government intervention plays an important role. But it is not always a win-win approach. In many cases economic freedom fosters the growth with low government intervention [45]. The Government has all the rights to monitor the type of facilities to be constructed in order to take care of environmental and social issues. However, the approach should be two way taking care of investors if the business is legal and will lead to development of the state in particular and country in general.

- **Political system**

Political system has been considered by many researchers as a major factor affecting facility location decisions especially when business is spread across globe and international locations are to be decided. The political system is affected by culture, governing norms and other political dimensions [46]. India has been one of the biggest democratic nation in the world and the political system in India has always welcomed business houses for business in India. However, developing countries like India should work on the deficiencies in political system in India for it to become a business powerhouse [47].

- **Political stability**

The Political stability of a country defines its economic growth [48, 49]. India has been on global map with recent changes in policies that have been brought about by the present government. If the government gets longer term to implement all the policies and put them in place then the country has to march towards a developmental path. However, most of the times if the government is instable, whatever may be the policy changes, the ruling party always proposes their own policies and due to instability, the policies are never implemented as they are changed with change in government. This is true in case of facility location as one government gives business house all permissions and by the time the facility is built there is change in governance that may affect the setup. Hence, political stability is considered as a prime factor influencing facility location decisions.

- **Internal threats**

In developing countries, at times, internal disturbance is politically motivated creating hindrances to ruling government. This creates indirect political instability suppressing the development. There are other internal threats through organizations that have been opposing government policies creating physical terrors and hence these areas are not in chosen list of alternatives when location decisions are taken. This act as major challenges to the internal security in the country [50, 51]. If there is no security against these threats than there is no way a business house will think of locating its facility in such areas.

- **Maturity of political leadership**

Another outcome of brainstorming session is to include maturity of political leadership in facility location decisions. This is because there is a strong need of mature leaders in the ruling government and opposition who can positively think on development of the state/country [52, 53]. Such need when satisfied will lead to positive Government and business house cooperation and coordination.

- **Neighbourhood stability**

A stable neighbourhood has to be considered while considering location choice. India has a concept of extended neighbourhood but with challenges [54]. This is because of the fact that there are constant threats if there is instability in surrounding areas. India as a developing country has always problems through its neighbouring countries especially in the north region. In a neighbouring country like Bangladesh, though India expects favourable relationships, there is a group of vested interest who project India otherwise [55]. The foreign investors in 'Make in India' projects will always have these questions hovering at the back of their mind.

4.2.2 Economic factors

The growth and progress of any country depends on the economy. The countries with rich natural resources have an edge over others as the raw materials can be sources internally for supply chains. The economy not only depends on the resources but also on the consumption of resources. The countries with strong resource pull will have a very good flow of funds. The government in turn can collect good amount of funds in terms of taxes and utilise it for overall infrastructure development. However, in some countries to save on taxes, the people try to build parallel economies through cash transactions and try to avoid taxes. In countries like India, parallel economy is a major issue. When location decision is taken, especially in case of international locations, economic factors of countries need to be accessed on priority. The static quantitative factors in this category will be land price, transportation costs, construction costs in the location of choice, sales & marketing costs and average salaries paid in the location of choice. Gross Domestic Product (GDP) & per capita income in location of choice are quantitative and are considered to be static. The static qualitative factors identified here are scope for expansion opportunities for industries, industry competitive scenario, impact of present industry status, market characteristics (customer proximity/purchasing power), supplier characteristics (quality/reliability), financial incentives, tax structure, trend of currency strength against U. S. dollar of the country of location choice, economic standing of the country of location choice and inflation trend. Role of parallel economy shall be considered as dynamic qualitative factor.

- **Average salaries paid in location of choice**

One of the major factors to be considered in business decisions is the salaries to be paid to the employees. Usually the salaries are decided depending on the category of sectors like Government, public, private etc. and various factors associated with the sectors [56]. The salaries are roughly decided in initial phase of human resource strategy using known job evaluation techniques. If the location decision also includes the average salaries paid in location of choice, the decision making on salaries to be paid to the employees is easier. If an organization decides on salaries prior to location selection and then plans to have its business in a particular location without investigating the average salaries paid in that location, the decision making may be affected.

- **Construction cost in location of choice**

Construction costs are a component of the overall costs incurred during the development of the facility [238]. These costs are incurred on the actual construction works, and are determined by the value of the contract with the contractor. These costs vary on a lesser scale across close regions but can vary on larger scales from states to states or from countries to

countries. Construction costs in a region need to be accounted for facility location decisions as they form major part of investments in the initial phase as well as expansion phase [11].

- **Economic standing of the country of location choice**

The development rate of the country depends on its economic standing i.e. the robustness of countries' economy. The economic growth is directly linked to the financial development of the country [57, 58]. Economically strong countries have large pool of resources and also good consumption potentials. It is advisable and profitable to do business in such countries. Hence, the economic standing of a country has to be included as a factor in location decisions.

- **Impact of present industry status**

While deciding on factors affecting facility location, one important aspect that needs to be studied is the impact of the existing status of industries in location of choice. Majority of the industries in India are presently aligned towards the service sector [59]. This factor should be viewed in terms of how much impact the proposed industry will create in terms of local economy, environment effect, job creation etc. in a particular locality.

- **Financial incentives**

The location or expansion of manufacturing and distribution facilities is a major decision in financial terms. In order to start or expand business that will boost the local or regional economy, the business houses look forward to beneficial economic incentives to support the efforts. Without financial incentives, some important plans may be side-lined owing to the prevailing conditions of the market. Nationalized banks, cooperative banks, housing development corporations, credit societies provide loans and also offer interest rates rebate and subsidies depending on type of business. Locating a unit in such favourable areas is always an added advantage. Hence location decisions should also consider financial incentives as a factor that influences the decisions [60 - 62].

- **Industry competitive scenario**

Industries look at existing and foreseen competition while deciding on facility locations to cater to new markets [63]. A thorough study on the existing industrial scenario in location of choice will lead to deciding on whether the location has a strong competitor; the market demand is already taken care of by present industries, and if there is scope for demand then whether the planned industry can withstand the foreseen competition. Hence the factor needs to be taken into account while deciding on location selection.

- **Inflation trend**

Inflation means the increase in the price of products and services of everyday use like food, clothing, housing, entertainment, transportation etc. Inflation is the average price change in a basket of products and services over time [239]. In a nutshell, inflation speaks about the

development rate of a country. The choice of location should consider this factor as the rise in inflation shall raise the prices of various elements thus leading to increased overheads, raising the salaries of employees and reductions in profits. In case of server facilities that cater to local markets, the demand can reduce due to increased inflation, thus leading to closures of facilities. Inflation rate rise leads to the reduction in purchasing power of the locality. Hence locations should be chosen based on the trend in inflation [11, 62]. A constant inflation rate over the years is advisable.

- **Land price**

Land price plays a major role in facility location decisions [64]. Being a fixed cost, land price decision is a part of strategic phase. Many a times industries tend to move away from urban areas for the reason of increasing land price in urban areas [240]. Therefore, the government in many states and countries create industrial zones and provide land at lesser costs or on long lease terms to attract the investors for business opportunities. However, as the investment in land price is high depending on the scale of business, the land price factor should be taken into due consideration for location selection.

- **Market characteristics (customer proximity/purchasing power)**

Markets are places for buyers and sellers. For facilities that cater to local markets i.e. with customers close to the facility, market characteristics should be considered in location decisions [66]. Most importantly if locations are closer to the markets they serve, the transportation costs are reduced while delivering the products to the end user. Product differentiation/uniqueness, pricing, negotiations determine the cost variables in markets that relate to the market structure. There is a direct correlation between customer purchasing power and the demand in the market. The effects of the market characteristics should be known to the decision makers [67]. If such market characteristics are studied then location decision making becomes a fruitful process.

- **Role of parallel economy**

Economy that generates black income is termed as parallel economy or as black economy in layman terms. It is illegal, unregulated and unreported. Countries with such economic environment are often avoided for business by giant business houses. Parallel economy is often not advisable for business as there is lot of scope for duplication of products. India needs to counter the challenges caused by black economy in the market [68, 69, 70]. Role of parallel economy should be considered as one of the factors affecting facility location decisions.

- **Sales & marketing costs**

In case of facilities that cater to the demand of the region in which they exist, it is necessary to

take into account sales and marketing costs. In India, majority of the times demand management works through trade promotions wherein actors, sportsperson are hired for advertisement of competitive products. Secondly, discounts and other offers go hand in hand. Majority of the organisations invest funds in sales and marketing [71, 72]. Hence looking upon sales and marketing costs is advantageous while selecting a location.

- **Scope for expansion opportunities for industries**

The location should be chosen in such way that there exists a scope for future expansion of facility[73, 74]. Many a times industries are lured for investments by authorities and with growth in business, the need for expansion arises. In such situation, there are possibilities that land may not be available or request for land for future expansion may be denied.

- **Supplier characteristics (quality/reliability)**

Suppliers are the integral part of the supply chain. Finished product quality always depends on raw material/component quality supplied. Hence a strong reliable supplier base for the required raw material/ components is required that will supply quality requirements within the specified lead time. The reliable suppliers should be available close to the choice of location to avoid long lead times between orders and receivables. The characteristics of available suppliers in location of choice should be known to the business houses [75]. It is reported that a country with strong supplier base need not lure investors on the basis of incentives offered [76]. The factor proves to be of great importance while deciding location.

- **Transportation costs**

Transportation costs have been looked upon as one of the pioneer factor affecting facility location since research on facility location has progressed. The initial models of facility location were designed on distances from sources and markets, quantity transported and optimizing the transportation costs associated with transporting the raw material from source to the manufacturer and transporting finished goods from manufacturer to the markets. By far, the transportation cost factor is still one of the major players in decision making in location of choice. However, there are various issue in terms of freight transportation costs [77], carrier and shipper problems related to modes of transportation [78], connect between transportation quality and costs [79] that need to be addressed before finalising the location.

- **Tax structure**

Majority of business houses tend to locate their facilities in regions where there are good tax incentives. To boost the economy, government tries to give tax rebates for industries. Many a time's free trade zones are declared for improving the local economy and job creation. Hence the tax structure in the location of choice should be studied thoroughly before deciding on alternatives and finalization of location[80 - 83].

- **Trend of currency strength against U. S. dollar of the country of location choice**

Countries have competed with each other on worthy resources through trade agreements, political dialogues, wars etc. as seen in the past. But in recent years the competition is on resources by using the power of their local economies. This power is interpreted by the global value of its national currency on international trade platform. Therefore, currency strength plays a major role when comparing the authority of a country in terms of the global economy [241]. For decision making on the locations of facilities that are planned across country borders, the currency strength of the location of choice needs to be assessed. The U.S. Dollar is the most powerful currency in the world. The U.S. economy has the biggest consumer market, and the U.S. Dollar is treated as the primary currency globally. Hence the trend of the currency strength of the location choice against U.S. Dollar should be considered for international location decisions [11, 84].

- **Gross Domestic Product (GDP)**

One of the prime measures of country's development is the Gross Domestic Product (GDP). The economic progress of the country depends on GDP. This factor has been considered as an important factor affecting facility location decision making in research [85]. GDP defines the rate of economic growth of the country. Majority of the industries depend on FDI for their economic growth. GDP has its effect on FDI [86]. The variations in GDP [87] also need to be accounted for.

- **Per capita income in location of choice**

While choosing facility location, the per capita income in location of choice has to be considered [62, 88]. For facilities that cater to local markets, higher per capita income has a positive impact on demand. Hence facilities can be located in such regions. For export oriented facilities, if the per capita income is low in the location choice, it is an advantage to the organization to keep starting salaries at lower levels. As economy depends on this factor, in this research the said factor is considered under economic factors.

4.2.3 Social factors

First and foremost, the businesses carried out should not affect people in location choices, and local people are expected to benefit through a new business coming up in that locality. However, this does not happen many a times. Due to such issues, there is unrest amongst locals leading to closures of businesses even before they pick up. As seen in the past research, social factors influence facility location decisions in a big way. Eighteen important social factors are considered in the present research. Knowledge base, medical facilities, education

system and avenues, labour characteristics (education/training facilities), motivation and enthusiasm of employees, employability, union flexibility, social ethos(pride in work of any type in the location of choice), linguistic barriers, affect on health of people due to industries, use of Vastu Shastra, religious beliefs, standard of living of people in location choice are considered as static qualitative Factors whereas blind belief in leadership, internal turbulence and consumer spending characteristics(demography/culture) are of dynamic nature. The operational static qualitative factors considered are employee integrity and ethics whereas health hazards due to industrialization will be of dynamic nature.

- **Affect on health of people due to industries**

It is not only genes or biological changes that can affect health. The social life and environment also cause a lot of ill effects. Over the years, it is observed that most of the industries give rise to some form of pollution eg. air pollution [89]. Though there are strict norms on pollution, some industries try to find loop holes and manage their business to run without paying much attention to the norms. In doing so, the health of people in the surrounding areas is affected over a long time period [90]. If the effects are severe, the government has to take strict actions leading to shifting of such industries.

- **Blind belief in leadership**

In most of the developing countries, a large part of the population lives in the villages, facing issues like poverty, illiteracy. These parts of population have a strong faith in their leaders. In some places in India, people treat leaders as god men and believe in whatever the leaders do. To sum up, there is blind belief in leadership. In recent times, people have been expressing views on leaders quoting flaws in some decisions [91]. In recent times, in India, the followers of the Prime Minister are referred as “andh bhakts” i.e., blind followers. Comparisons have been made n leadership styles of leaders in literature [92]. Some of the recent examples in Indian manufacturing scenario of biggest organizations shifting their business due to local pressures identify blind faith and blind following as the main reason behind the actions. Hence this factor is accounted for while choosing a facility location in the present research.

- **Consumer spending characteristics (demography/culture)**

While locating server facilities, one of the major factors to be considered is the spending characteristics of people in and around the choice of location. The consumer spending behaviour changes with demography, culture and even tax structures [93, 94]. Countries with large population are always preferred destinations for facility location as the market size is huge. Many a times the ideas, beliefs in a particular country may act as a barrier and avoid buying particular products. In many countries, consumers tend to purchase products that are

made in their own countries even though the products are costlier to support their patriotic pride. Hence this factor has been considered in the research.

- **Education system and avenues**

A location selected for a facility should have infrastructure that supports its employees in all aspects. Most of the times, the employees are transferred from one state to other state on promotions. In such scenario, the education of their wards is always hampered. This is also expected whenever a new facility is established; many experienced employees of the organisation are posted in that facility. In India, the education system needs a lot of revival in terms of infrastructure and quality and quantity of institutes both in lower and higher education [95, 96]. Hence the education system and avenues need to be included in list of factors affecting location of a facility as seen in literature.

- **Employability**

Employability is an extremely important connect to facility location. Choosing right employee for the right type of job is always an issue in developing countries. There are gaps that are identified between the employee skills and employers expectations [97, 98]. There should be a strong pool of employable people available in choice of location especially in developing countries like India. The sole reason behind this is the fact that the local government is always in favour of jobs for locals. In some of the places, there is a quota kept for locals in industry. If at all employable people are not available and the recruitments are done on quota systems, then the productivity takes a back foot.

- **Employee integrity & ethics**

Employees form the backbone of any organisation. Employee Integrity is always accounted for in the workplace the employee belongs to [99]. In the present context, practicing professional ethics is the need of the hour as the employers cross the international borders to locate business[100]. In the choice of location, ethical, integral and honest employees are looked for. Hence this is one more factor to be taken into consideration during location selection.

- **Health hazards due to industrialization**

Occupational health hazards is also a long term health related issue that needs to be addressed while addressing effects on health of people working in industries [101]. Workers are exposed to harmful fumes and are unaware of the consequences [102]. In some developing countries like Nigeria, workplace hazards are common leading to labour exploitation [103]. Huge risks are associated in working environments like underground coal mines [104]. A healthy environment needs to be developed and maintained in the location of choice. An organisation that does not take care of their employees will always have a strong opposition. Hence

addressing this issue in strategic decisions is a must for any business house. Safety hazards also need to be looked upon in location selection. For e.g., in case of mining operations, if there are chances of higher output in particular areas with higher risks/hazards, the organisation can move decide on alternative location that is less risk prone. Secondly, In case of risky-operation industries, locations decisions should be based on immunity and physical health of probable employees from the locality.

- **Internal turbulence**

The internal security system of a country should be strong enough to take care of the internal turbulence. The major cause of internal turbulence, especially in developing countries like India, is the private forces and political groups that mix legislative issues with violence [105]. Many a times it is a herculean task to identify a safe location for facility for business houses trying to locate facilities in their own country. The earlier research has not considered such factors in facility location selection as important ones. But in developing countries such a factor needs to be considered.

- **Knowledge base**

Locating a facility in such a place where there is a strong knowledge base will always yield positive results to the business house. It is a known fact that countries with strong knowledge base have developed at a faster pace as compared to others. India is known for rich ancient knowledge base, but somehow in recent times has faced a lot of difficulties to march forward as a knowledge powerhouse [106, 107]. Many a times, business houses locate their facilities in other countries to gain access to the expertise and knowledge base.

- **Labour characteristics (education/training facilities)**

The survival of any labour-oriented industry depends on labour characteristics. Labour characteristic has been included as a factor affecting location decisions in past research [62]. India has been regarded as a country with strong pool of labour [108]. However, present industry scenario is more inclined towards hiring contract labour. In such conditions, the industry does not own responsibility of training and education of the labour. The location of choice should have labour that is educated and well trained in present context.

- **Linguistic barriers**

One of the major issues while dealing with business across boundaries is the language of the people in location of choice. In international business dealings, language barrier forms a major challenge [109]. In countries like India, across north to south and from east to west, where each state has its own dialect, it is a challenging situation for industries to cope up with the barriers in language.

- **Medical facilities**

Employees provide strongest support in business. It is well known fact that the organisations that provide ample incentives to its employees have a better employee retention rate. Health benefits are always preferred as incentives by employees when they are given an opportunity to choose their pay structures [110]. The healthcare system in location of choice has to be considered on strong basis as most of the employees prefer medical facilities as incentives if given a choice.

- **Motivation & enthusiasm of employees**

Supply chain relationship management is broadly classified in three categories i. e. Supplier Relationship Management (SRM), Customer Relationship Management (CRM), and internal Supply Chain Management (ISCM). The internal supply chain management consists of organisational relationships. If the organisations are internally strong and positive, the other two categories can be handled in the best manner thus leading to strong supply chain performance. The internal supply chain consists of employee-employer relationships and employee-employee relationships. To keep employees always on the move, a strong motivation and support should come from the employers. Every individual associated with organisation should be motivated using different procedures as every individual is different [111]. The motivation provided shall create positive enthusiasm in employees thus leading to higher degree of individual capability in particular and organisational capability in general [112]. However, it is difficult to build such enthusiasm and motivation in employees in most of the cases. Therefore, if the choice of location considers locations that have inbuilt enthusiastic culture amongst locals considered for employment with other required skills, the organisations can have an upper hand on building a strong supply chain.

- **Religious beliefs**

People of various religions stay in India in particular and world in general. The religions are further divided into caste systems. Each religion has their beliefs. In countries like India, the religious belief has an interrelationship with economic activities [114]. This is one factor that can harm the decision making in location of choice. For example, a meat plant will always be opposed if all the people in the surrounding locality are pure vegetarians. There is a need to include such a factor in facility location decision in countries having citizens of different religions.

- **Social ethos (pride in work of any type in the location of choice)**

Social and civilizational ethos exist in developing countries like India slowing down country's human driven advancement [115]. Many a times, people have their own choice of doing certain type of work. This is mainly due to the social upbringing of people. They develop a

particular set of ideas or attitude when living in the society. Such thinking can affect decision of taking up any type of work for making a living. The business house may end up setting a business in a particular locality wherein the locals might not be interested in doing jobs in the organisation due to their own restrictions. This can create a lot of issues as there won't be availability of workforce and the facility might face problems of shut down. Hence the above factor has to be included in facility location decision.

- **Standard of living of people in location choice**

The country progresses due to development of industries and individuals. The locations are many times identified based on the standard of living of people who live there [11]. Standard of living is one of the major identifiers of the economic progress of a place. Hence this factor needs to be included in facility location decisions.

- **Union flexibility**

The employer employee relationships have to be taken care by industry for its growth. The indirect conflicts, bitterness in terms of workloads, have to be resolved on a common platform. The trade unions are social associations that thrive for better pay and working conditions for the workers [116, 117]. But many a times there are over-demands rising to friction between employer and employees. The unions need to work with flexible approach in decision making and can't be rigid on certain pits that can be solved with fruitful discussions. Hence decision makers should consider locations that have flexible trade unions.

- **Use of Vastu Shastra**

India is a country with rich cultural heritage. In the recent years, many of the ancient architectural designs have been in discussions for the positive and negative energy they have around them. This has led to an ancient science of Vastu Shastra gaining a lot of importance nowadays in India [118, 119]. The location, position, direction, placement of various aspects of a new construction is touched upon in Vastu Shastra for constant positivity and growth. Hence Vastu Shastra can be of added importance in facility location decisions in countries like India.

4.2.4 Technological factors

The developed countries boast about their development on basis of knowledge and technological growth. May it be express highways or railways for high-speed bullet trains, may it be manufacturing or processing, technology has always been a prime source of inspiration. The infrastructure improvements take place with changes in technology. The technological growth has not only changed the way industrial powerhouses do business but it

also has changed their approach towards location of selection of their facility to do business. Majority of the businesses plan to invest in locations that are technologically advanced so that they can reap the advantages offered by technology savvy surroundings. In this research work, Technology costs and IT costs are considered as Static quantitative factors. Alternate energy sources & backup, power supply, availability of skilled labour, infrastructure availability, availability of transportation facility (road/rail/ports/air) and availability of utility services (assistance to main services) are of static qualitative nature.

- **Alternate energy sources and backup**

With rising costs of commercial energy consumption and load capping and environmental regulations, there's been an increased need for alternative energy sources [120]. The top five alternative energy sources available to mankind are solar, wind power, hydro-electric energy, biomass and geothermal power. In case of power failures, the entire industrial operations come to a halt, leading to loss of working hours and productivity. Though many industries have diesel generator sets but it is a costly affair to run operations during long power failures, in addition the systems being non environment friendly. In this regard having an alternate back up, in the form of clean or green energy is always feasible. Many industries try to invest in locations that have strong alternate energy sources and hence alternate energy sources and backup is considered as one of the factors affecting facility location in this research.

- **Infrastructure availability**

Infrastructure means the basic systems and services that industry needs in order to function properly. Infrastructure of a country includes water, roads, railways, utilities, sewage, telecommunication systems, bridges, airports, sea ports etc. and services like healthcare system, law and order system, emergency, education system etc. These infrastructure systems, though require large initial investments, are vital for enhancing the productivity of an economy. For industrial growth, a strong infrastructure is absolutely necessary. The infrastructural changes occur with technological changes and therefore the factor needs a consideration during facility location selection decision making [62, 121, 122].

- **IT costs**

One of the major strategies for exploring new business opportunities is technology adaption and investments in Information Technology (IT) [123, 124, 125]. This is true as information acts as a major driver of supply chain. Use of Information Technology is an essential part of any operation. Implementation of a successful IT system requires considerable time and money. Management should ensure that the finalised location meets the IT needs. The availability of efficient information technology is prime issue in facility selection decision. Highly skilled employees are needed in IT operations as well as IT development. Most of the

companies relocate to developed countries due to inefficient logistics system in developing countries having a poorly developed IT system.

- **Availability of skilled labour**

Availability of skilled labour has been considered as one of the important factors in location decisions [11, 62, 126, 127]. The issue of availability of sufficient number of labours with particular set of skills has to be considered during facility location. Labour import is a costly affair hence if skilled labour is available at the location of choice, it is an added advantage. Even the training of unskilled and semiskilled labour is a matter that has direct relation with the facility location, in terms of the availability of training personnel and training infrastructure availability in the catchment area.

- **Power supply**

Uninterrupted power supply is a must for industries as the need for continuous and ample supply of quality electricity is of vital importance. The non-availability of power may lead to a situation of survival crisis for industries. Some industries need continuous and large quantity of power supply and they must be located in a place where there is uninterrupted power supply throughout the year. Use of power generators for industrial operations is by and large high increasing industry's overhead cost. Availability of constant and quality power supply needs to be given a major thought while choosing location [62].

- **Technology costs**

Technology costs vary from country to country. The costs incurred in investments in technology are one of the major deciders on productivity of any industry. The quality and market pricing of product is also affected on technology investment decisions. The investments in cheap technology machines can yield good returns on investments in the initial stage but over the years the machines can be burden with rising maintenance costs. The investments should be looked in the direction of robust technology at optimal costs to ensure cheaper product availability to customers [128]. In case the location does not have access to purchasing technologically driven machinery having low maintenance costs then the machines need to be imported raising the costs. Secondly, an imported machine always requires replacement parts to be ordered that can hamper the production schedule, increase inventory carrying costs of spares and increase downtime thus leading to productivity decline.

- **Availability of transportation facility (road/rail/ports/air)**

Business houses depend upon high quality and efficient transportation services. For moving raw material from source to processing/manufacturing plants and distribution of finished goods from and to the designated points including the end consumer transportation facilities should be available in the form of roads, railway, and sea & air ports. Pipelines also form a

part of transportation systems when products like oil and gas are transported. The cost of the available means of transportation also should be taken into consideration. Thus availability of transportation facilities becomes an important factor in choice of facility location [11].

- **Availability of utility services (assistance to main services)**

Utility services mean cable, power, natural gas, telephone and telecommunication infrastructure, water, and wastewater treatment services. The services include installation, maintenance, rearrangement or repair of cables, pipes, utility poles, utility structures, wires, and other infrastructure associated with such services. In industrial applications, boilers, chilling plants etc. also come under heading of utilities. Such services are also required to be considered in facility location decisions [62, 130].

4.2.5 Legal factors

Policy framing is the first step to create formal documentation. Policies are the initial phase for law to come in force. A policy printed in legal language by the government is called as a Law. A regulation is a rule inside the law. Regulations are crucial for law implementation. Regulations can be modified over time with feedback from stake holders. For any choice of location, the legal factors have to be looked into with deep thoughts. First and foremost, due consideration has to be given to those locations in which the government has firm and positive policies for industries. Usually as policies are initial phase of law, they keep changing depending on the ruling governments. Hence the investors need to study the history of the policy changes in given location of choice before finalising the location. The Government stability has a direct link to the firm and strong policies. In this research, Government policies for industry and Government laws & regulations for industries are considered as static qualitative factors.

- **Government laws and regulations for industries**

The Government, may it be state in particular or country in general, has defined set of laws and regulations. Many a times, the laws and regulations are defined centrally through central government and are imposed on all the states. India as a developing country has framed industrial laws that provide social justice to employees. Government laws and regulation have been considered in facility location decisions as seen in the past literature [126, 132]. In countries where the laws and regulations concerning industries are full proof and beneficial both to the employer and employees, facility location decision making adds a positive advantage to the investor.

- **Government policies for industry**

The Government always targets to frame a set of industrial policies that support industrialization and in turn enhances economy [133]. However, in case of instable political scenario, the policies may keep changing every time new Government is formed. A location with firm industrial policies is always a better choice for investors. Hence the factor has to be considered on a prime note while making facility location decisions [61, 134].

4.2.6 Environmental factors

The habitat to which the human species belong should be protected for better living. Environment needs to be taken care of and this is the duty of every individual. However, with the industrial growth, there is a chance of rise in pollution. The Government has strict policies, laws and regulations on environment protection but the same is not properly taken care of. Some industrial zones have already harmed the environment to the maximum and the after effects in terms of pollution leading to health issues are alarming. Some locations are prone to natural disasters. Many of the researchers have spent years on assessing the impact of global warming on environment and have considered pollution to be one of the major factors leading to global warming. Directly or indirectly, industries come in this assessment as source of pollution. As an investor, it is the prime duty to strictly adhere to the environmental rules and regulations. But majority of business houses overlook this aspect. It is therefore the duty of the investor to take into account various environmental factors while choosing location for their business. Climatic conditions, water availability and impact of industrialization on environment are qualitative factors of static nature. Disaster risks is qualitative factor of Dynamic nature.

- **Climatic conditions**

The climate across the globe changes with time period. Though we define the climatic conditions in terms of seasons, the conditions in the recent year do not strictly adhere to seasonal changes. Climate change is the buzzword of the day and sustainability has to be taken into account while deciding on locations [29]. Most of the industries can work in any climate conditions, but for some industries, a particular environment is required for its production. Though artificial environment can be created within the industry premise, the surroundings need to be supporting the artificial environment. Hence it is required that the climatic conditions in locality of choice suit the type of industry that is proposed to be constructed. Localities with high variations in climatic conditions need to be avoided as it may harm the productivity in the long run. It is also advisable to avoid locations where industrialization has already caused harm to the climatic conditions.

- **Disaster risks**

One of the major decisions to be taken while selecting a location for business is how prone the location is to disasters. The natural disasters can cause major issues to the industries [135, 136]. Disaster risks have to be considered in location decisions as the entire investment can go into a total loss if there is a disaster.

- **Impact of industrialization on environment**

Industrialization has its own pros and cons. The economic growth and development of the country depends is directly related to the growth of industrial sector. On the other hand, industrialization may also have harmful effects on the environment[137, 138, 242]. Air and Water pollution, climate changes are some of the major ill effects of industrialization on environment. The impact of industrialization on the environment of existing industries needs to be assessed while selecting the location.

- **Water availability**

Water is the most important criteria for survival. Natural sources of water are available in plenty all across globe. However, looking at micro scales, majority of the places have dearth of water mostly due to improper water management. For any industrial operations, need of water is certain [140]. Water shortage has been a major concern due to population expansion as addressed in literature [141]. The water should be available in abundance for industries and hence water availability has been addressed as one of the factors in facility location decision making.

4.3 Framework

Considering the above classification of the factors identified from brainstorming and factors available in literature, framework has been designed using PESTLE Analysis as shown in the Table 4.1.

Table 4.1: Framework for facility location factors using PESTLE analysis

PESTLE	Strategic factors			Operational factors		
	Quantitative	Qualitative	Dynamic qualitative	Quantitative	Qualitative	Dynamic qualitative
Political		-Political system	-Political stability -Maturity of political leadership -Internal threats -Neighbourhood stability -Bureaucratic hurdles			-Government intervention

Economic	-Land price -Construction cost in location of choice -Transportation costs -Gross domestic product (GDP) -Per capita income in location of choice	-Scope for expansion opportunities for industries -Industry competitive scenario -Impact of present industry status -Market characteristics (customer proximity/ purchasing power) -Supplier characteristics (quality/ reliability) -Financial incentives -Tax structure - Trend of currency strength against U. S. dollar of the country of location choice -Economic standing of the country of location choice - Inflation trend		-Sales & marketing costs -Average salaries paid in location of choice		-Role of parallel economy
Social		-Knowledge base -Medical facilities -Education system and avenues -Labour characteristics (education/training facilities) -Motivation & enthusiasm of employees -Employability -Union flexibility -Social ethos (pride in work of any type in the location of choice) -Linguistic barriers -Affect on health of people due to industries -Use of vastushastra -Religious beliefs - Standard of living of people in location choice	-Blind belief in leadership -Internal turbulence -Consumer spending characteristics (demography/culture)		-Employee integrity & ethics	-Health hazards due to industrialization

Technological	-Technology costs	-Alternate energy sources & backup -Power supply -Availability of skilled labour -Infrastructure availability -Availability of utility services (assistance to main services) -Availability of transportation facility (road/rail/ ports/ air)		-IT costs		
Legal		-Government policies for industry -Government laws & regulations for industries				
Environmental		-Climatic conditions -Water availability -Impact of industrialization on environment	-Disaster risks			

4.4 Summary

In this chapter, the various factors which affecting facility location identified through literature and brain storming are classified in terms of strategic and operational factors using PESTLE tool. In developing countries, it is seen that lot of dormant qualitative factors prevail and can surface when optimal location of the plant is already decided. These factors hamper the supply chain performance directly or indirectly. Such factors can eventually turn out to be vital adversely affecting the decisions made and forcing relocation of plant. Hence an effort has been made to identify such factors. In the next chapter, an innovative fuzzy based ranking method is proposed for ranking of these factors. Further, the existing fuzzy AHP approach is modified to take care of large data matrix and the ranking of factors by proposed method is validated against it.

Chapter 5

Ranking of Factors in Static Environment

5.1 General

There are many methods in literature that are used for ranking. One of the widely used methods is ranking by paired comparison. However in most of the paired comparison methods the size of the matrix is limited due to information processing capacity of human beings [243]. The common method of ranking by paired comparison gives results that may lead to similar scores when we have more factors to be considered. This is evident from the fact that the method uses only three numbers i.e., 1 for small difference, 2 for medium difference and 3 for major difference. Further, the method works well with maximum of fifteen factors. In the present context, fifty-seven factors are taken into consideration. Hence an alternate method has been devised which takes into account the qualitative assessment using fuzzy numbers.

5.2 Fuzzy Numbers

A generalization of a real number that does not refer to one single value but rather to associated set of values, where each possible value has its own weight between 0 and 1 is called a fuzzy number [244]. The weight is called membership function. Fuzzy number calculations incorporate the uncertainty associated with variables which are often defined in terms of linguistic scales. A linguistic variable is a variable whose values are words or sentences in a normal or simulated language. The study addresses the logical human response according to the linguistic variable [19] i. e. no influence, very low influence, low influence, high influence and very high influence, and are represented by positive triangular fuzzy numbers as shown in Table 5.1. Figure 5.1 displays a triangular fuzzy numbers for linguistic variables represented on a scale of 0 to 1.

Table 5.1: Linguistic terms and values [245]

Linguistic Terms	Linguistic Values
Very High Influence (VHI)	(0.75,1,1)
High Influence (HI)	(0.5,0.75,1)
Low Influence (LI)	(0.25,0.5,0.75)
Very Low Influence (VLI)	(0,0.25,0.5)
No Influence (NI)	(0,0,0.25)

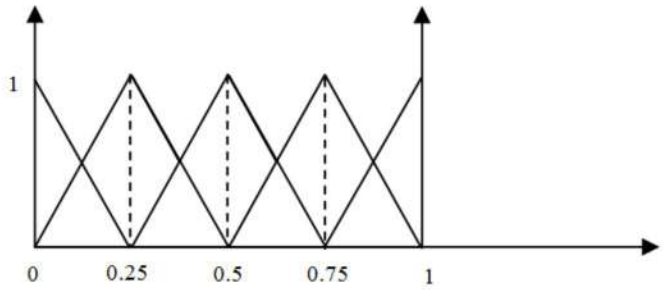

Figure 5.1: Triangular fuzzy numbers for linguistic variables [245]

5.3 Survey

Google forms were designed for ranking of factors as per their importance in locating a facility. The target survey group consisted of respondents belonging to industries, business houses, Government organisations, NGOs and academicians. The respondents were asked to input their responses in linguistic scale. All the factors including the quantitative factors are considered in linguistic terms in the case studies. In the present case, the data collection is done in India. If we consider land price which is a quantitative factor, it varies across the nation, states and even locality. If we consider comparison of factors in particular localities, for finding the best alternative, we can take into account direct values of land price. But here as the price vary across nation; we have considered such factors also in linguistic scale. Figure 5.2 and Table 5.2 shows sample Google form and sample survey responses respectively. Table 5.3 shows the responses converted to fuzzy numbers.

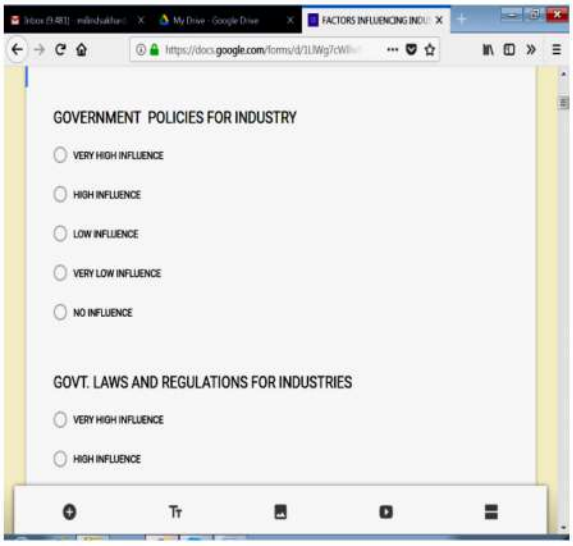

Figure 5.2: Sample Google form

Table 5.2: Sample survey responses

RESPONDENT	GOVERNMENT POLICIES FOR INDUSTRY	GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	POLITICAL SYSTEM	SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES
1	HIGH INFLUENCE	HIGH INFLUENCE	HIGH INFLUENCE	HIGH INFLUENCE
2	HIGH INFLUENCE	HIGH INFLUENCE	HIGH INFLUENCE	HIGH INFLUENCE
3	LOW INFLUENCE	LOW INFLUENCE	HIGH INFLUENCE	VERY HIGH INFLUENCE
4	VERY HIGH INFLUENCE	VERY HIGH INFLUENCE	VERY HIGH INFLUENCE	HIGH INFLUENCE
5	HIGH INFLUENCE	HIGH INFLUENCE	LOW INFLUENCE	HIGH INFLUENCE
6	HIGH INFLUENCE	HIGH INFLUENCE	LOW INFLUENCE	LOW INFLUENCE

Table 5.3: Responses converted to fuzzy numbers

GOVERNMENT POLICIES FOR INDUSTRY			GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES			POLITICAL SYSTEM			SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES			INDUSTRY COMPETITIVE SCENARIO		
0.5	0.75	1	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1
0.5	0.75	1	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1
0.25	0.5	0.75	0.25	0.5	0.75	0.5	0.75	1	0.75	1	1	0.75	1	1
0.75	1	1	0.75	1	1	0.75	1	1	0.5	0.75	1	0.5	0.75	1
0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.5	0.75	1	0.25	0.5	0.75
0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.25	0.5	0.75	0.5	0.75	1

5.4 Proposed Method

From the responses of various stakeholders, the final influence importance values (IIVs) are calculated in terms of average or aggregate values that can be represented as fuzzy number [a, b, c]. In the next step a matrix of all the factors is formed. In the given matrix, differences between scores are mentioned. The difference between the factors will be represented by a fuzzy number [p, q, r]. Further, centroid value of this fuzzy number [p, q, r] is calculated as$\frac{p+q+r}{3}$ [246]. If Factor A in the horizontal column is superior to Factor B in the vertical

column, then positive difference of centroids is mentioned in the corresponding cell pertaining to both and if Factor A in the horizontal column is inferior to Factor B in the vertical column, then negative difference of centroids is mentioned in the corresponding cell pertaining to both. Then sum of all positive differences of centroids pertaining to Factors in the row is calculated. Similarly sum of all negative differences of centroids pertaining to the Factors in the columns is calculated. Finally, the negative sums are added as numbers to positive sums to get final scores and ranking is done based descending scores of factors.

5.5 Mathematical Model

Step 1: The average or aggregate influence importance values of factors are in the matrix A given by

$$A = [a, b, c]_{1xn} \tag{5.1}$$

Step 2: Generate the difference matrix B

$$X_{ij} = [p, q, r]_{ij} = [a, b, c]_i - [a, b, c]_j \qquad \forall\ i{:}1 \text{ to } n; \qquad j{:}\ (i+1) \text{ to } n; \tag{5.2}$$

Step 3: Generate the centroid matrix C

$$X_{ij} = \frac{[p,q,r]}{3_{ij}} \qquad \forall\ i{:}1 \text{ to } n; \qquad j{:}\ (i+1) \text{ to } n; \tag{5.3}$$

Step 4: Scan along all the rows (i) to get positive sums of centroids

$$\text{sump}(i) = \sum_{j=i+1}^{n} (X_{ij}); \qquad \forall X_{ij} > 0 \tag{5.4}$$

Step 5: Scan along all the columns (j) to get negative sums of centroids

$$\text{sumn}(j) = \sum_{i=j+1}^{n} (X_{ij}); \qquad \forall X_{ij} < 0 \tag{5.5}$$

Step 6: Get the summationof positive sums and negative sums of centroids

$$\text{summation}(i) = \text{sump}(i) + [-1 \times \text{sumn}(i)]; \qquad \forall\ i{:}\ 1 \text{ to } n \tag{5.6}$$

Step 7: Rank the factors based on descending order of Summation (i)

5.6 Case Study 1

The case study is carried out to authenticate the working of the proposed method. In the step towards the use of the model a sample of twenty responses are used for the analysis with sample data being used as average fuzzy numbers and aggregate fuzzy numbers [247, 248].

5.6.1 Sample calculations with average fuzzy numbers

The sample calculations are shown in Tables appended below. First the average fuzzy numbers are found from survey responses as shown in Table 5.4. The average fuzzy number

is represented as $(mina_n, average\ b_n, maxc_n)$ for a set of 'n' fuzzy numbers. Table 5.5 shows the difference matrix obtained using average fuzzy numbers and centroid values calculated from difference matrix of average values. Once all the centroids are calculated, positive centroids for each factor are summed up as one total in horizontal rows and negative centroids for each factor are summed up as one total in vertical rows. The total sum of positive and negative values is then added as shown in Table 5.6 to calculate final sum that will ensure ranking of the factors as shown in Table 5.7.

Table 5.4: Average values of fuzzy numbers

GOVERNMENT POLICIES FOR INDUSTRY			GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES			POLITICAL SYSTEM		
0.25	0.838235	1	0.25	0.838235	1	0.25	0.75	1

Table 5.5: Difference matrix of average fuzzy numbers with centroids

	GOVERNMENT POLICIES FOR INDUSTRY			GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES			POLITICAL SYSTEM		
GOVERNMENT POLICIES FOR INDUSTRY	0	0	0	-0.75	0	0.75	-0.75	0.088235	0.75
CENTROID				0			0.029412		
GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES				0	0	0	-0.75	0.088235	0.75
CENTROID							0.029412		
POLITICAL SYSTEM							0	0	0

Table 5.6: Sum of positive and negative sums of centroids

	POSITIVE	NEGATIVE	SUM
GOVERNMENT POLICIES FOR INDUSTRY	5.686275	0	5.686275
GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	5.686275	0	5.686275

POLITICAL SYSTEM	4.303922	0	4.303922
SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES	4.656863	-0.00980392	4.666667

Table 5.7: Final ranking of factors based on fuzzy data based on average values

FACTOR	SUM SCORE	RANK
AVAILABILITY OF TRANSPORTATION FACILITY (ROAD/RAIL/PORTS/AIR)	12.18627	1
WATER AVAILABILITY	10.53922	2
GOVERNMENT POLICIES FOR INDUSTRY	5.686275	3
GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	5.686275	3
MARKET CHARACTERISTICS (CUSTOMER PROXIMITY/PURCHASING POWER)	5.401961	4
AVAILABILITY OF UTILITY SERVICES (ASSISTANCE TO MAIN SERVICES)	5.343137	5
SUPPLIER CHARACTERISTICS (QUALITY/RELIABILITY)	4.946078	6
LAND PRICE	4.666667	7
GOVERNMENT INTERVENTION	4.666667	7
IMPACT OF PRESENT INDUSTRY STATUS	4.666667	7
SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES	4.666667	7
POLITICAL SYSTEM	4.303922	8
TREND OF CURRENCY STRENGTH AGAINST U. S. DOLLAR IN COUNTRY OF LOCATION CHOICE	4.215686	9
LABOUR SKILLS	4.215686	9
HEALTH HAZARDS DUE TO INDUSTRIALIZATION	4.004902	10
BUREAUCRATIC HURDLES	3.79902	11
CONSTRUCTION COSTS	3.598039	12
TRANSPOTATION COSTS	3.598039	12
INDUSTRY COMPETITIVE SCENARIO	3.598039	12
SALES & MARKETING COSTS	3.22549	13
POLITICAL STABILITY	3.044118	14
DISASTER RISKS	2.514706	15
IT COSTS	2.343137	16
POWER SUPPLY	2.176471	17
INFRASTRUCTURE AVAILABILITY	2.014706	18
FINANCIAL INCENTIVES	2.009804	19
INTERNAL THREATS	1.681373	20
TAX STRUCTURE	1.465686	21

IMPACT OF INDUSTRIALIZATION ON ENVIRONMENT	1.392157	22
AFFECT ON HEALTH OF PEOPLE DUE TO INDUSTRIES	1.102941	23
TECHNOLOGY COST	0.965686	24
EMPLOYEE INTEGRITY & ETHICS	0.745098	25
GROSS DOMESTIC PRODUCT (GDP)	0.70098	26
AVERAGE SALARIES PAID IN LOCATION CHOICE	0.70098	26
UNION FLEXIBILITY IN INDUSTRIES	0.70098	26
MOTIVATION & ENTHUSIASM OF EMPLOYEES	0.70098	26
LABOUR CHARACTERISTICS (EDUCATION/TRAINING FACILITIES)	0.598039	27
EMPLOYABILITY	0.598039	27
ECONOMIC STANDING OF THE COUNTRY OF LOCATION CHOICE	0.504902	28
ALTERNATE ENERGY SOURCES AND BACKUP	0.416667	29
PER CAPITA INCOME IN LOCATION CHOICE	0.352941	30
KNOWLEDGE BASE	0.338235	31
CLIMATIC CONDITIONS	0.338235	31
MATURITY OF POLITICAL LEADERSHIP	0.338235	31
NEIGHBORHOOD STABILITY	0.338235	31
BLIND BELIEF IN LEADERSHIP	0.338235	31
INTERNAL TURBULENCE	0.338235	31
CONSUMER SPENDING CHARACTERISTICS (DEMOGRAPHY/CULTURE)	0.338235	31
INFLATION TREND	0.25	32
ROLE OF PARALLEL ECONOMY	0.132353	33
SOCIAL ETHOS YOUR REGION (PRIDE IN WORK OF ANY TYPE IN LOCATION CHOICE)	0.132353	33
EDUCATION SYSTEM AND AVENUES	0.102941	34
MEDICAL FACILITIES	0.078431	35
STANDARD OF LIVING IN LOCATION OF CHOICE	0.058824	36
LINGUISTIC BARRIERS	0	37
USE OF VASTU SHASTRA	0	37
RELIGIOUS BELIEFS	0	37

5.6.2 Sample calculations with aggregate fuzzy numbers

The sample calculations are shown in Tables appended below. First the Aggregate Fuzzy numbers are found from survey responses as shown in Table 5.8. The aggregate fuzzy number is given as $(average\ of\ a_n, average\ of\ b_n, average\ of\ c_n)$ for a set of 'n' fuzzy numbers.Table 5.9 shows the difference matrix obtained using aggregate fuzzy numbers and centroid values calculated from difference matrix of aggregate values. Once all the centroids are calculated, positive centroids for each factor are summed up as one total in horizontal

rows and negative centroids for each factor are summed up as one total in vertical rows. The total sum of positive and negative values is then summed up as shown in Table 5.10 to calculate final numbers that will ensure ranking of the factors as shown in Table 5.11.

Table 5.8: Aggregate values of fuzzy numbers

GOVERNMENT POLICIES FOR INDUSTRY			GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES			POLITICAL SYSTEM		
0.588235	0.838235	0.985294	0.588235	0.838235	0.985294	0.5	0.75	0.941176

Table 5.9: Difference matrix of aggregate values with centroids

	GOVERNMENT POLICIES FOR INDUSTRY			GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES			POLITICAL SYSTEM		
GOVERNMENT POLICIES FOR INDUSTRY	0	0	0	-0.39706	0	0.397059	-0.35294	0.088235	0.485294
CENTROID				0			0.073529		
GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES				0	0	0	-0.35294	0.088235	0.485294
CENTROID							0.073529		
POLITICAL SYSTEM							0	0	0

Table 5.10: Sum of positive and negative sums of centroids

	POSITIVE	NEGATIVE	SUM
GOVERNMENT POLICIES FOR INDUSTRY	7.45098	0	7.45098
GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	7.45098	0	7.45098
POLITICAL SYSTEM	3.995098	0	3.995098
SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES	4.946078	-0.024509804	4.970588

Table 5.11: Final ranking of factors based on fuzzy data based on aggregate values

FACTOR	SUM SCORE	RANK
AVAILABILITY OF TRANSPORTATION FACILITY (ROAD/RAIL/PORTS/AIR)	11.55392	1
WATER AVAILABILITY	8.259804	2
GOVERNMENT POLICIES FOR INDUSTRY	7.45098	3
GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	7.45098	3
AVAILABILITY OF UTILITY SERVICES (ASSISTANCE TO MAIN SERVICES)	6.588235	4
POWER SUPPLY	6.411765	5
MARKET CHARACTERISTICS (CUSTOMER PROXIMITY/PURCHASING POWER)	6.147059	6
FINANCIAL INCENTIVES	5.980392	7
INFRASTRUCTURE AVAILABILITY	5.911765	8
SUPPLIER CHARACTERISTICS (QUALITY/RELIABILITY)	5.480392	9
LAND PRICE	4.970588	10
SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES	4.970588	10
GOVERNMENT INTERVENTION	4.970588	10
IMPACT OF PRESENT INDUSTRY STATUS	4.539216	11
POLITICAL SYSTEM	3.995098	12
TAX STRUCTURE	3.931373	13
TREND OF CURRENCY STRENGTH AGAINST U. S. DOLLAR IN COUNTRY OF LOCATION CHOICE	3.906863	14
LABOUR SKILLS	3.906863	15
HEALTH HAZARDS DUE TO INDUSTRIALIZATION	3.519608	16
IMPACT OF INDUSTRIALIZATION ON ENVIRONMENT	3.480392	17
BUREAUCRATIC HURDLES	3.151961	18
AFFECT ON HEALTH OF PEOPLE DUE TO INDUSTRIES	3.151961	18
TECHNOLOGY COSTS	2.980392	19
TRANSPOTATION COSTS	2.813725	20
INDUSTRY COMPETITIVE SCENARIO	2.651961	21
INTERNAL THREATS	2.504902	22
GROSS DOMESTIC PRODUCT (GDP)	2.495098	23
CONSTRUCTION COSTS	2.343137	24
AVERAGE SALARIES PAID IN LOCATION CHOICE	2.196078	25
UNION FLEXIBILITY IN INDUSTRIES	2.196078	25
MOTIVATION & ENTHUSIASM OF EMPLOYEES	2.196078	25
EMPLOYEE INTEGRITY & ETHICS	1.980392	26
SALES & MARKETING COSTS	1.936275	27

EMPLOYABILITY	1.818627	28
LABOUR CHARACTERISTICS (EDUCATION/TRAINING FACILITIES)	1.705882	29
ECONOMIC STANDING OF THE COUNTRY OF LOCATION CHOICE	1.705882	29
POLITICAL STABILITY	1.5	30
ALTERNATE ENERGY SOURCES AND BACKUP	1.205882	31
MATURITY OF POLITICAL LEADERSHIP	1.029412	32
BLIND BELIEF IN LEADERSHIP	1.029412	32
PER CAPITA INCOME IN LOCATION CHOICE	1.02451	33
NEIGHBORHOOD STABILITY	1.019608	34
KNOWLEDGE BASE	0.955882	35
INTERNAL TURBULENCE	0.955882	35
CONSUMER SPENDING CHARACTERISTICS (DEMOGRAPHY/CULTURE)	0.955882	35
CLIMATIC CONDITIONS	0.897059	36
DISASTER RISKS	0.843137	37
IT COSTS	0.696078	38
INFLATION TREND	0.651961	39
ROLE OF PARALLEL ECONOMY	0.377451	40
SOCIAL ETHOS YOUR REGION (PRIDE IN WORK OF ANY TYPE IN LOCATION CHOICE)	0.343137	41
EDUCATION SYSTEM AND AVENUES	0.254902	42
MEDICAL FACILITIES	0.205882	43
STANDARD OF LIVING OF PEOPLE IN LOCATION CHOICE	0.166667	44
USE OF VASTU SHASTRA	0.034314	45
RELIGIOUS BELIEFS	0.004902	46
LINGUISTIC BARRIERS	0	47

5.6.3 Case study 1 discussions

As seen in Section 5.6.1 and 5.6.2, with use of average fuzzy numbers and aggregate fuzzy numbers, there is a change in ranking of factors. The average value of fuzzy numbers (a_n, b_n, c_n) is at a slight disadvantage as minimum of minimum has to be taken as the lower value of the triangular fuzzy number (min. of all a_ns) and maximum of maximum (max. of all c_ns) is to be taken at right end of fuzzy number$(a_{nmin}, \frac{\Sigma b_n}{n}, c_{nmax})$. This can produce results in a way that many factors will have similar end points of their representative fuzzy numbers. If the incoming data is not consistent, then using average fuzzy number may give very close results as seen in the final ranking of average values. In case of average fuzzy numbers, the total ranks given to fifty-seven fuzzy numbers are just thirty-seven as many of the factors fall in common weightage. Using aggregate values will give a clear-cut distinction between maximum and minimum values of fuzzy numbers. It is evident from the fact that fifty-seven

factors have a total ranking of forty-seven. The comparison of ranking is shown in Table 5.12. In the present context, for the pilot study, only twenty samples were taken and analysed. This case study clearly indicates that use of aggregate fuzzy numbers is better than average fuzzy numbers when it comes to distinct ranking. Although, the existing literature has not given much importance to the number of experts to be considered for the conduct of the group decision techniques like AHP, the decision making for large data problems will be reliable if the number of experts is substantial [249]. To verify if there is an improvement in distinct ranking, the sample size is increased to fifty-six responses and analysis is carried out using aggregate fuzzy numbers as shown in case study 2. The case study 2 also takes into consideration data validation.

Table 5.12: Comparison of ranking

FACTOR	AVERAGE		FACTOR	AGGREGATE	
	SUM	RANK		SUM	RANK
AVAILABILITY OF TRANSPORTATION FACILITY (ROAD/RAIL/PORTS/AIR)	12.18627	1	AVAILABILITY OF TRANSPORTATION FACILITY (ROAD/RAIL/PORTS/AIR)	11.55392	1
WATER AVAILABILITY	10.53922	2	WATER AVAILABILITY	8.259804	2
GOVERNMENT POLICIES FOR INDUSTRY	5.686275	3	GOVERNMENT POLICIES FOR INDUSTRY	7.45098	3
GOVERNEMENT LAWS AND REGULATIONS FOR INDUSTRIES	5.686275	3	GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	7.45098	3
MARKET CHARACTERISTICS (CUSTOMER PROXIMITY/ PURCHASING POWER)	5.401961	4	AVAILABILITY OF UTILITY SERVICES (ASSISTANCE TO MAIN SERVICES)	6.588235	4
AVAILABILITY OF UTILITY SERVICES (ASSISTANCE TO MAIN SERVICES)	5.343137	5	POWER SUPPLY	6.411765	5
SUPPLIER CHARACTERISTICS (QUALITY/RELIABILITY)	4.946078	6	MARKET CHARACTERISTICS (CUSTOMER PROXIMITY/PURCHASING POWER)	6.147059	6
LAND PRICE	4.666667	7	FINANCIAL INCENTIVES	5.980392	7
GOVERNMENT INTERVENTION	4.666667	7	INFRASTRUCTURE AVAILABILITY	5.911765	8
IMPACT OF PRESENT INDUSTRY STATUS	4.666667	7	SUPPLIER CHARACTERISTICS (QUALITY/RELIABILITY)	5.480392	9
SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES	4.666667	7	LAND PRICE	4.970588	10
POLITICAL SYSTEM	4.303922	8	SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES	4.970588	10
TREND OF CURRENCY STRENGTH AGAINST U. S. DOLLAR IN COUNTRY OF LOCATION CHOICE	4.215686	9	GOVERNMENT INTERVENTION	4.970588	10
LABOUR SKILLS	4.215686	9	IMPACT OF PRESENT INDUSTRY STATUS	4.539216	11
HEALTH HAZARDS DUE TO	4.004902	10	POLITICAL SYSTEM	3.995098	12

INDUSTRIALIZATION					
BUREAUCRATIC HURDLES	3.79902	11	TAX STRUCTURE	3.931373	13
CONSTRUCTION COSTS	3.598039	12	TREND OF CURRENCY STRENGTH AGAINST U. S. DOLLAR IN COUNTRY OF LOCATION CHOICE	3.906863	14
TRANSPOTATION COSTS	3.598039	12	LABOUR SKILLS	3.906863	15
INDUSTRY COMPETITIVE SCENARIO	3.598039	12	HEALTH HAZARDS DUE TO INDUSTRIALIZATION	3.519608	16
SALES & MARKETING COSTS	3.22549	13	IMPACT OF INDUSTRIALIZATION ON ENVIRONMENT	3.480392	17
POLITICAL STABILITY	3.044118	14	BUREAUCRATIC HURDLES	3.151961	18
DISASTER RISKS	2.514706	15	AFFECT ON HEALTH OF PEOPLE DUE TO INDUSTRIES	3.151961	18
IT COSTS	2.343137	16	TECHNOLOGY COSTS	2.980392	19
POWER SUPPLY	2.176471	17	TRANSPOTATION COSTS	2.813725	20
INFRASTRUCTURE AVAILABILITY	2.014706	18	INDUSTRY COMPETITIVE SCENARIO	2.651961	21
FINANCIAL INCENTIVES	2.009804	19	INTERNAL THREATS	2.504902	22
INTERNAL THREATS	1.681373	20	GROSS DOMESTIC PRODUCT (GDP)	2.495098	23
TAX STRUCTURE	1.465686	21	CONSTRUCTION COSTS	2.343137	24
IMPACT OF INDUSTRIALIZATION ON ENVIRONMENT	1.392157	22	AVERAGE SALARIES PAID IN LOCATION OF CHOICE	2.196078	25
AFFECT ON HEALTH OF PEOPLE DUE TO INDUSTRIES	1.102941	23	UNION FLEXIBILITY IN INDUSTRIES	2.196078	25
TECHNOLOGY COST	0.965686	24	MOTIVATION & ENTHUSIASM OF EMPLOYEES	2.196078	25
EMPLOYEE INTEGRITY & ETHICS	0.745098	25	EMPLOYEE INTEGRITY & ETHICS	1.980392	26
GROSS DOMESTIC PRODUCT (GDP)	0.70098	26	SALES & MARKETING COSTS	1.936275	27
AVERAGE SALARIES PAID IN LOCATION OF CHOICE	0.70098	26	EMPLOYABILITY	1.818627	28
UNION FLEXIBILITY IN INDUSTRIES	0.70098	26	LABOUR CHARACTERISTICS (EDUCATION/TRAINING FACILITIES)	1.705882	29
MOTIVATION & ENTHUSIASM OF EMPLOYEES	0.70098	26	ECONOMIC STANDING OF THE COUNTRY OF LOCATION CHOICE	1.705882	29
LABOUR CHARACTERISTICS (EDUCATION/TRAINING FACILITIES)	0.598039	27	POLITICAL STABILITY	1.5	30
EMPLOYABILITY	0.598039	27	ALTERNATE ENERGY SOURCES AND BACKUP	1.205882	31
ECONOMIC STANDING OF THE COUNTRY OF LOCATION CHOICE	0.504902	28	MATURITY OF POLITICAL LEADERSHIP	1.029412	32
ALTERNATE ENERGY SOURCES AND BACKUP	0.416667	29	BLIND BELIEF IN LEADERSHIP	1.029412	32
PER CAPITA INCOME IN LOCATION OF CHOICE	0.352941	30	PER CAPITA INCOME IN LOCATION OF CHOICE	1.02451	33
KNOWLEDGE BASE	0.338235	31	NEIGHBORHOOD STABILITY	1.019608	34
CLIMATIC CONDITIONS	0.338235	31	KNOWLEDGE BASE	0.955882	35
MATURITY OF POLITICAL LEADERSHIP	0.338235	31	INTERNAL TURBULENCE	0.955882	35
NEIGHBORHOOD STABILITY	0.338235	31	CONSUMER SPENDING CHARACTERISTICS	0.955882	35

			(DEMOGRAPHY/CULTURE)		
BLIND BELIEF IN LEADERSHIP	0.338235	31	CLIMATIC CONDITIONS	0.897059	36
INTERNAL TURBULENCE	0.338235	31	DISASTER RISKS	0.843137	37
CONSUMER SPENDING CHARACTERISTICS (DEMOGRAPHY/CULTURE)	0.338235	31	IT COSTS	0.696078	38
INFLATION TREND	0.25	32	INFLATION TREND	0.651961	39
ROLE OF PARALLEL ECONOMY	0.132353	33	ROLE OF PARALLEL ECONOMY	0.377451	40
SOCIAL ETHOS (PRIDE IN WORK OF ANY TYPE IN LOCATION OF CHOICE)	0.132353	33	SOCIAL ETHOS (PRIDE IN WORK OF ANY TYPE IN LOCATION OF CHOICE)	0.343137	41
EDUCATION SYSTEM AND AVENUES	0.102941	34	EDUCATION SYSTEM AND AVENUES	0.254902	42
MEDICAL FACILITIES	0.078431	35	MEDICAL FACILITIES	0.205882	43
STANDARD OF LIVING OF PEOPLE IN LOCATION OF CHOICE	0.058824	36	STANDARD OF LIVING OF PEOPLE IN LOCATION OF CHOICE	0.166667	44
LINGUISTIC BARRIERS	0	37	USE OF VASTU SHASTRA	0.034314	45
USE OF VASTU SHASTRA	0	37	RELIGIOUS BELIEFS	0.004902	46
RELIGIOUS BELIEFS	0	37	LINGUISTIC BARRIERS	0	47

5.7 Case Study 2

In this case study, fifty-seven factors are taken into consideration for ranking as in case study 1 but the number of experts (responses) are fifty-six as against twenty as in case study 1. The data for fifty-six respondents is as shown in Appendix 1. The respondents were asked to input their responses in a linguistic scale as shown in Table 5.1. The responses from respondents are shown in Table 5.13 as sample. The responses are then converted to TFNs using the fuzzy scale as shown in Table 5.14.

Table 5.13: Sample survey responses

RESPONDANT	GOVERNMENT POLICIES FOR INDUSTRY	GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	POLITICAL SYSTEM	SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES
1	VERY HIGH INFLUENCE	VERY HIGH INFLUENCE	HIGH INFLUENCE	HIGH INFLUENCE
2	VERY HIGH INFLUENCE	VERY HIGH INFLUENCE	HIGH INFLUENCE	HIGH INFLUENCE
3	HIGH INFLUENCE	HIGH INFLUENCE	LOW INFLUENCE	HIGH INFLUENCE

Table 5.14: Sample responses represented as fuzzy numbers

RESPONDENT	GOVERNMENT POLICIES FOR INDUSTRY	GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	POLITICAL SYSTEM	SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES
1	(0.75,1,1)	(0.75,1,1)	(0.5,0.75,1)	(0.5,0.75,1)
2	(0.75,1,1)	(0.75,1,1)	(0.5,0.75,1)	(0.5,0.75,1)
3	(0.5,0.75,1)	(0.5,0.75,1)	(0.25,0.5,0.75)	(0.5,0.75,1)
4	(0.75,1,1)	(0.75,1,1)	(0.75,1,1)	(0.5,0.75,1)
5	(0.5,0.75,1)	(0.5,0.75,1)	(0.5,0.75,1)	(0.75,1,1)

5.7.1 Data validation using Cronbach's alpha

In case study 1, the collected sample data is directly used for analysis. This can lead to improper final decisions. The sample data needs to be validated for consistency. Cronbach's alpha, a measure for data validation is used in the present case study for data validation[250]. However, so far Cronbach's Alfa (α) test has never been carried out on fuzzy numbers. Hence, the authors have applied Cronbach's Alfa test on sample data using aggregate fuzzy values. The aggregate value of a triangular fuzzy number (a, b, c) is given as $\sqrt{\frac{1}{3}(a^2 + b^2 + c^2)}$ [251, 252]. Table 5.15 shows the conversion of fuzzy numbers as aggregate numbers in cells and the results of the Cronbach's Alfa test.

Table 5.15: Cronbach's Alfa results

Respondent	GOVERNMENT POLICIES FOR INDUSTRY	GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	POLITICAL SYSTEM	SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES
1	0.9242	0.9242	0.7773	0.7773
2	0.9242	0.9242	0.7773	0.7773
	-	-	-	-
56	0.7773	0.9242	0.5401	0.5401
VAR	0.0088	0.0141	0.0246	0.0242
K =57	Sigvar=1.5463	Var=22.9112	α=0.9492	

5.7.2 Sample calculations with aggregate fuzzy numbers

The aggregate fuzzy numbers are found from survey responses as shown in Table 5.16. The centroid values calculated from dominance matrix of aggregate values. Once all the centroids are calculated, positive centroids for each factor are summed up as one total in horizontal rows and negative centroids for each factor are summed up as one total in vertical rows. The total sum of positive and negative values as numbers is then summed up to calculate final numbers that will ensure ranking of the factors as shown in Table 5.17.

Table 5.16: Sample aggregate values

FACTOR 1	L	M	U
1	0.625	0.875	0.991071
2	0.580357	0.830357	0.973214
3	0.491071	0.736607	0.928571
4	0.504464	0.754464	0.928571

Table 5.17: Final ranking of factors based on fuzzy data based on aggregate values

FACTOR	SUM	WEIGHT	RANK
POWER SUPPLY	9.625003	0.059911	1
AVAILABILITY OF TRANSPORTATION FACILITY (ROAD/RAIL/PORTS/AIR)	9.124998	0.056799	2
GOVERNMENT POLICIES FOR INDUSTRY	9.043151	0.056289	3
WATER AVAILABILITY	7.757443	0.048286	4
GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	7.12649	0.044359	5
INFRASTRUCTURE AVAILABILITY	6.971729	0.043396	6
SUPPLIER CHARACTERISTICS (QUALITY/RELIABILITY)	5.833331	0.03631	7
TECHNOLOGY COST	5.61012	0.03492	8
TRANSPORTATION COSTS	5.391372	0.033559	9
AVAILABILITY OF UTILITY SERVICES (ASSISTANCE TO MAIN SERVICES)	5.248512	0.03267	10
GOVERNMENT INTERVENTION	5.108632	0.031799	11
AVAILABILITY OF SKILLED LABOUR	4.971722	0.030947	12
IMPACT OF INDUSTRIALIZATION ON ENVIRONMENT	4.101192	0.025528	13
SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES	3.970241	0.024713	14
POLITICAL SYSTEM	3.522321	0.021925	15
TAX STRUCTURE	3.272323	0.020369	16
LABOUR CHARACTERISTICS (EDUCATION/TRAINING	3.272323	0.020369	16

FACILITIES)			
LAND PRICE	3.153275	0.019628	17
KNOWLEDGE BASE	3.095237	0.019266	18
MARKET CHARACTERISTICS (CUSTOMER PROXIMITY/PURCHASING POWER)	2.982139	0.018562	19
FINANCIAL INCENTIVES	2.982139	0.018562	19
EMPLOYABILITY	2.92857	0.018229	20
ALTERNATE ENERGY SOURCES AND BACKUP	2.824406	0.017581	21
BUREAUCRATIC HURDLES	2.773809	0.017266	22
SALES & MARKETING COSTS	2.528275	0.015737	23
INDUSTRY COMPETITIVE SCENARIO	2.480652	0.015441	24
POLITICAL STABILITY	2.434521	0.015154	25
AVERAGE SALARIES PAID IN LOCATION OF CHOICE	2.122026	0.013209	26
DISASTER RISKS	2.122026	0.013209	26
MATURITY OF POLITICAL LEADERSHIP	1.955355	0.012171	27
EMPLOYEE INTEGRITY & ETHICS	1.834821	0.011421	28
AFFECT ON HEALTH OF PEOPLE DUE TO INDUSTRIES	1.834821	0.011421	28
HEALTH HAZARDS DUE TO INDUSTRIALIZATION	1.797621	0.011189	29
UNION FLEXIBILITY	1.654762	0.0103	30
MOTIVATION & ENTHUSIASM OF EMPLOYEES	1.586307	0.009874	31
IMPACT OF PRESENT INDUSTRY STATUS	1.520833	0.009466	32
GROSS DOMESTIC PRODUCT (GDP)	1.520833	0.009466	32
ECONOMIC STANDING OF THE COUNTRY OF LOCATION CHOICE	1.46131	0.009096	33
CONSTRUCTION COST IN LOCATION OF CHOICE	1.348214	0.008392	34
INTERNAL THREATS	1.241071	0.007725	35
IT COSTS	1.215774	0.007568	36
INFLATION TREND	1.072918	0.006678	37
EDUCATION SYSTEM AND AVENUES	0.98363	0.006123	38
CLIMATIC CONDITIONS	0.921132	0.005734	39
CONSUMER SPENDING CHARACTERISTICS (DEMOGRAPHY/CULTURE)	0.805059	0.005011	40
NEIGHBORHOOD STABILITY	0.751488	0.004678	41
INTERNAL TURBULENCE	0.751488	0.004678	41
SOCIAL ETHOS (PRIDE IN WORK OF ANY TYPE IN THE LOCATION OF CHOICE)	0.677084	0.004215	42
PER CAPITA INCOME IN LOCATION OF CHOICE	0.596727	0.003714	43
ROLE OF PARALLEL ECONOMY	0.572916	0.003566	44
TREND OF CURRENCY STRENGTH AGAINST U. S. DOLLAR OF THE COUNTRY OF LOCATION CHOICE	0.5625	0.003501	45

MEDICAL FACILITIES	0.526785	0.003279	46
LINGUISTIC BARRIERS	0.377975	0.002353	47
BLIND BELIEF IN LEADERSHIP	0.354167	0.002205	48
STANDARD OF LIVING OF PEOPLE IN LOCATION CHOICE	0.322916	0.00201	49
RELIGIOUS BELIEFS	0.028274	0.000176	50
USE OF VASTU SHASTRA	0	0	51

5.7.3 Case study 2 discussions

The case study validates the fact that increase in responses give better outputs for distinct rankings. In case study 1, the total ranks of fifty-seven factors were forty-seven and in case study 2 the ranks are fifty-one. Cronbach's Alfa test is used for validation of the responses. The Alfa value is calculated as 0.9492. Taber (2018) has proposed that the authors working on the research have to justify the Alfa value themselves as some of the researchers claim that the Alfa value can be very high due to redundancy in questions [250]. In the case study, the authors have considered different criteria affecting facility location decisions. If the experts treat some criteria on par then their scores will be similar for rankings, though the criteria are not same. Hence, the responses are used for further analysis. In this case study, the data validation for fuzzy numbers is carried out for the first time using Cronbach's Alfa and the results show that the incoming data is reliable. However, the proposed method however needs to be validated against a well-established method to prove its worth and the same is done in further sections.

5.8 Validation of Proposed Method

Fuzzy AHP, a well-known method is used for the validation of the proposed method. The conventional AHP is inadequate for dealing with the imprecise or vague nature of linguistic assessment. In fuzzy AHP [210, 237] common sense linguistic statements have been used in the pair-wise comparison which can be represented by the triangular fuzzy numbers. The Fuzzy Scale [253] used to convert linguistic variables to Triangular Fuzzy numbers is shown in Table 5.18.

Table 5.18: Scale for fuzzy AHP [253]

Equally Important	EI	(1,1,3)
Weakly Important	WI	(1,3,5)
Essential or Strongly Important	SI	(3,5,7)

Very Strongly Important	VSI	5,7,9)
Extremely Preferred	EP	(7,9,9)

5.8.1 Fuzzy AHP algorithm

The Fuzzy AHP algorithm suggested by Buckley (1985) for calculating weights using geometric mean is used for the analysis. The algorithm is presented earlier in section 3.6.2.1 in detail.

5.8.2 Fuzzy AHP used for large data matrix

Since its inception, Fuzzy AHP has found lot of importance in various applications wherein prioritization of criteria and alternative selection is required to be carried out. Fuzzy set theory [16], introduced to represent ambiguity was consequently extended for general decision making applications by Bellman and Zadeh, (1970) [20]. Fuzzy AHP was first proposed by Van Laarhoven and Pedrycz (1983), who proposed to replace precise pairwise comparisons with Triangular Fuzzy Numbers (TFNs) [210]. Since then, many methodologies have been proposed by researchers for improvement in outcomes [237, 254-257]. However, it is seen that the size of pairwise comparison matrix is still a limitation.

The past research on fuzzy AHP identifies the following areas of concern:

5.8.2.1. Consistency in pairwise comparisons

Consistency in pairwise comparisons has been a major hurdle in solving large matrices. Based on the early research on human information processing capacity [243], most of the researchers have restricted the number of criteria in matrix for making pairwise comparisons. Saaty (1977), founder of AHP, proposed Consistency Index (CI) and calculated Random Indexes (RI) up to matrix for fifteen criteria[258]. Donegan and Dodd (1991), Alonso and Lamata (2006) have worked on Consistency Ratio (CR) of large matrices [259, 260]. The paired comparisons are carried out by expert. If the comparisons are inconsistent then the entire process needs to be revised, thus consuming time.

5.8.2.2. Multilevel approach

Most of the researchers have solved the fuzzy AHP issues in various applications like Perfomance Evaluation, Education, Supplier Selection, Financial Performance, Priority Assessment, Construction Project Management, Cost Benefit Analysis by using minimum number of criteria to account for the consistency[143, 165, 167, 170, 177, 178, 181, 185, 189,

193, 197, 200, 204-208, 210, 214] .To overcome higher order matrix comparison consistency problems, the researchers have introduced multi-level formats for problems. So far in the literature problems are solved in various areas like knowledge management, human capital, safety management, bridge construction, ERP systems, personal selection, supplier selection, website quality evaluation, computer aided maintenance management systems, service quality in healthcare, production system performance, ICT service industry, new technology product, sustainable SCM, supplier selection, financial performance evaluation, coal pile safety, green design, risk analysis, ship operational energy efficiency measures, mining, performance measurement, sustainable development, internet of things, CSR drivers, reverse logistics, sectoral investments, risk assessment considering 2 levels [16, 141, 142, 144-149, 151-157, 159, 160, 162, 163, 166, 169, 171-173, 175, 179, 180, 182-184, 186-188, 190-192, 194-196, 198, 199, 201-203, 211, 212, 215, 251] and 3 levels [150, 158, 168, 174, 183, 188] . However, in multi-level formats, though the size of pairwise comparison is reduced, the number of matrices increases. Secondly, the importance of high impact local level criteria can reduce on global level if the global level is given less weightage.

5.8.2.3 Decision makers/ experts

The decision makers/experts form the focal point of solutions, as they carry out the major work of pairwise comparison. Finding experts in the relevant field for pairwise comparisons is difficult in real life situations and may act as a limitation. Further, in many research applications, exact number of experts is not specified [141, 144, 145, 147, 149-153, 156, 157, 160, 163, 165, 166, 168, 170, 172, 174, 177, 179, 183, 185, 188, 189, 195, 197, 199, 200, 202, 205-208, 210, 212, 251] .

5.8.3 Limitations of fuzzy AHP for solving large data matrix problems

Fuzzy AHP applications have been reviewed to identify the areas of concern. It is seen that the maximum number of criteria considered in the literature review carried out is 36 [184] and the problem is solved as a multi-level problem. The maximum criteria considered in single level problems are 20 [211]. For single level problems, each expert solves only one pairwise comparison matrix, but as the levels increase, the numbers of pairwise comparison matrix to be solved by each expert increases. For example, a three level problem [184], will have twelve pairwise comparisons. The exact number of experts is not mentioned in many research papers. In the present context, the authors have tried to identify key limitations from the literature review. The major limitation of using fuzzy AHP is the number of criteria to be considered. As the number of criteria increase, the difficulty in solving pairwise comparison

matrix increases. In such cases, the experts have to invest more time and mental efforts and in spite of doing so, the consistency may not be achieved. If the comparisons fail on consistency then the experts have to rework all the comparisons. In recent research papers, the criteria are further divided in global and local levels and the problem is formulated as a multi-level problem to account for reduced pairwise comparisons. Firstly, the number of comparison matrices increase in this case. Secondly, a criterion may lose its overall significance in spite of high local weightage due to low global weightage. Another limitation is the number of experts required. As seen in the literature, though there is no correlation between number of criteria and number of experts, it is obvious in statistical analysis that, as the sample size increases there is always a chance of getting better results. Whenever fuzzy AHP has been used in analysing real life situations, the literature shows either a few experts or number of experts has not been specified. The proposed methodology takes care of these limitations.

5.8.4 Proposed approach for solving large data matrix problems in fuzzy AHP

The same data from experts received in simple linguistic terms and converted to respective linguistic values needs to be used to validate the proposed method against Fuzzy AHP. Hence an innovative approach of mapping of data is introduced to take care of the incoming responses.

5.8.4.1 Mapping of data for fuzzy AHP calculations

Consider, a respondent has given fuzzy values for two criteria. The difference between the two will actually be the comparison between the two. The fuzzy Scale used in fuzzy AHP to convert linguistic variables to triangular fuzzy numbers is as shown in Table 5.18. The authors have devised an innovative method to map the experts' opinions in linguistic terms from Table 5.1 to fuzzy scale in Table 5.18.

Table 5.19: Mapping of data

FUZZY AHP SCALE	DIFFERENCE OF RESPONSES				
EI	VHI-VHI	HI- HI	LI-LI	VLI-VLI	NI-NI
WI	VHI-HI	HI-LI	LI-VLI	VLI-NI	
SI	VHI-LI	HI-VLI	LI-NI		
VSI	VHI-VLI	HI-NI			

EP	VHI-NI				

Table 5.19 shows the mapping of responses to comparisons. For example, if the respondent has to compare two criteria and has given equal opinion to both criteria i.e., both are given responses of high influence (HI) then the comparison matrix will map the difference to equally important (EI). Similarly, various combinations of responses are mapped to the fuzzy scale for comparisons. Here, the experts compare the criteria on individual basis and need not give pairwise comparison matrix as done in the existing research. Secondly, as the number of criteria increase, the consistency of opinions is a major issue. This too has been addressed by mapping methodology. The experts' time is saved as the input data taken from them is in simple format and then mapping of data helps in creating fuzzy AHP comparison matrices that can be solved using programming. Another advantage is the incoming data can be validated using data validation techniques. If the incoming data is not consistent, the experts can be asked to revise their opinions.

5.8.5 Fuzzy AHP calculations

The data used for proposed algorithm is thus mapped to fuzzy AHP matrix. As there are fifty-six respondents, fifty-six different pair wise comparisons are obtained. This was done using python program. The weights are calculated for each respondent and then added to get final weights as shown in following Tables. The final weights are then used to rank the factors. Table 5.20 shows sample data set for respondent 1 for fuzzy AHP mapping.

Table 5.20: Sample data set for respondent 1 for fuzzy AHP after mapping

	FACTOR				
	1	2	3	4	5
1	1,1,1	0.2,0.3333,1	1,3,5	1,3,5	1,3,5
2	1,3,5	1,1,1	3,5,7	3,5,7	5,7,9
3	0.2,0.3333,1	0.1428,0.2,0.3333	1,1,1	1,1,3	1,3,5
4	0.2,0.3333,1	0.1428,0.2,0.3333	1,1,3	1,1,1	1,3,5
5	0.1428,0.2,0.3333	0.1111,0.1428,0.2	0.2,0.3333,1	0.2,0.3333,1	1,1,1

The weights of individual respondent obtained after paired comparison for each criteria as shown in Appendix 2 are then added to get final weights and the ranking of factors is done accordingly using fuzzy AHP.

5.8.6 Fuzzy AHP ranking

The fuzzy AHP ranking after mapping of data is as shown in Table 5.21.

Table 5.21: Fuzzy AHP ranking

FACTOR	WEIGHT	RANK
POWER SUPPLY	0.028600335	1
AVAILABILITY OF TRANSPORTATION FACILITY (ROAD/RAIL/PORTS/AIR)	0.028068937	2
GOVERNMENT POLICIES FOR INDUSTRY	0.027388722	3
WATER AVAILABILITY	0.02539807	4
GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	0.02480975	5
INFRASTRUCTURE AVAILABILITY	0.024791391	6
SUPPLIER CHARACTERISTICS (QUALITY/RELIABILITY)	0.022484094	7
TECHNOLOGY COST	0.022199169	8
GOVERNMENT INTERVENTION	0.021651245	9
AVAILABILITY OF SKILLED LABOUR	0.021592806	10
AVAILABILITY OF UTILITY SERVICES (ASSISTANCE TO MAIN SERVICES)	0.021497162	11
TRANSPORTATION COSTS	0.021451837	12
SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES	0.020760025	13
IMPACT OF INDUSTRIALIZATION ON ENVIRONMENT	0.020520327	14
LABOUR CHARACTERISTICS (EDUCATION/TRAINING FACILITIES)	0.020261235	15
TAX STRUCTURE	0.019879095	16
POLITICAL SYSTEM	0.019647934	17
ALTERNATE ENERGY SOURCES AND BACKUP	0.019507237	18
MARKET CHARACTERISTICS (CUSTOMER PROXIMITY/PURCHASING POWER)	0.019416456	19
FINANCIAL INCENTIVES	0.01926987	20
BUREAUCRATIC HURDLES	0.019232258	21
LAND PRICE	0.018783668	22
EMPLOYABILITY	0.018629378	23
KNOWLEDGE BASE	0.018512127	24
POLITICAL STABILITY	0.018396257	25
DISASTER RISKS	0.017775793	26
INDUSTRY COMPETITIVE SCENARIO	0.017671455	27
SALES & MARKETING COSTS	0.017589595	28
AFFECT ON HEALTH OF PEOPLE DUE TO INDUSTRIES	0.017577281	29

MATURITY OF POLITICAL LEADERSHIP	0.01747216	30
EMPLOYEE INTEGRITY & ETHICS	0.017429419	31
HEALTH HAZARDS DUE TO INDUSTRIALIZATION	0.016819098	32
MOTIVATION & ENTHUSIASM OF EMPLOYEES	0.016705877	33
AVERAGE SALARIES PAID IN LOCATION OF CHOICE	0.016638556	34
UNION FLEXIBILITY	0.016154329	35
ECONOMIC STANDING OF THE COUNTRY OF LOCATION CHOICE	0.015881713	36
IMPACT OF PRESENT INDUSTRY STATUS	0.015792743	37
GROSS DOMESTIC PRODUCT (GDP)	0.015649635	38
INTERNAL THREATS	0.015006103	39
IT COSTS	0.014942806	40
EDUCATION SYSTEM AND AVENUES	0.014600788	41
CONSTRUCTION COST IN LOCATION OF CHOICE	0.014587525	42
CLIMATIC CONDITIONS	0.014553082	43
INFLATION TREND	0.014362238	44
CONSUMER SPENDING CHARACTERISTICS (DEMOGRAPHY/CULTURE)	0.013505142	45
INTERNAL TURBULENCE	0.013436689	46
TREND OF CURRENCY STRENGTH AGAINST U. S. DOLLAR OF THE COUNTRY OF LOCATION CHOICE	0.013419649	47
NEIGHBORHOOD STABILITY	0.013317429	48
SOCIAL ETHOS (PRIDE IN WORK OF ANY TYPE IN THE LOCATION OF CHOICE)	0.013210179	49
MEDICAL FACILITIES	0.012746053	50
PER CAPITA INCOME IN LOCATION OF CHOICE	0.012387195	51
ROLE OF PARALLEL ECONOMY	0.011921057	52
STANDARD OF LIVING OF PEOPLE IN LOCATION CHOICE	0.011185724	53
LINGUISTIC BARRIERS	0.010779927	54
BLIND BELIEF IN LEADERSHIP	0.010762634	55
RELIGIOUS BELIEFS	0.006825639	56
USE OF VASTU SHASTRA	0.006543101	57

5.9 Fuzzy AHP Ranking Discussions

5.9.1 Data consistency

As the data is mapped, the inconsistency arising due to human perception in pairwise comparisons is taken care off. To check for Data Consistency, estimations of Random index (RI) of Donegan and Dodd (1991) and Alonso and Lamata (2006) have been used [259, 260].

Donegan and Dodd (1991), have presented the values of RI for matrix order of 50 and 60 as 1.6102 and 1.6178 respectively. As the matrix in case study is of the order of 57, an interpolated RI value of 1.6155 for calculations has been used.

Alonso and Lamata (2006) have suggested methods to calculate RI for higher number of criteria. They have proved that squared adjustment curve as RI estimator decreases after reaching maximum and hence is not a good estimator. In the next attempt, a cube function adjustment curve is tested and as it increases exponentially with increased number of criteria, they have disapproved its use for RI estimation.

The cubic curve is given as

$$RI(n) = 0.00149\, n^3 - 0.05121\, n^2 + 0.59150\, n - 0.79124 \quad (5.7)$$

Alonso and Lamata have used a least square line to estimate RI using $\bar{\lambda}_{max}$i. e. the largest principal eigen value) and have proposed that the least square line estimate is very accurate as an RI estimator.

The equation is given as

$$\bar{\lambda}_{max}(n) = 2.7699\, n - 4.3513 \quad (5.8)$$

However, it is noticed that the calculated values of Table 4 of [260] of RI and $\bar{\lambda}_{max}$ for the number of matrix above 15 do not match with the equation 5.8. Hence the following equation has been introduced based on the calculated values in the Table.

$$\bar{\lambda}_{max}(n) = 2.7698\, n - 4.35016 \quad (5.9)$$

Though Alonso and Lamata (2006) have mentioned that equation 5.7 is not a good choice, but for the reason that RI increases with the number of criteria, the equation has been used for CR calculations along with equations 5.8 and 5.9. Although the data input for case study is in fuzzy format, for consistency check the authors have used mapped linear scales as the consistency check is on same data [262]. Table 5.22 shows mapping scales with increments of 1 and 2. The mapped data is converted to ordinary scale i. e. {1, 3, 5, 7, 9} with increment of 2. It should be noted that Saaty's scale has values of {1, 2, 3, 4, 5, 6, 7, 8, 9} with increment of 1 which is the basis of all RI calculations. To match this scale, CI calculations are done with a scale of {1, 2, 3, 4, 5} with increment of 1 and scale of {1, 3, 5, 7, 9} with increment of 2, to crosscheck the results. In theory for best consistency, CR has to be less than 0.1. But it is seen in literature that CR up to 0.2 is also tolerable [263]. Klaus (2014) in his article has stated that the acceptance of CR depends on nature of problem and will vary based on the scale constructed and number of criteria [264]. He has also achieved CR values of 0.3, as stated in his article. Table 5.23 shows the calculated values of CIs and CRs. The equations 5.7, 5.8 and 5.9 are referred as Eq1, Eq2 and Eq3 respectively in Table 5.23 and further in

Figures 5.3 and 5.4. The results obtained using 2 input scales i.e single incremental mapping scale and double incremental mapping scale are shown in Fig. 5.3 and Fig. 5.4. The results with Alonso and Lamata (2006) equations show CRs for equation 5.7 to be far below 0.1 for both input scales. Further using equations 5.8 and 5.9, the average CR for 56 respondents is 0.1377 and 0.1437 with input scale of increment 1 and 0.3438 and 0.3588 with input scale of increment 2. The CR is 0.1469 with single incremental mapping scale and is 0.3669 with double incremental mapping scale using RI proposed by Donegan and Dodd (1991). The RIs used are calculated using single incremental mapping scale and this may be the reason for higher CRs for double incremental mapping scale. This opens up a broader research area for creating lower incremental scales with lower range for higher order matrices. The RI curve shown by Alonso and Lamata (2006) tends to flatten as the number of criteria increase above a certain point leading to a research question. Secondly, the limit of CR for higher order matrices is also an area of concern.

Table 5.22: Mapped scales for CR calculations (increment 1 and increment 2)

Linguistic term	Fuzzy Term	Increment 1	Increment 2
Equally Important (EI)	(1,1,3)	1	1
Weakly Important (WI)	(1,3,5)	2	3
Essential or Strongly Important (SI)	(3,5,7)	3	5
Very Strongly Important (VSI)	(5,7,9)	4	7
Extremely Preferred (EP)	(7,9,9)	5	9

Table 5.23: CI and CR values

APPROACH	ALONSO & LAMATA (2006)				DONEGAN & DODD (1991)	ALONSO & LAMATA (2006)				DONEGAN & DODD (1991)
INCREMENTS	1 (1,2,3,4,5)					2 (1,3,5,7,9)				
RI=		142.48	1.7237	1.6516	1.6155	RI=	142.48	1.7237	1.6516	1.6155
RESPONDENT	CI	CR			CR	CI	CR			CR
		Eq1	Eq2	Eq3			Eq1	Eq2	Eq3	
1	0.1996	0.0014	0.1158	0.1208	0.1235	0.4994	0.0035	0.2897	0.3024	0.3092
2	0.1585	0.0011	0.092	0.096	0.0981	0.4144	0.0029	0.2404	0.2509	0.2565
3	0.1565	0.0011	0.0908	0.0947	0.0968	0.3956	0.0028	0.2295	0.2395	0.2449
4	0.1673	0.0012	0.0971	0.1013	0.1036	0.4354	0.0031	0.2526	0.2636	0.2695
5	0.1575	0.0011	0.0914	0.0953	0.0975	0.411	0.0029	0.2384	0.2489	0.2544
6	0.1575	0.0011	0.0914	0.0953	0.0975	0.411	0.0029	0.2384	0.2489	0.2544
7	0.2964	0.0021	0.172	0.1795	0.1835	0.7331	0.0051	0.4253	0.4439	0.4538

8	0.2483	0.0017	0.1441	0.1503	0.1537	0.6171	0.0043	0.358	0.3736	0.382
9	0.1421	0.001	0.0825	0.0861	0.088	0.3704	0.0026	0.2149	0.2243	0.2293
10	0.3034	0.0021	0.176	0.1837	0.1878	0.7489	0.0053	0.4345	0.4534	0.4636
11	0.1482	0.001	0.086	0.0897	0.0917	0.3858	0.0027	0.2238	0.2336	0.2388
12	0.3019	0.0021	0.1751	0.1828	0.1869	0.7504	0.0053	0.4353	0.4543	0.4645
13	0.3782	0.0027	0.2194	0.229	0.2341	0.9223	0.0065	0.535	0.5584	0.5709
14	0.3131	0.0022	0.1817	0.1896	0.1938	0.775	0.0054	0.4496	0.4693	0.4798
15	0.2037	0.0014	0.1182	0.1233	0.1261	0.5198	0.0036	0.3016	0.3147	0.3218
16	0.3784	0.0027	0.2195	0.2291	0.2342	0.9214	0.0065	0.5345	0.5578	0.5703
17	0.0459	0.0003	0.0267	0.0278	0.0284	0.1103	0.0008	0.064	0.0668	0.0683
18	0.233	0.0016	0.1352	0.1411	0.1442	0.5888	0.0041	0.3416	0.3565	0.3645
19	0.2103	0.0015	0.122	0.1273	0.1302	0.5363	0.0038	0.3111	0.3247	0.332
20	0.2354	0.0017	0.1366	0.1425	0.1457	0.5958	0.0042	0.3457	0.3607	0.3688
21	0.2354	0.0017	0.1366	0.1425	0.1457	0.5958	0.0042	0.3457	0.3607	0.3688
22	0.2194	0.0015	0.1273	0.1328	0.1358	0.5572	0.0039	0.3233	0.3374	0.3449
23	0.2791	0.002	0.1619	0.169	0.1728	0.6912	0.0049	0.401	0.4185	0.4279
24	0.2359	0.0017	0.1369	0.1428	0.146	0.5983	0.0042	0.3471	0.3623	0.3704
25	0.2967	0.0021	0.1721	0.1796	0.1837	0.7355	0.0052	0.4267	0.4453	0.4553
26	0.2455	0.0017	0.1424	0.1486	0.1519	0.6198	0.0044	0.3596	0.3753	0.3837
27	0.2303	0.0016	0.1336	0.1394	0.1425	0.5851	0.0041	0.3394	0.3542	0.3622
28	0.3615	0.0025	0.2097	0.2189	0.2238	0.884	0.0062	0.5128	0.5352	0.5472
29	0.2575	0.0018	0.1494	0.1559	0.1594	0.6467	0.0045	0.3752	0.3916	0.4003
30	0.2605	0.0018	0.1511	0.1577	0.1613	0.6433	0.0045	0.3732	0.3895	0.3982
31	0.1951	0.0014	0.1132	0.1181	0.1208	0.5001	0.0035	0.2902	0.3028	0.3096
32	0.1463	0.001	0.0849	0.0886	0.0906	0.3848	0.0027	0.2232	0.233	0.2382
33	0.2253	0.0016	0.1307	0.1364	0.1395	0.5598	0.0039	0.3248	0.3389	0.3465
34	0.3705	0.0026	0.215	0.2243	0.2294	0.9037	0.0063	0.5243	0.5472	0.5594
35	0.1752	0.0012	0.1017	0.1061	0.1085	0.4545	0.0032	0.2637	0.2752	0.2813
36	0.0548	0.0004	0.0318	0.0332	0.0339	0.1462	0.001	0.0848	0.0885	0.0905
37	0.1855	0.0013	0.1076	0.1123	0.1148	0.4785	0.0034	0.2776	0.2897	0.2962
38	0.228	0.0016	0.1323	0.138	0.1411	0.5786	0.0041	0.3357	0.3503	0.3581
39	0.1693	0.0012	0.0982	0.1025	0.1048	0.4389	0.0031	0.2546	0.2657	0.2717
40	0.1233	0.0009	0.0715	0.0747	0.0763	0.3253	0.0023	0.1887	0.197	0.2014

41	0.5768	0.004	0.3346	0.3492	0.357	1.3561	0.0095	0.7868	0.8211	0.8395
42	0.1046	0.0007	0.0607	0.0634	0.0648	0.275	0.0019	0.1595	0.1665	0.1702
43	0.44	0.0031	0.2553	0.2664	0.2724	1.0574	0.0074	0.6135	0.6402	0.6546
44	0.2544	0.0018	0.1476	0.154	0.1575	0.6364	0.0045	0.3692	0.3853	0.3939
45	0.3059	0.0021	0.1775	0.1852	0.1894	0.7488	0.0053	0.4344	0.4534	0.4635
46	0.1766	0.0012	0.1025	0.1069	0.1093	0.4559	0.0032	0.2645	0.276	0.2822
47	0.1729	0.0012	0.1003	0.1047	0.107	0.4484	0.0031	0.2602	0.2715	0.2776
48	0.1966	0.0014	0.114	0.119	0.1217	0.5027	0.0035	0.2917	0.3044	0.3112
49	0.3791	0.0027	0.2199	0.2295	0.2347	0.9222	0.0065	0.535	0.5583	0.5708
50	0.2258	0.0016	0.131	0.1367	0.1398	0.5619	0.0039	0.326	0.3402	0.3478
51	0.1933	0.0014	0.1121	0.117	0.1197	0.4961	0.0035	0.2878	0.3003	0.3071
52	0.2622	0.0018	0.1521	0.1588	0.1623	0.6522	0.0046	0.3784	0.3949	0.4037
53	0.1828	0.0013	0.106	0.1107	0.1131	0.4104	0.0029	0.2381	0.2485	0.254
54	0.3548	0.0025	0.2058	0.2148	0.2196	0.8666	0.0061	0.5027	0.5247	0.5364
55	0.2123	0.0015	0.1231	0.1285	0.1314	0.536	0.0038	0.311	0.3245	0.3318
56	0.322	0.0023	0.1868	0.1949	0.1993	0.7926	0.0056	0.4598	0.4799	0.4906
AVERAGE		0.0017	0.1377	0.1437	0.1469		0.0042	0.3438	0.3588	0.3669

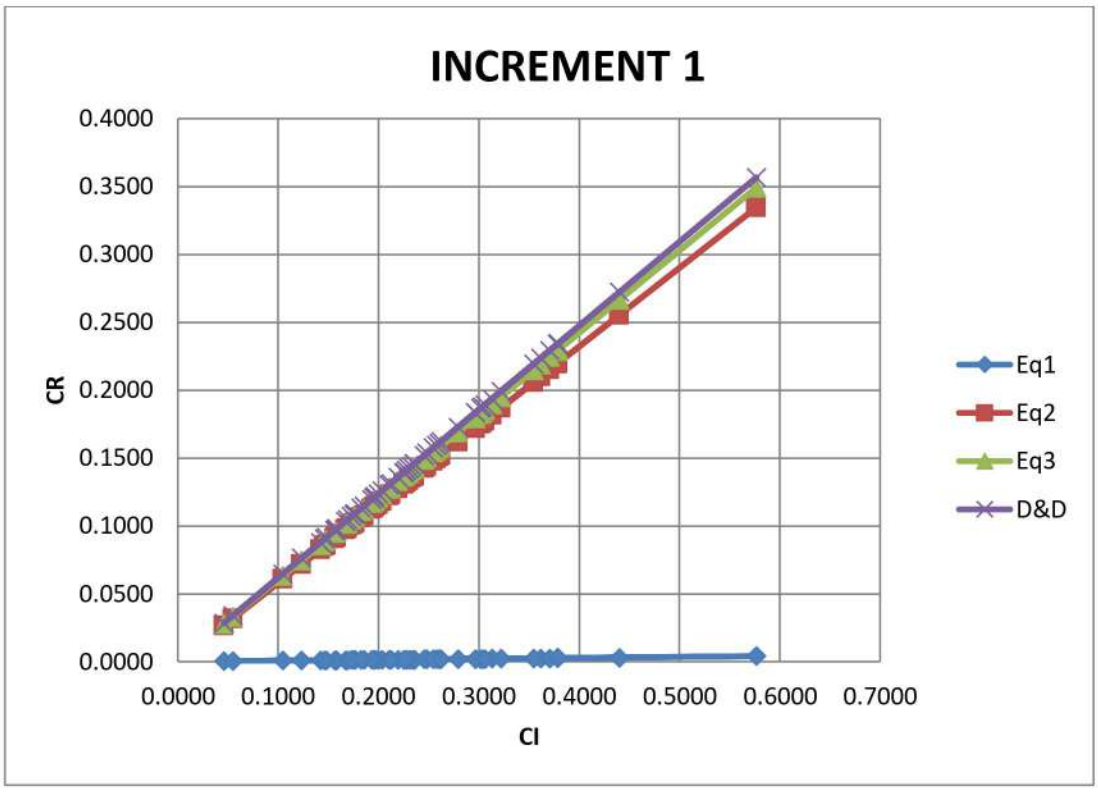

Figure 5.3: CR values with mapping scale of increment 1

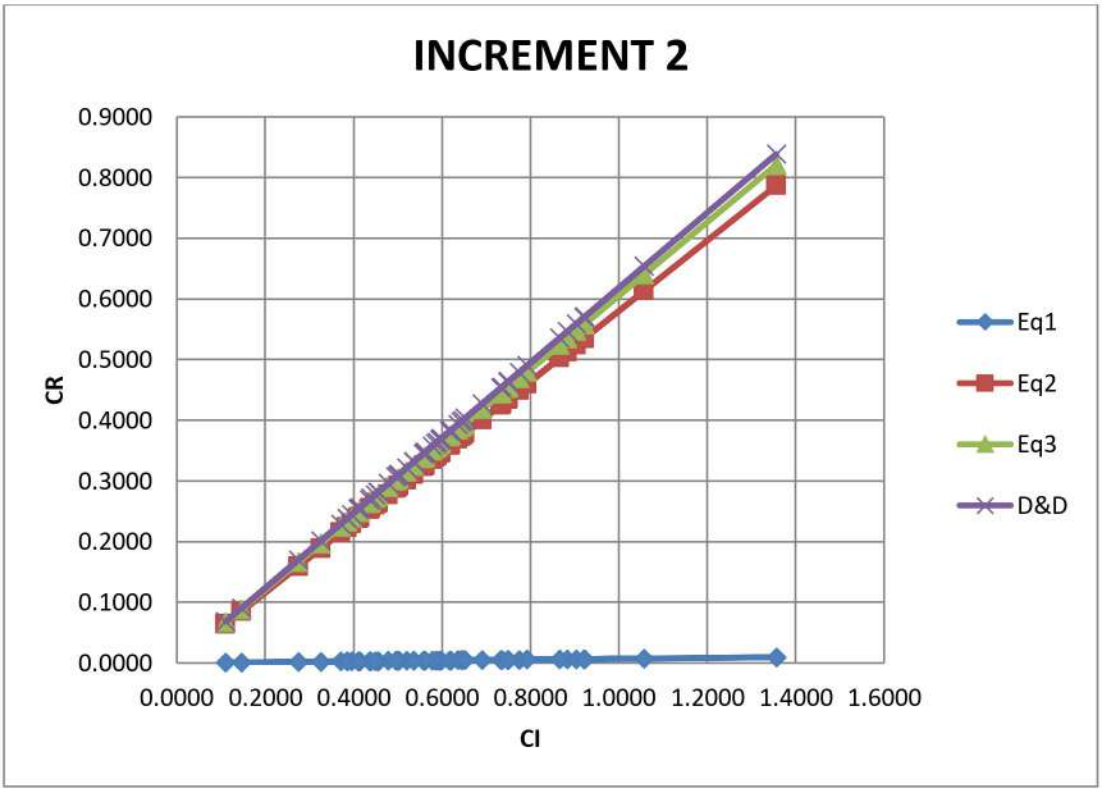

Figure 5.4: CR values with mapping scale of increment 2

5.9.2 Data ranking

The responses of fifty-six experts have been considered for calculations. The ranking of the data is as per the calculations in fuzzy AHP based on expert's weights as shown in Table 5.24. The data to be collected from experts is in a very simple and time efficient format. The experts' opinions are taken in linguistic terms on individual criteria and the need for pairwise comparison by expert is eliminated. This also allows participation of a larger number of experts. The data validation is taken care by the problem solvers. As all the criteria are compared directly with each other, the global and local level limitation is eliminated. As this is a sample case study, the incoming data is directly considered as input after the data validation. However, the entire data can be further screened with the use of statistical tools for variations further requesting experts for revisions and more robust reliable data can be used. Further, weights may be allotted to categorize the experts so that more precise solutions can be obtained. If the individual CR values are considered instead of average CR values, the results of respondents having higher CRs can be ignored and the results of respondents having lower CRs can be used for further analysis as per the intensity of the case study carried out. It is seen from the CR calculations that respondents 13, 16, 28, 34, 41, 43, 49 and 54 have very high CRs. if the decision making of these respondents is not considered then, the average CRs fall to 0.1215, 0.1268 and 0.1295 for single increment mapping scale and 0.3064, 0.3198 and 0.3267 with double incremental mapping scale.

5.10 Comparison of Proposed Method and Fuzzy AHP Results

The ranking of factors obtained by proposed method and fuzzy AHP is compared for analysis. For comparisons the ranking of fuzzy AHP with all fifty-six respondents' inputs is taken into consideration as the ranks of proposed method are with fifty-six respondents. The rankings if seen closely do not differ much as seen in Table 5.24. The results show that there is no much difference between ranking by fuzzy AHP and ranking by proposed method. In Table 5.24, there are two columns made for proposed method ranking. This is to know the difference between the rankings of two methods considering a rank skip for the immediate next criteria when two criteria are ranked at same level.

Table 5.24: Comparison of ranking results

FACTOR	FAHP RANK	PROPOSED METHOD RANK (ACTUAL)	PROPOSED METHOD RANK (WITH SKIP)	DIFFERENCE (FAHP & SKIP)
POWER SUPPLY	1	1	1	0
AVAILABILITY OF TRANSPORTATION FACILITY (ROAD/RAIL/PORTS/AIR)	2	2	2	0
GOVERNMENT POLICIES FOR INDUSTRY	3	3	3	0
WATER AVAILABILITY	4	4	4	0
GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	5	5	5	0
INFRASTRUCTURE AVAILABILITY	6	6	6	0
SUPPLIER CHARACTERISTICS (QUALITY/RELIABILITY)	7	7	7	0
TECHNOLOGY COST	8	8	8	0
GOVERNMENT INTERVENTION	9	11	11	-2
AVAILABILITY OF SKILLED LABOUR	10	12	12	-2
AVAILABILITY OF UTILITY SERVICES (ASSISTANCE TO MAIN SERVICES)	11	10	10	1
TRANSPORTATION COSTS	12	9	9	3
SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES	13	14	14	-1
IMPACT OF INDUSTRIALIZATION ON ENVIRONMENT	14	13	13	1
LABOUR CHARACTERISTICS (EDUCATION/TRAINING FACILITIES)	15	16	16	-1
TAX STRUCTURE	16	16	16	0
POLITICAL SYSTEM	17	15	15	2
ALTERNATE ENERGY SOURCES AND BACKUP	18	21	23	-5
MARKET CHARACTERISTICS (CUSTOMER PROXIMITY/ PURCHASING POWER)	19	19	20	-1
FINANCIAL INCENTIVES	20	19	20	0

BUREAUCRATIC HURDLES	21	22	24	-3
LAND PRICE	22	17	18	4
EMPLOYABILITY	23	20	22	1
KNOWLEDGE BASE	24	18	19	5
POLITICAL STABILITY	25	25	27	-2
DISASTER RISKS	26	26	28	-2
INDUSTRY COMPETITIVE SCENARIO	27	24	26	1
SALES & MARKETING COSTS	28	23	25	3
AFFECT ON HEALTH OF PEOPLE DUE TO INDUSTRIES	29	28	31	-2
MATURITY OF POLITICAL LEADERSHIP	30	27	30	0
EMPLOYEE INTEGRITY & ETHICS	31	28	31	0
HEALTH HAZARDS DUE TO INDUSTRIALIZATION	32	29	33	-1
MOTIVATION & ENTHUSIASM OF EMPLOYEES	33	31	35	-2
AVERAGE SALARIES PAID IN LOCATION OF CHOICE	34	26	28	6
UNION FLEXIBILITY	35	30	34	1
ECONOMIC STANDING OF THE COUNTRY OF LOCATION CHOICE	36	33	38	-2
IMPACT OF PRESENT INDUSTRY STATUS	37	32	36	1
GROSS DOMESTIC PRODUCT (GDP)	38	32	36	2
INTERNAL THREATS	39	35	40	-1
IT COSTS	40	36	41	-1
EDUCATION SYSTEM AND AVENUES	41	38	43	-2
CONSTRUCTION COST IN LOCATION OF CHOICE	42	34	39	3
CLIMATIC CONDITIONS	43	39	44	-1
INFLATION TREND	44	37	42	2
CONSUMER SPENDING CHARACTERISTICS (DEMOGRAPHY/CULTURE)	45	40	45	0
INTERNAL TURBULENCE	46	41	46	0
TREND OF CURRENCY STRENGTH AGAINST U. S. DOLLAR OF THE COUNTRY OF LOCATION CHOICE	47	45	51	-4

NEIGHBORHOOD STABILITY	48	41	46	2
SOCIAL ETHOS (PRIDE IN WORK OF ANY TYPE IN THE LOCATION OF CHOICE)	49	42	48	1
MEDICAL FACILITIES	50	46	52	-2
PER CAPITA INCOME IN LOCATION OF CHOICE	51	43	49	2
ROLE OF PARALLEL ECONOMY	52	44	50	2
STANDARD OF LIVING OF PEOPLE IN LOCATION CHOICE	53	49	55	-2
LINGUISTIC BARRIERS	54	47	53	1
BLIND BELIEF IN LEADERSHIP	55	48	54	1
RELIGIOUS BELIEFS	56	50	56	0
USE OF VASTU SHASTRA	57	51	57	0

5.11 Validation Using Correlation Methods

To validate the correlation between the proposed and fuzzy AHP results, Spearman rank correlation method and Kendall's coefficient of concordance method [265, 266] are used as follows.

5.11.1 Spearman rank correlation

Spearman rank correlation is a non-parametric test that is used to measure the degree of association between two variables.

Spearman rank correlation is given by

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)} \tag{5.10}$$

where,

ρ= Spearman rank correlation coefficient

d_i= the difference between the ranks of corresponding variables

n= number of observations

Using data from Table 5.24, the Spearman rank correlation coefficient is calculated as 0.99924, which is within -1 and +1 and proving very strong correlation [265].

5.11.2 Kendall's coefficient of concordance 'W'

The Kendall's coefficient of concordance 'W' is given as

$$W = \frac{12R}{m^2(k^3-k)} \tag{5.11}$$

Where,

$R = \sum_{i=1}^{k}(R_i - \overline{R})^2$

$R_i = \sum_{j=1}^{m} r_{ij}$

m= number of raters (experts)

n = number of subjects (criteria)

r_{ij} = the rating rater j gives to subject i

R_i= summation of the ratings given by rater to the subject

$\overline{R}$ = mean of R_i

R = squared deviation

In this method, first we add the ranks and then find deviation to get mean. The calculations result in Kendall's Tau value to be 0.9378 which shows very strong correlation of ranks[266].

5.12 Validation of Methods Using Random Data

As seen in 5.11, the results of the proposed method as well as the existing fuzzy AHP method for ranking of factors are compared by Spearman's coefficient for correlation and Kendall's coefficient of concordance method and it is observed that there is a strong positive co relationship between the rankings of both the methods. To ensure that the method gives correct results, 100 data sets are generated randomly and the data generated is used for solving the problem using both fuzzy AHP and proposed method for three cases i.e. with 50, 100 and 300 respondents. The spearman's coefficients calculated for all three cases shows that both the methods have very strong positive co relationship.

5.12.1 Generating random data

One hundred random data sets are generated by python program for fifty-seven criteria with 50, 100 and 300 respondents. The data sets generated are used for ranking using fuzzy AHP and proposed method. As a total of 100 data sets with 50, 100 and 300 no. of respondents, in each data set, 50, 100 and 300 comparison matrices have to be generated. In the present exercise therefore, a total of 5000, 10000 and 30000 comparison matrices are generated in the three cases respectively. Whereas in proposed method for random data set validation, only 100 paired comparison matrices are generated in all the three cases for 100 data sets (for each

data set only one matrix is generated) proving as a major advantage over fuzzy AHP. If the problem was to be actually solved in real-time using field data, the time taken for each expert to fill up a fifty-seven-size matrix would be very high. Moreover, patience of the expert is put to test as he has to compare each factor with fifty-seven other factors for comparison values. In real life situations, this is a tedious and time-consuming job. On the other hand, in proposed method, the respondents are asked to input only one value against each factor and comparison is taken care by the proposed method. The researcher working on large data comparisons will always find it difficult to use fuzzy AHP for comparison as he will have to identify experts who have a lot of free time. But in real life situations it is impossible to find experts with free time.

5.12.2 Spearman's coefficient for random data

The ranking for 100 data sets with the three cases of 50, 100 and 300 respondents, using fuzzy AHP and proposed method is then tested for co-relationship using Spearman's coefficient correlation. Table 5.25 shows Spearman's coefficients for 100 data sets for the three cases i.e. with 50, 100 and 300 experts. The average value of Spearman's coefficient for 100 data sets with 50 experts is 0.945612, 100 experts is 0.942802 and 300 experts is 0.944662 respectively, thus proving very strong correlation between both the methods[265]. Further, change in number of experts does not change the strength of correlation in randomly generated data sets.

Table 5.25: Spearman's coefficients for 100 data sets with 50, 100 and 300 experts

50 EXPERTS				100 EXPERTS				300 EXPERTS			
NO	ρ	NO	ρ	NO	P	NO	P	NO	ρ	NO	P
1	0.944864	51	0.974944	1	0.943667	51	0.953392	1	0.942244	51	0.956911
2	0.953596	52	0.950717	2	0.978219	52	0.95352	2	0.95978	52	0.950395
3	0.945178	53	0.896452	3	0.942546	53	0.957491	3	0.944557	53	0.918083
4	0.949194	54	0.966803	4	0.950311	54	0.943878	4	0.951157	54	0.962079
5	0.961202	55	0.946939	5	0.934224	55	0.941281	5	0.938839	55	0.963636
6	0.94396	56	0.945383	6	0.941966	56	0.956684	6	0.95041	56	0.932601
7	0.939626	57	0.943932	7	0.947474	57	0.939697	7	0.944854	57	0.944709
8	0.950303	58	0.93608	8	0.922551	58	0.93302	8	0.9497	58	0.948774
9	0.908802	59	0.912957	9	0.926481	59	0.93568	9	0.9555	59	0.939213
10	0.959627	60	0.952836	10	0.962061	60	0.960927	10	0.953829	60	0.955062
11	0.925999	61	0.907765	11	0.939617	61	0.954509	11	0.967039	61	0.923074
12	0.95363	62	0.955625	12	0.94931	62	0.912132	12	0.910782	62	0.960476

13	0.940877	63	0.955218	13	0.973828	63	0.95412	13	0.946783	63	0.974558
14	0.94919	64	0.920848	14	0.958431	64	0.926927	14	0.968612	64	0.93482
15	0.953628	65	0.967442	15	0.955937	65	0.914271	15	0.940282	65	0.916195
16	0.968331	66	0.941773	16	0.952372	66	0.928564	16	0.944011	66	0.948027
17	0.948087	67	0.954025	17	0.924152	67	0.965321	17	0.936397	67	0.941983
18	0.938499	68	0.942572	18	0.943243	68	0.940412	18	0.871079	68	0.91372
19	0.95506	69	0.961879	19	0.952616	69	0.963017	19	0.970976	69	0.942113
20	0.960241	70	0.93788	20	0.942984	70	0.947739	20	0.88827	70	0.96336
21	0.953082	71	0.957274	21	0.920299	71	0.949818	21	0.957965	71	0.954201
22	0.959256	72	0.967683	22	0.940877	72	0.929871	22	0.945731	72	0.948965
23	0.947786	73	0.888021	23	0.970196	73	0.941769	23	0.933932	73	0.928742
24	0.945209	74	0.926504	24	0.946862	74	0.940995	24	0.931821	74	0.934044
25	0.899407	75	0.954691	25	0.958055	75	0.918674	25	0.927659	75	0.961058
26	0.900566	76	0.939624	26	0.957851	76	0.91628	26	0.940755	76	0.941417
27	0.965171	77	0.942107	27	0.940557	77	0.962076	27	0.944791	77	0.961206
28	0.958911	78	0.955854	28	0.936968	78	0.938988	28	0.94803	78	0.966245
29	0.948378	79	0.943636	29	0.936635	79	0.95511	29	0.947058	79	0.946278
30	0.968707	80	0.912925	30	0.973386	80	0.883371	30	0.907282	80	0.927757
31	0.93753	81	0.946906	31	0.914383	81	0.912712	31	0.940948	81	0.954284
32	0.955544	82	0.922795	32	0.959304	82	0.964555	32	0.946215	82	0.942502
33	0.960472	83	0.951413	33	0.945809	83	0.945093	33	0.962811	83	0.967751
34	0.893971	84	0.965401	34	0.955514	84	0.95384	34	0.948371	84	0.959763
35	0.960665	85	0.946176	35	0.961444	85	0.949893	35	0.944885	85	0.962112
36	0.934993	86	0.966339	36	0.955191	86	0.937914	36	0.94795	86	0.972712
37	0.925698	87	0.934075	37	0.934141	87	0.958658	37	0.943962	87	0.937705
38	0.972969	88	0.94172	38	0.922386	88	0.956822	38	0.926901	88	0.939636
39	0.949161	89	0.947587	39	0.948759	89	0.951514	39	0.943443	89	0.952017
40	0.935985	90	0.953307	40	0.934336	90	0.944941	40	0.929444	90	0.936866
41	0.960858	91	0.965773	41	0.930241	91	0.944366	41	0.936784	91	0.932309
42	0.95736	92	0.968972	42	0.942904	92	0.947689	42	0.93286	92	0.941708
43	0.94715	93	0.931054	43	0.957948	93	0.92923	43	0.95187	93	0.962015
44	0.956098	94	0.933184	44	0.957152	94	0.936892	44	0.949637	94	0.961967
45	0.937832	95	0.919678	45	0.931058	95	0.937251	45	0.948515	95	0.938519
46	0.958633	96	0.924857	46	0.924575	96	0.948563	46	0.951754	96	0.892958
47	0.944313	97	0.963129	47	0.911127	97	0.911755	47	0.954073	97	0.960229
48	0.937314	98	0.954687	48	0.918417	98	0.917512	48	0.956133	98	0.962353
49	0.97885	99	0.949223	49	0.954074	99	0.923045	49	0.915228	99	0.955905
50	0.960878	100	0.951881	50	0.946614	100	0.959371	50	0.958724	100	0.962567

5.13 Advantages of Proposed Method over Fuzzy AHP

Although most of the decision making methods are considered to work with less number of decision makers as the existing literature has not given much importance to the number of experts to be considered for the conduct of the group decision techniques like AHP, decision making for large data problems will be reliable if the number of experts is substantial [249]. The proposed method has a major advantage of including a greater number of experts for data inputs leading to stronger and unbiased inferences. Considering time complexity of the algorithm, the proposed method output takes very less time as compared to the fuzzy AHP. As the number of pair-wise comparisons to be made depend on experts considering individual decision making, the space complexity also proves advantageous for proposed method as there is only one pair-wise comparison matrix to be solved regardless of number of experts. The distinct advantage of this method is that the reliability of incoming data can be checked as the data is considered in totality for obtaining final solution. In case for particular criteria, the opinions are totally different, the aggregation of those criteria will be of average value. For eg. if we have only five respondents, and all give different responses, the aggregation will be average thus getting response for that criteria to be average. In such cases, there is a possibility of going back to the respondents and getting the inputs redone. In case of fuzzy AHP, the criteria are compared to each other on individual expert basis. Thereby, we get weights of criteria against each other for each expert. These weights are added in the end. The response of each expert for each criterion is not known and such situation can lead to misleading results. The proposed method takes care of considering response of each expert for a given criteria and aggregates the response gaining a major advantage over fuzzy AHP.

5.14 Summary

In this chapter, the factors identified using PESTLE in previous chapter are ranked. A new fuzzy method is proposed in line with ranking by paired comparison to take care of large data matrix. There are 2 case studies presented. In the first case study, the proposed method is used for a data set of 20 responses and average and aggregate fuzzy numbers are used for analysis. The results show that the use of aggregate fuzzy numbers in analysis yield better results. To account for distinct ranking, the sample size is increased to 56 in the second case study and analysis is carried out using aggregate fuzzy numbers. The data is also validated for reliability using Cronbach's Alfa test which is used for the first time for fuzzy data in this research. The proposed method is validated against this existing fuzzy AHP method. As fuzzy AHP has a limitation of solving large data matrix on a single level, a novel mapping approach is

proposed to solve the large data matrix problems using fuzzy AHP. The results are checked for correlation and the correlation proves to be very strong with the Spearman coefficient value of 0.99924 and Kendall's tau value of 0.9374 further justifying that the rank results obtained by both the methods are similar. Randomly generated data sets are used for three cases of 100 data sets with 50,100 and 300 experts give average values of around 0.94 proving the results of proposed method and fuzzy AHP are very strongly correlated. The advantages of proposed method over fuzzy AHP in terms of time and space complexity are discussed at the end of the chapter. In the next chapter, the proposed method is extended as a risk based ranking method for use in dynamic environment to account for the dormant factors that can surface unexpectedly and cause harm to the extent of closure of business.

Chapter 6

Risk Based Ranking to Address the Dynamic Behaviour of Factors

6.1 General

The ranking of factors carried out in the previous chapter only takes into consideration the importance of the factors identified that influence facility location. As seen from the ranking results, most of the dormant factors still fall in lower half of importance ranking and those factors which are already known to influence are prioritized. Hence, risk-based ranking can be a better option to address the dynamic nature of some factors. It is seen that many a times some of the factors if not considered with due respect, can cause severe consequences including shutting down of plants and shifting of entire plants to new location. Many a times such factors are difficult to detect. Hence the concept of Risk Priority Numbers (RPN) can be introduced in the ranking methodology to address such issues.

6.2 Risk Priority Number (RPN)

Risk priority number is a popular way to evaluate risk in traditional FMEA [267]. RPN is usually expressed as RPN =O*S*D, where O, S, and D, are three main risk factors which denote the occurrence (O) of a failure mode, the severity (S) of a failure effect, and probability of detection (D), respectively. In the present context, in place of occurrence importance/ influence of factor affecting facility location is considered. If the factor is not given enough importance, then how much can be the severity on the decision making is taken care by the severity component of RPN. Some factors are difficult to detect and if not detected in advance can cause tremendous negative impact on decision making. Such issues are covered by the detection component in RPN.

Google forms are designed for risk-based ranking of factors (importance in locating a facility) as shown in Figure 6.1. The present study is a pilot study to check effectiveness of method and hence a few respondents have been considered for the study. The respondents were asked to input their responses in a linguistic scale as shown in Table 5.1 in the previous chapter [245]. Here, all the three dimensions of RPN i.e., occurrence (duly considered here as importance/ influence), severity and detection are in fuzzy scales. All the factors have been

considered to be in linguistic scale though there are some quantitative factors for which real data can be easily obtained. But, in a true sense, whenever the factors are used in generalized form, it is always better to present all factors in linguistics scale as discussed in the previous chapter. The linguistic responses received from respondents are converted to TFNs using the fuzzy scale and the RPNs are calculated as shown as a sample in Table 6.1. The entire TFNs are enclosed as Appendix 3.

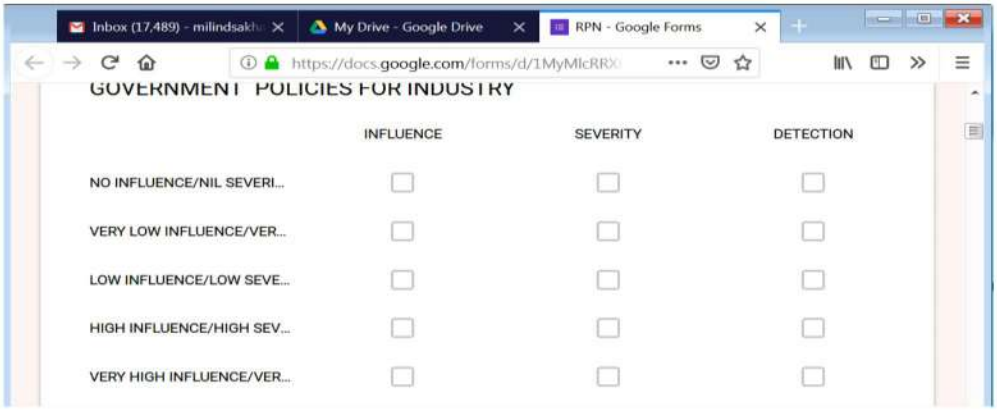

Figure 6.1: Sample Google form

Table 6.1: Sample responses represented as fuzzy RPNs

RESONDENT	GOVERNMENT POLICIES FOR INDUSTRY									RPN		
	IMPORTANCE			SEVERITY			DETECTION					
1	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75	0	0.140625	0.75
2	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.0625	0.28125	0.75
3	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75	0	0.140625	0.75
4	0.5	0.75	1	0.75	1	1	0.75	1	1	0.28125	0.75	1

6.3 Data Validation Using Cronbach's Alpha

The RPN's are aggregated to carry out the Cronbach's Alfa test as shown in Table 6.2.

Table 6.2: Aggregate fuzzy RPNs

	GOVERNMENT POLICIES FOR INDUSTRY	GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	POLITICAL SYSTEM	SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES

1	0.440559	0.342802	0.246228	0.463863
2	0.463863	0.630768	0.246228	0.246228
3	0.440559	0.440559	0.447796	0.630768

The Aggregate values of RPNs are tested for data validity using Cronbach's Alfa test and it is seen that that the final value of Alfa of 0.871 suggests that the data is reliable [250] and hence the sample data can be used for further analysis. The results of Cronbach's Alfa test are shown in Table 6.3.

Table 6.3: Cronbach's Alfa test results

	GOVERNMENT POLICIES FOR INDUSTRY	GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	POLITICAL SYSTEM	SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES
1	0.440559	0.342802	0.246228	0.463863
2	0.463863	0.630768	0.246228	0.246228
3	0.440559	0.440559	0.447796	0.630768
4	0.73973	0.144338	0.144338	0.440559
5	0.342802	0.342802	0.440559	0.326758
6	0.440559	0.456435	0.329239	0.463863
Var	0.018237	0.025938	0.014395	0.017427
K	57			
Sigvar	1.099973			
Var	7.653661			
α	0.871572			

6.4 Extension of Proposed Method for Risk Based Ranking

In the present context, fifty-seven factors are taken into consideration. A modified fuzzy set-based approach has been devised as seen in chapter five that takes into account qualitative assessment of target survey group that can counter the disadvantage of the traditional method. To extend the method further for risk-based ranking, risk factor is also considered and hence modifications to the initial data collection are done. The data collected for ranking by paired comparison is risk based i. e. includes severity and detection factors along with influence/ importance. The average or aggregate fuzzy number defined in the algorithm i. e. $A = [a, b, c]_{1xn}$ considers the multiplication of three fuzzy numbers i. e. influence/importance, severity and detection. From the responses, the average or aggregate fuzzy number for each

factor is calculated taking into consideration the multiplication of three fuzzy numbers i.e. influence/importance, severity and detection. The proposed algorithm is then applied to get final ranking.

6.4.1 Sample Calculations with average risk based fuzzy numbers

The sample calculations are shown in Tables appended below. First the average fuzzy numbers are found from survey responses as shown in Table 6.4. Table 6.5 shows the dominance matrix formed by aggregate values and centroid values calculated from dominance matrix of aggregate values. Once all the centroids are calculated, positive centroids for each factor are summed up as one total in horizontal rows and negative centroids for each factor are summed up as one total in vertical rows. The total sum of positive and negative values is then summed up as shown in Table 6.6 to calculate final numbers that will ensure ranking of the factors as shown in Table 6.7.

Table 6.4: Average values of risk based fuzzy numbers

	GOVERNMENT POLICIES FOR INDUSTRY			GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES			POLITICAL SYSTEM		
AVERAGE	0	0.2734375	1	0	0.197917	1	0	0.091146	0.75

Table 6.5: Dominance matrix of average values with centroids

	GOVERNMENT POLICIES FOR INDUSTRY			GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES			POLITICAL SYSTEM		
GOVERNMENT POLICIES FOR INDUSTRY	0	0	0	-1	0.0755	1	-0.75	0.182291667	1
CENTROID				0.025173611			0.144097222		
GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES				0	0	0	-0.75	0.106770833	1
CENTROID							0.118923611		
POLITICAL SYSTEM							0	0	0
CENTROID									

Table 6.6: Sum of positive and negative sums of centroids

FACTOR	POSITIVE	NEGATIVE	SUM
GOVERNMENT POLICIES FOR INDUSTRY	4.991319	0	4.991319444
GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	3.880208	0	3.880208333
POLITICAL SYSTEM	0.252604	0	0.252604167
SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES	3.896701	-0.125868056	4.022569444

Table 6.7: Final ranking of factors based on average values

FACTOR	SCORE	RANK
DISASTER RISKS	7.424479167	1
BLIND BELIEF IN LEADERSHIP	6.500868056	2
TRANSPOTATION COSTS	6.453125	3
LAND PRICE	6.21875	4
IMPACT OF INDUSTRIALIZATION ON ENVIRONMENT	6.162326389	5
AFFECT ON HEALTH OF PEOPLE DUE TO INDUSTRIES	5.854166667	6
INTERNAL THREATS	5.755208333	7
BUREAUCRATIC HURDLES	5.455729167	8
GOVERNMENT INTERVENTION	5.241319444	9
PER CAPITA INCOME IN LOCATION OF CHOICE	5.203125	10
GOVERNMENT POLICIES FOR INDUSTRY	4.991319444	11
POLITICAL STABILITY	4.510416667	12
UNION FLEXIBILITY	4.4921875	13
MATURITY OF POLITICAL LEADERSHIP	4.355902778	14
IMPACT OF PRESENT INDUSTRY STATUS	4.131944444	15
SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES	4.022569444	16
GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	3.880208333	17
GROSS DOMESTIC PRODUCT (GDP)	3.602430556	18
AVERAGE SALARIES PAID IN LOCATION OF CHOICE	3.534722222	19
INDUSTRY COMPETITIVE SCENARIO	3.435763889	20
LABOUR SKILLS	2.504340278	21
ROLE OF PARALLEL ECONOMY	1.441840278	22

INFRASTRUCTURE AVAILABILITY	1.3203125	23
SUPPLIER CHARACTERISTICS (QUALITY/RELIABILITY)	1.209201389	24
POWER SUPPLY	1.202256944	25
INFLATION TREND	1.144965278	26
MARKET CHARACTERISTICS (CUSTOMER PROXIMITY/PURCHASING POWER)	1.138888889	27
INTERNAL TURBULENCE	1.089409722	28
CONSTRUCTION COSTS	0.860243056	29
IT COSTS	0.8359375	30
AVAILABILITY OF TRANSPORTATION FACILITY (ROAD/RAIL/PORTS/AIR)	0.7890625	31
HEALTH HAZARDS DUE TO INDUSTRIALIZATION	0.7890625	31
MOTIVATION & ENTHUSIASM OF EMPLOYEES	0.788194444	32
FINANCIAL INCENTIVES	0.780381944	33
LABOR CHARACTERISTICS (EDUCATION/TRAINING FACILITIES)	0.651909722	34
TECHNOLOGY COSTS	0.625868056	35
ALTERNATE ENERGY SOURCES AND BACKUP	0.625868056	35
STANDARD OF LIVING	0.519097222	36
CONSUMER SPENDING CHARACTERISTICS (DEMOGRAPHY/CULTURE)	0.470486111	37
NEIGHBORHOOD STABILITY	0.455729167	38
TAX STRUCTURE	0.453993056	39
WATER AVAILABILITY	0.440972222	40
SOCIAL ETHOS YOUR REGION (PRIDE IN WORK OF ANY TYPE IN LOCATION OF CHOICE)	0.414930556	41
KNOWLEDGE BASE	0.389756944	42
AVAILABILITY OF UTILITY SERVICES (ASSISTANCE TO MAIN SERVICES)	0.318576389	43
EDUCATION SYSTEM AND AVENUES	0.318576389	43
RELIGIOUS BELIEFS	0.270833333	44
POLITICAL SYSTEM	0.252604167	45
TREND OF CURRENCY STRENGTH AGAINST U. S. DOLLAR IN COUNTRY OF LOCATION OF CHOICE	0.236979167	46

ECONOMIC STANDING OF THE COUNTRY	0.223090278	47
EMPLOYABILITY	0.2109375	48
USE OF VASTU SHASTRA	0.1953125	49
CLIMATIC CONDITIONS	0.169270833	50
LINGUISTIC BARRIERS	0.162326389	51
SALES & MARKETING COSTS	0.050347222	52
EMPLOYEE INTEGRITY & ETHICS	0.008680556	53
MEDICAL FACILITIES	0	54

6.4.2 Sample Calculations with aggregate risk based fuzzy numbers

The sample calculations are shown in Tables appended below. First the aggregate fuzzy numbers are found from survey responses as shown in Table 6.8. Table 6.9 shows the dominance matrix formed by aggregate values and centroid values calculated from dominance matrix of aggregate values. Once all the centroids are calculated, positive centroids for each factor are summed up as one total in horizontal rows and negative centroids for each factor are summed up as one total in vertical rows. The total sum of positive and negative values is then summed up as shown in Table 6.10 to calculate final numbers that will ensure ranking of the factors as shown in Table 6.11.

Table 6.8: Aggregate values of fuzzy numbers

AGGREGATE	GOVERNMENT POLICIES FOR INDUSTRY			GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES			POLITICAL SYSTEM		
	0.0625	0.273438	0.760417	0.03125	0.197917	0.645833	0.010417	0.091146	0.526042

Table 6.9: Dominance matrix of aggregate values with centroids

	GOVERNMENT POLICIES FOR INDUSTRY			GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES			POLITICAL SYSTEM		
GOVERNMENT POLICIES FOR INDUSTRY	0	0	0	-0.58333	0.075521	0.729167	-0.46354	0.182292	0.75
CENTROID				0.073785					
GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES				0	0	0	-0.49479	0.106771	0.635417

CENTROID							0.082465		
POLITICAL SYSTEM							0	0	0

Table 6.10: Sum of positive and negative sums of centroids

	POSITIVE	NEGATIVE	SUM
GOVERNMENT POLICIES FOR INDUSTRY	5.164063	0	5.164063
GOVERNMENT LAWS AND REGULATIONS	2.141493	0	2.141493
POLITICAL SYSTEM	0.403646	0	0.403646

Table 6.11: Final ranking of factors based on aggregate values

FACTOR	SCORE	RANK
DISASTER RISKS	8.040799	1
BLIND BELIEF IN LEADERSHIP	7.311632	2
TRANSPOTATION COSTS	7.311632	2
AFFECT ON HEALTH OF PEOPLE DUE TO INDUSTRIES	6.842882	3
LAND PRICE	6.060764	4
BUREAUCRATIC HURDLES	5.294271	5
INTERNAL THREATS	5.185764	6
GOVERNMENT POLICIES FOR INDUSTRY	5.164063	7
LABOUR SKILLS	5.121528	8
PER CAPITA INCOME IN LOCATION OF CHOICE	5.114583	9
IMPACT OF INDUSTRIALIZATION ON ENVIRONMENT	5.083333	10
GOVERNMENT INTERVENTION	4.996528	11
POLITICAL STABILITY	3.815972	12
INFRASTRUCTURE AVAILABILITY	3.663194	13
SUPPLIER CHARACTERISTICS (QUALITY/RELIABILITY)	3.449653	14
MATURITY OF POLITICAL LEADERSHIP	3.439236	15

UNION FLEXIBILITY	3.247396	16
ROLE OF PARALLEL ECONOMY	3.152778	17
INFLATION TREND	3.118924	18
SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES	3.085938	19
IMPACT OF PRESENT INDUSTRY STATUS	2.925347	20
INTERNAL TURBULENCE	2.612847	21
HEALTH HAZARDS DUE TO INDUSTRIALIZATION	2.491319	22
MARKET CHARACTERISTICS (CUSTOMER PROXIMITY/PURCHASING POWER)	2.353299	23
CONSTRUCTION COSTS	2.197049	24
GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	2.141493	25
FINANCIAL INCENTIVES	2.061632	26
AVAILABILITY OF TRANSPORTATION FACILITY (ROAD/RAIL/PORTS/AIR)	1.928819	27
POWER SUPPLY	1.903646	28
MOTIVATION & ENTHUSIASM OF EMPLOYEES	1.875868	29
AVERAGE SALARIES PAID IN LOCATION OF CHOICE	1.71441	30
LABOR CHARACTERISTICS (EDUCATION/TRAINING FACILITIES)	1.230903	31
GROSS DOMESTIC PRODUCT (GDP)	1.150174	32
TAX STRUCTURE	1.100694	33
KNOWLEDGE BASE	1.008681	34
STANDARD OF LIVING OF PEOPLE IN LOCATION OF CHOICE	0.967882	35
TECHNOLOGY COSTS	0.912326	36
IT COSTS	0.878472	37
WATER AVAILABILITY	0.831597	38
NEIGHBORHOOD STABILITY	0.817708	39
ALTERNATE ENERGY SOURCES AND BACKUP	0.772569	40
INDUSTRY COMPETITIVE SCENARIO	0.689236	41
CONSUMER SPENDING CHARACTERISTICS (DEMOGRAPHY/CULTURE)	0.676215	42
SOCIAL ETHOS YOUR REGION (PRIDE IN WORK OF ANY TYPE	0.554687	43

IN LOCATION OF CHOICE)		
EDUCATION SYSTEM AND AVENUES	0.475694	44
AVAILABILITY OF UTILITY SERVICES (ASSISTANCE TO MAIN SERVICES)	0.434028	45
POLITICAL SYSTEM	0.403646	46
EMPLOYABILITY	0.317708	47
ECONOMIC STANDING OF THE COUNTRY	0.270833	48
SALES & MARKETING COSTS	0.25	49
TREND OF CURRENCY STRENGTH AGAINST U. S. DOLLAR IN COUNTRY OF LOCATION CHOICE	0.18316	50
EMPLOYEE INTEGRITY & ETHICS	0.094618	51
USE OF VASTU SHASTRA	0.085938	52
CLIMATIC CONDITIONS	0.082465	53
RELIGIOUS BELIEFS	0.032986	54
LINGUISTIC BARRIERS	0.022569	55
MEDICAL FACILITIES	0	56

6.5 Comparison of Results with Existing Data

The ranking for the existing data is done considering only the importance and is compared to the risk based ranking as shown in Table 6.12 and 6.13 for average and aggregate fuzzy numbers.

Table 6.12: Comparison of factors for average fuzzy numbers

AVERAGE FUZZY NUMBERS			CHANGE
RANK	CONSIDERING IMPORTANCE OF EXISTING STUDY	RISK BASED	
1	POWER SUPPLY	**DISASTER RISKS**	
2	AVAILABILITY OF TRANSPORTATION FACILITY (ROAD/RAIL/PORTS/AIR)	**BLIND BELIEF IN LEADERSHIP**	
3	LABOUR SKILLS	TRANSPOTATION COSTS	
4	WATER AVAILABILITY	LAND PRICE	
5	LAND PRICE	IMPACT OF INDUSTRIALIZATION ON ENVIRONMENT	

6	TRANSPOTATION COSTS	AFFECT ON HEALTH OF PEOPLE DUE TO INDUSTRIES	
7	AFFECT ON HEALTH OF PEOPLE DUE TO INDUSTRIES	**INTERNAL THREATS**	
8	INFRASTRUCTURE AVAILABILITY	**BUREAUCRATIC HURDLES**	
9	POLITICAL STABILITY	GOVERNMENT INTERVENTION	
10	CONSTRUCTION COSTS	PER CAPITA INCOME IN LOCATION OF CHOICE	
11	MARKET CHARACTERISTICS (CUSTOMER PROXIMITY/PURCHASING POWER)	GOVERNMENT POLICIES FOR INDUSTRY	
12	KNOWLEDGE BASE	POLITICAL STABILITY	
13	IMPACT OF INDUSTRIALIZATION ON ENVIRONMENT	UNION FLEXIBILITY IN INDUSTRIES	
14	**BUREAUCRATIC HURDLES**	**MATURITY OF POLITICAL LEADERSHIP**	14 TO 8
15	GOVERNMENT INTERVENTION	IMPACT OF PRESENT INDUSTRY STATUS	
16	HEALTH HAZARDS DUE TO INDUSTRIALIZATION	SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES	
17	INFLATION TREND	GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	
18	GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	GROSS DOMESTIC PRODUCT (GDP)	
19	INDUSTRY COMPETITIVE SCENARIO	AVERAGE SALARIES PAID IN LOCATION OF CHOICE	
20	**INTERNAL THREATS**	INDUSTRY COMPETITIVE SCENARIO	20 TO 7
21	PER CAPITA INCOME IN LOCATION OF CHOICE	LABOUR SKILLS	
22	SUPPLIER CHARACTERISTICS (QUALITY/RELIABILITY)	**ROLE OF PARALLEL ECONOMY**	
23	AVAILABILITY OF UTILITY SERVICES (ASSISTANCE TO MAIN SERVICES)	INFRASTRUCTURE AVAILABILITY	
24	TECHNOLOGY COSTS	SUPPLIER CHARACTERISTICS (QUALITY/RELIABILITY)	

25	**MATURITY OF POLITICAL LEADERSHIP**	POWER SUPPLY	25 TO 14
26	**ROLE OF PARALLEL ECONOMY**	INFLATION TREND	26 TO 22
27	GOVERNMENT POLICIES FOR INDUSTRY	MARKET CHARACTERISTICS (CUSTOMER PROXIMITY/PURCHASING POWER)	
28	EMPLOYABILITY	**INTERNAL TURBULENCE**	
29	MOTIVATION & ENTHUSIASM OF EMPLOYEES	CONSTRUCTION COSTS	
30	EDUCATION SYSTEM AND AVENUES	IT COSTS	
31	**BLIND BELIEF IN LEADERSHIP**	AVAILABILITY OF TRANSPORTATION FACILITY (ROAD/RAIL/PORTS/AIR)	31 TO 2
32	**INTERNAL TURBULENCE**	HEALTH HAZARDS DUE TO INDUSTRIALIZATION	32 TO 28
33	UNION FLEXIBILITY	MOTIVATION & ENTHUSIASM OF EMPLOYEES	
34	SALES & MARKETING COSTS	FINANCIAL INCENTIVES	
35	**DISASTER RISKS**	LABOR CHARACTERISTICS (EDUCATION/TRAINING FACILITIES)	35 TO 1
36	STANDARD OF LIVING OF PEOPLE IN LOCATION OF CHOICE	TECHNOLOGY COSTS	
37	CONSUMER SPENDING CHARACTERISTICS (DEMOGRAPHY/CULTURE)	ALTERNATE ENERGY SOURCES AND BACKUP	
38	TREND OF CURRENCY STRENGTH AGAINST U. S. DOLLAR IN COUNTRY OF LOCATION CHOICE	STANDARD OF LIVING OF PEOPLE IN LOCATION OF CHOICE	
39	TAX STRUCTURE	CONSUMER SPENDING CHARACTERISTICS (DEMOGRAPHY/CULTURE)	
40	IT COSTS	NEIGHBORHOOD STABILITY	
41	ALTERNATE ENERGY SOURCES AND BACKUP	TAX STRUCTURE	
42	LABOR CHARACTERISTICS (EDUCATION/TRAINING	WATER AVAILABILITY	

	FACILITIES)		
43	GROSS DOMESTIC PRODUCT (GDP)	SOCIAL ETHOS YOUR REGION (PRIDE IN WORK OF ANY TYPE IN LOCATION OF CHOICE)	
44	AVERAGE SALARIES PAID IN LOCATION OF CHOICE	KNOWLEDGE BASE	
45	FINANCIAL INCENTIVES	AVAILABILITY OF UTILITY SERVICES (ASSISTANCE TO MAIN SERVICES)	
46	SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES	EDUCATION SYSTEM AND AVENUES	
47	CLIMATIC CONDITIONS	RELIGIOUS BELIEFS	
48	NEIGHBORHOOD STABILITY	POLITICAL SYSTEM	
49	POLITICAL SYSTEM	TREND OF CURRENCY STRENGTH AGAINST U. S. DOLLAR IN COUNTRY OF LOCATION OF CHOICE	
50	LINGUISTIC BARRIERS	ECONOMIC STANDING OF THE COUNTRY OF LOCATION CHOICE	
51	IMPACT OF PRESENT INDUSTRY STATUS	EMPLOYABILITY	
52	ECONOMIC STANDING OF THE COUNTRY OF LOCATION CHOICE	USE OF VASTU SHASTRA	
53	MEDICAL FACILITIES	CLIMATIC CONDITIONS	
54	SOCIAL ETHOS YOUR REGION (PRIDE IN WORK OF ANY TYPE IN LOCATION OF CHOICE)	LINGUISTIC BARRIERS	
55	EMPLOYEE INTEGRITY & ETHICS	SALES & MARKETING COSTS	
56	USE OF VASTU SHASTRA	EMPLOYEE INTEGRITY & ETHICS	
57	RELIGIOUS BELIEFS	MEDICAL FACILITIES	

Table 6.13: Comparison of factors for aggregate fuzzy numbers

AGGREGATE FUZZY NUMBERS			CHANGE
RANK	CONSIDERING IMPORTANCE OF EXISTING STUDY	RISK BASED	
1	POWER SUPPLY	**DISASTER RISKS**	
2	AVAILABILITY OF	**BLIND BELIEF IN LEADERSHIP**	

	TRANSPORTATION FACILITY (ROAD/RAIL/PORTS/AIR)		
3	LABOUR SKILLS	TRANSPOTATION COSTS	
4	WATER AVAILABILITY	AFFECT ON HEALTH OF PEOPLE DUE TO INDUSTRIES	
5	LAND PRICE	LAND PRICE	
6	TRANSPOTATION COSTS	**BUREAUCRATIC HURDLES**	
7	AFFECT ON HEALTH OF PEOPLE DUE TO INDUSTRIES	**INTERNAL THREATS**	
8	POLITICAL STABILITY	GOVERNMENT POLICIES FOR INDUSTRY	
9	INFRASTRUCTURE AVAILABILITY	LABOUR SKILLS	
10	CONSTRUCTION COSTS	PER CAPITA INCOME IN LOCATION OF CHOICE	
11	MARKET CHARACTERISTICS (CUSTOMER PROXIMITY/PURCHASING POWER)	IMPACT OF INDUSTRIALIZATION ON ENVIRONMENT	
12	KNOWLEDGE BASE	GOVERNMENT INTERVENTION	
13	HEALTH HAZARDS DUE TO INDUSTRIALIZATION	POLITICAL STABILITY	
14	**BUREAUCRATIC HURDLES**	INFRASTRUCTURE AVAILABILITY	14 TO 6
15	GOVERNMENT INTERVENTION	SUPPLIER CHARACTERISTICS (QUALITY/RELIABILITY)	
16	INDUSTRY COMPETITIVE SCENARIO	**MATURITY OF POLITICAL LEADERSHIP**	
17	INFLATION TREND	UNION FLEXIBILITY	
18	GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	**ROLE OF PARALLEL ECONOMY**	
19	PER CAPITA INCOME IN LOCATION OF CHOICE	INFLATION TREND	
20	IMPACT OF INDUSTRIALIZATION ON ENVIRONMENT	SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES	
21	SUPPLIER CHARACTERISTICS (QUALITY/RELIABILITY)	IMPACT OF PRESENT INDUSTRY STATUS	

22	**MATURITY OF POLITICAL LEADERSHIP**	**INTERNAL TURBULENCE**	22 TO 16
23	GOVERNMENT POLICIES FOR INDUSTRY	HEALTH HAZARDS DUE TO INDUSTRIALIZATION	
24	AVAILABILITY OF UTILITY SERVICES (ASSISTANCE TO MAIN SERVICES)	MARKET CHARACTERISTICS (CUSTOMER PROXIMITY/PURCHASING POWER)	
25	EMPLOYABILITY	CONSTRUCTION COSTS	
26	TECHNOLOGY COSTS	GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	
27	**ROLE OF PARALLEL ECONOMY**	FINANCIAL INCENTIVES	27 TO 18
28	**INTERNAL THREATS**	AVAILABILITY OF TRANSPORTATION FACILITY (ROAD/RAIL/PORTS/AIR)	28 TO 7
29	AVERAGE SALARIES PAID IN LOCATION OF CHOICE	POWER SUPPLY	
30	TAX STRUCTURE	MOTIVATION & ENTHUSIASM OF EMPLOYEES	
31	IT COSTS	AVERAGE SALARIES PAID IN LOCATION OF CHOICE	
32	GROSS DOMESTIC PRODUCT (GDP)	LABOR CHARACTERISTICS (EDUCATION/TRAINING FACILITIES)	
33	ALTERNATE ENERGY SOURCES AND BACKUP	GROSS DOMESTIC PRODUCT (GDP)	
34	LABOR CHARACTERISTICS (EDUCATION/TRAINING FACILITIES)	TAX STRUCTURE	
35	MOTIVATION & ENTHUSIASM OF EMPLOYEES	KNOWLEDGE BASE	
36	EDUCATION SYSTEM AND AVENUES	STANDARD OF LIVING OF PEOPLE IN LOCATION OF CHOICE	
37	SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES	TECHNOLOGY COSTS	
38	FINANCIAL INCENTIVES	IT COSTS	
39	UNION FLEXIBILITY	WATER AVAILABILITY	
40	CLIMATIC CONDITIONS	NEIGHBORHOOD STABILITY	

41	**DISASTER RISKS**	ALTERNATE ENERGY SOURCES AND BACKUP	41 TO 1
42	**BLIND BELIEF IN LEADERSHIP**	INDUSTRY COMPETITIVE SCENARIO	42 TO 2
43	**INTERNAL TURBULENCE**	CONSUMER SPENDING CHARACTERISTICS (DEMOGRAPHY/CULTURE)	43 TO 22
44	SALES & MARKETING COSTS	SOCIAL ETHOS YOUR REGION (PRIDE IN WORK OF ANY TYPE IN LOCATION OF CHOICE)	
45	NEIGHBORHOOD STABILITY	EDUCATION SYSTEM AND AVENUES	
46	LINGUISTIC BARRIERS	AVAILABILITY OF UTILITY SERVICES (ASSISTANCE TO MAIN SERVICES)	
47	IMPACT OF PRESENT INDUSTRY STATUS	POLITICAL SYSTEM	
48	POLITICAL SYSTEM	EMPLOYABILITY	
49	STANDARD OF LIVING OF PEOPLE IN LOCATION OF CHOICE	ECONOMIC STANDING OF THE COUNTRY	
50	CONSUMER SPENDING CHARACTERISTICS (DEMOGRAPHY/CULTURE)	SALES & MARKETING COSTS	
51	ECONOMIC STANDING OF THE COUNTRY	TREND OF CURRENCY STRENGTH AGAINST U. S. DOLLAR IN COUNTRY OF LOCATION CHOICE	
52	TREND OF CURRENCY STRENGTH AGAINST U. S. DOLLAR IN COUNTRY OF LOCATION CHOICE	EMPLOYEE INTEGRITY & ETHICS	
53	SOCIAL ETHOS YOUR REGION (PRIDE IN WORK OF ANY TYPE IN LOCATION OF CHOICE)	USE OF VASTU SHASTRA	
54	MEDICAL FACILITIES	CLIMATIC CONDITIONS	
55	EMPLOYEE INTEGRITY & ETHICS	RELIGIOUS BELIEFS	
56	USE OF VASTU SHASTRA	LINGUISTIC BARRIERS	
57	RELIGIOUS BELIEFS	MEDICAL FACILITIES	

6.6 Comparison of Results with Previous Data

The existing risk based ranking results are compared to the pilot study results carried out as obtained in Sections 5.6.1 and 5.6.2. The results are tabulated in Tables 6.14 and 6.15 respectively.

Table 6.14: Comparison of factors for average fuzzy numbers

AVERAGE FUZZY NUMBERS			CHANGE
RANK	CONSIDERING IMPORTANCE OF PREVIOUS STUDY	RISK BASED	
1	AVAILABILITY OF TRANSPORTATION FACILITY (ROAD/RAIL/PORTS/AIR)	**DISASTER RISKS**	
2	WATER AVAILABILITY	**BLIND BELIEF IN LEADERSHIP**	
3	GOVERNMENT POLICIES FOR INDUSTRY	TRANSPOTATION COSTS	
4	GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	LAND PRICE	
5	MARKET CHARACTERISTICS (CUSTOMER PROXIMITY/PURCHASING POWER)	IMPACT OF INDUSTRIALIZATION ON ENVIRONMENT	
6	AVAILABILITY OF UTILITY SERVICES (ASSISTANCE TO MAIN SERVICES)	AFFECT ON HEALTH OF PEOPLE DUE TO INDUSTRIES	
7	SUPPLIER CHARACTERISTICS (QUALITY/RELIABILITY)	**INTERNAL THREATS**	
8	LAND PRICE	**BUREAUCRATIC HURDLES**	
9	GOVERNMENT INTERVENTION	GOVERNMENT INTERVENTION	
10	IMPACT OF PRESENT INDUSTRY STATUS	PER CAPITA INCOME IN LOCATION OF CHOICE	
11	SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES	GOVERNMENT POLICIES FOR INDUSTRY	
12	POLITICAL SYSTEM	POLITICAL STABILITY	
13	TREND OF CURRENCY STRENGTH AGAINST U. S. DOLLAR IN COUNTRY OF LOCATION CHOICE	UNION FLEXIBILITY IN INDUSTRIES	
14	LABOUR SKILLS	**MATURITY OF POLITICAL LEADERSHIP**	

15	HEALTH HAZARDS DUE TO INDUSTRIALIZATION	IMPACT OF PRESENT INDUSTRY STATUS	
16	**BUREAUCRATIC HURDLES**	SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES	16 TO 8
17	CONSTRUCTION COSTS	GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	
18	TRANSPOTATION COSTS	GROSS DOMESTIC PRODUCT (GDP)	
19	INDUSTRY COMPETITIVE SCENARIO	AVERAGE SALARIES PAID IN LOCATION OF CHOICE	
20	SALES & MARKETING COSTS	INDUSTRY COMPETITIVE SCENARIO	
21	POLITICAL STABILITY	LABOUR SKILLS	
22	**DISASTER RISKS**	**ROLE OF PARALLEL ECONOMY**	22 TO 1
23	IT COSTS	INFRASTRUCTURE AVAILABILITY	
24	POWER SUPPLY	SUPPLIER CHARACTERISTICS (QUALITY/RELIABILITY)	
25	INFRASTRUCTURE AVAILABILITY	POWER SUPPLY	
26	FINANCIAL INCENTIVES	INFLATION TREND	
27	**INTERNAL THREATS**	MARKET CHARACTERISTICS (CUSTOMER PROXIMITY/PURCHASING POWER)	27 TO 7
28	TAX STRUCTURE	**INTERNAL TURBULENCE**	
29	IMPACT OF INDUSTRIALIZATION ON ENVIRONMENT	CONSTRUCTION COSTS	
30	AFFECT ON HEALTH OF PEOPLE DUE TO INDUSTRIES	IT COSTS	
31	TECHNOLGY COST	AVAILABILITY OF TRANSPORTATION FACILITY (ROAD/RAIL/PORTS/AIR)	
32	EMPLOYEE INTEGRITY & ETHICS	HEALTH HAZARDS DUE TO INDUSTRIALIZATION	
33	GROSS DOMESTIC PRODUCT (GDP)	MOTIVATION & ENTHUSIASM OF EMPLOYEES	
34	AVERAGE SALARIES PAID IN LOCATION CHOICE	FINANCIAL INCENTIVES	
35	UNION FLEXIBILITY IN INDUSTRIES	LABOR CHARACTERISTICS (EDUCATION/TRAINING FACILITIES)	

36	MOTIVATION & ENTHUSIASM OF EMPLOYEES	TECHNOLOGY COSTS	
37	LABOUR CHARACTERISTICS (EDUCATION/TRAINING FACILITIES)	ALTERNATE ENERGY SOURCES AND BACKUP	
38	EMPLOYABILITY	STANDARD OF LIVING	
39	ECONOMIC STANDING OF THE COUNTRY OF LOCATION CHOICE	CONSUMER SPENDING CHARACTERISTICS (DEMOGRAPHY/CULTURE)	
40	ALTERNATE ENERGY SOURCES AND BACKUP	NEIGHBORHOOD STABILITY	
41	PER CAPITA INCOME IN LOCATION CHOICE	TAX STRUCTURE	
42	KNOWLEDGE BASE	WATER AVAILABILITY	
43	CLIMATIC CONDITIONS	SOCIAL ETHOS YOUR REGION (PRIDE IN WORK OF ANY TYPE IN LOCATION OF CHOICE)	
44	**MATURITY OF POLITICAL LEADERSHIP**	KNOWLEDGE BASE	44 TO 14
45	NEIGHBORHOOD STABILITY	AVAILABILITY OF UTILITY SERVICES (ASSISTANCE TO MAIN SERVICES)	
46	**BLIND BELIEF IN LEADERSHIP**	EDUCATION SYSTEM AND AVENUES	46 TO 2
47	**INTERNAL TURBULENCE**	RELIGIOUS BELIEFS	47 TO 28
48	CONSUMER SPENDING CHARACTERISTICS (DEMOGRAPHY/CULTURE)	POLITICAL SYSTEM	
49	INFLATION TREND	TREND OF CURRENCY STRENGTH AGAINST U. S. DOLLAR IN COUNTRY OF LOCATION OF CHOICE	
50	**ROLE OF PARALLEL ECONOMY**	ECONOMIC STANDING OF THE COUNTRY OF LOCATION CHOICE	5O TO 22
51	SOCIAL ETHOS YOUR REGION (PRIDE IN WORK OF ANY TYPE IN LOCATION CHOICE)	EMPLOYABILITY	
52	EDUCATION SYSTEM AND AVENUES	USE OF VASTU SHASTRA	
53	MEDICAL FACILITIES	CLIMATIC CONDITIONS	

54	STANDARD OF LIVING IN LOCATION OF CHOICE	LINGUISTIC BARRIERS	
55	LINGUISTIC BARRIERS	SALES & MARKETING COSTS	
56	USE OF VASTU SHASTRA	EMPLOYEE INTEGRITY & ETHICS	
57	RELIGIOUS BELIEFS	MEDICAL FACILITIES	

Table 6.15: Comparison of factors for aggregate fuzzy numbers

AGGREGATE FUZZY NUMBERS			CHANGE
RANK	CONSIDERING IMPORTANCE OF PREVIOUS STUDY	RISK BASED	
1	AVAILABILITY OF TRANSPORTATION FACILITY (ROAD/RAIL/PORTS/AIR)	**DISASTER RISKS**	
2	WATER AVAILABILITY	**BLIND BELIEF IN LEADERSHIP**	
3	GOVERNMENT POLICIES FOR INDUSTRY	TRANSPOTATION COSTS	
4	GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	AFFECT ON HEALTH OF PEOPLE DUE TO INDUSTRIES	
5	AVAILABILITY OF UTILITY SERVICES (ASSISTANCE TO MAIN SERVICES)	LAND PRICE	
6	POWER SUPPLY	**BUREAUCRATIC HURDLES**	
7	MARKET CHARACTERISTICS (CUSTOMER PROXIMITY/PURCHASING POWER)	**INTERNAL THREATS**	
8	FINANCIAL INCENTIVES	GOVERNMENT POLICIES FOR INDUSTRY	
9	INFRASTRUCTURE AVAILABILITY	LABOUR SKILLS	
10	SUPPLIER CHARACTERISTICS (QUALITY/RELIABILITY)	PER CAPITA INCOME IN LOCATION OF CHOICE	
11	LAND PRICE	IMPACT OF INDUSTRIALIZATION ON ENVIRONMENT	
12	SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES	GOVERNMENT INTERVENTION	
13	GOVERNMENT INTERVENTION	POLITICAL STABILITY	
14	IMPACT OF PRESENT INDUSTRY	INFRASTRUCTURE AVAILABILITY	

	STATUS		
15	POLITICAL SYSTEM	SUPPLIER CHARACTERISTICS (QUALITY/RELIABILITY)	
16	TAX STRUCTURE	**MATURITY OF POLITICAL LEADERSHIP**	
17	TREND OF CURRENCY STRENGTH AGAINST U. S. DOLLAR IN COUNTRY OF LOCATION CHOICE	UNION FLEXIBILITY	
18	LABOUR SKILLS	**ROLE OF PARALLEL ECONOMY**	
19	HEALTH HAZARDS DUE TO INDUSTRIALIZATION	INFLATION TREND	
20	IMPACT OF INDUSTRIALIZATION ON ENVIRONMENT	SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES	
21	**BUREAUCRATIC HURDLES**	IMPACT OF PRESENT INDUSTRY STATUS	21 TO 6
22	AFFECT ON HEALTH OF PEOPLE DUE TO INDUSTRIES	**INTERNAL TURBULENCE**	
23	TECHNOLOGY COSTS	HEALTH HAZARDS DUE TO INDUSTRIALIZATION	
24	TRANSPOTATION COSTS	MARKET CHARACTERISTICS (CUSTOMER PROXIMITY/PURCHASING POWER)	
25	INDUSTRY COMPETITIVE SCENARIO	CONSTRUCTION COSTS	
26	**INTERNAL THREATS**	GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES	26 TO 7
27	GROSS DOMESTIC PRODUCT (GDP)	FINANCIAL INCENTIVES	
28	CONSTRUCTION COSTS	AVAILABILITY OF TRANSPORTATION FACILITY (ROAD/RAIL/PORTS/AIR)	
29	AVERAGE SALARIES PAID IN LOCATION CHOICE	POWER SUPPLY	
30	UNION FLEXIBILITY IN INDUSTRIES	MOTIVATION & ENTHUSIASM OF EMPLOYEES	
31	MOTIVATION & ENTHUSIASM OF EMPLOYEES	AVERAGE SALARIES PAID IN LOCATION OF CHOICE	
32	EMPLOYEE INTEGRITY & ETHICS	LABOR CHARACTERISTICS (EDUCATION/TRAINING	

		FACILITIES)	
33	SALES & MARKETING COSTS	GROSS DOMESTIC PRODUCT (GDP)	
34	EMPLOYABILITY	TAX STRUCTURE	
35	LABOUR CHARACTERISTICS (EDUCATION/TRAINING FACILITIES)	KNOWLEDGE BASE	
36	ECONOMIC STANDING OF THE COUNTRY OF LOCATION CHOICE	STANDARD OF LIVING OF PEOPLE IN LOCATION OF CHOICE	
37	POLITICAL STABILITY	TECHNOLOGY COSTS	
38	ALTERNATE ENERGY SOURCES AND BACKUP	IT COSTS	
39	**MATURITY OF POLITICAL LEADERSHIP**	WATER AVAILABILITY	39 TO 16
40	**BLIND BELIEF IN LEADERSHIP**	NEIGHBORHOOD STABILITY	40 TO 2
41	PER CAPITA INCOME IN LOCATION CHOICE	ALTERNATE ENERGY SOURCES AND BACKUP	
42	NEIGHBORHOOD STABILITY	INDUSTRY COMPETITIVE SCENARIO	
43	KNOWLEDGE BASE	CONSUMER SPENDING CHARACTERISTICS (DEMOGRAPHY/CULTURE)	
44	**INTERNAL TURBULENCE**	SOCIAL ETHOS YOUR REGION (PRIDE IN WORK OF ANY TYPE IN LOCATION OF CHOICE)	44 TO 22
45	CONSUMER SPENDING CHARACTERISTICS (DEMOGRAPHY/CULTURE)	EDUCATION SYSTEM AND AVENUES	
46	CLIMATIC CONDITIONS	AVAILABILITY OF UTILITY SERVICES (ASSISTANCE TO MAIN SERVICES)	
47	**DISASTER RISKS**	POLITICAL SYSTEM	47 TO 1
48	IT COSTS	EMPLOYABILITY	
49	INFLATION TREND	ECONOMIC STANDING OF THE COUNTRY	
50	**ROLE OF PARALLEL ECONOMY**	SALES & MARKETING COSTS	50 TO 18
51	SOCIAL ETHOS YOUR REGION (PRIDE IN WORK OF ANY TYPE IN	TREND OF CURRENCY STRENGTH AGAINST U. S. DOLLAR IN	

	LOCATION CHOICE)	COUNTRY OF LOCATION CHOICE	
52	EDUCATION SYSTEM AND AVENUES	EMPLOYEE INTEGRITY & ETHICS	
53	MEDICAL FACILITIES	USE OF VASTU SHASTRA	
54	STANDARD OF LIVING OF PEOPLE IN LOCATION CHOICE	CLIMATIC CONDITIONS	
55	USE OF VASTU SHASTRA	RELIGIOUS BELIEFS	
56	RELIGIOUS BELIEFS	LINGUISTIC BARRIERS	
57	LINGUISTIC BARRIERS	MEDICAL FACILITIES	

6.7 Results and Discussions

The results of the comparisons in both the cases as seen in section 6.5 and section 6.6 clearly indicate that the underlying factors are addressed more prominently through risk based ranking approach. The comparison of risk based ranking with importance ranking for same data shows the upward movement for some of the factors with lower jumps. However, there is a better overall jump is noticed when the risk based ranking results are compared with importance ranking of previous data as seen in Table 6.16. This opens up an interesting observation throwing light on the experts' mindsets while judging the factors. When the experts give their opinions based only on importance they have not considered the dynamism in most of the factors and the common factors that are known are given more importance. Whereas when the judges do a risk based ranking, their mindset will work in the directions of risk to be incorporated and the judges will consider those factors that can be risky with more importance.

Table 6.16: Summary of ranking of underlying factors

FACTOR	AVERAGE FUZZY NUMBER		AGGREGATE FUZZY NUMBER	
	EXISTING DATA COMPARISON	PREVIOUS DATA COMPARISON	EXISTING DATA COMPARISON	PREVIOUS DATA COMPARISON
MATURITY OF POLITICAL LEADERSHIP	25 TO 14	44 TO 14	22 TO 16	39 TO 16
BLIND BELIEF IN LEADERSHIP	31 TO 2	46 TO 2	42 TO 2	40 TO 2
BUREAUCRATIC HURDLES	14 TO 8	16 TO 8	14 TO 6	21 TO 6
INTERNAL TURBULENCE	32 TO 28	47 TO 28	43 TO 22	44 TO 22
INTERNAL THREATS	20 TO 7	27 TO 7	28 TO 7	26 TO 7
ROLE OF PARALLEL	26 TO 22	50 TO 22	27 TO 18	50 TO 18

ECONOMY				

6.8 Summary

In this chapter, risk-based ranking is done using proposed method to identify the dynamic nature of factors affecting facility location. As seen in Section 6.4.1 and 6.4.2, with use of average fuzzy numbers and aggregate fuzzy numbers, there is a change in ranking of factors. With risk-based ranking, the ranking results show change in positions. Sections 6.5 and 6.6 clearly show that risk-based ranking affects the overall ranking results. The underlying factors like maturity of political leadership, blind belief in leadership, bureaucratic hurdles, internal turbulence, internal threats, role of parallel economy that are not considered for facility location selection till now show an upward trend of movement in ranking with risk based ranking approach. Disaster risks factor shows a noticeable change in risk based ranking. The mindset of experts' while giving judgements is also an important observation noticed in this chapter. In the next chapter, the ranking of sectors identified through 'Make in India' is done using fuzzy AHP and proposed method with some thoughts on decision making perspectives of academicians and industry professionals.

Chapter 7

Ranking of Sectors Identified in Make in India

7.1 General

The Indian Government introduced 'Make in India' in 2014 with objectives of job creation and GDP growth in twenty-five manufacturing sectors [268]. The initiative targeted skill enhancement, foreign investments and development of well-organized infrastructure. But post-launch, the initiative did not gain the boost as expected. In the existing situation of the COVID-19 (Corona virus disease of 2019) pandemic, most of the countries have plans to shift their business from existing locations creating the right situation for India to grab the opportunity [269]. However, there is a need to recognize potentials for targeted twenty-five sectors identified by the government in the context of supply chains. The current pandemic has disrupted global supply chains that have forced thousands of industries across the world in the temporary shutdown of their assembly lines including India [270]. India needs to move ahead despite such issues and challenges. The following sections present the scenario.

7.1.1 'Make in India' amidst global supply chain disruption due to pandemic

Epidemic outbreaks lead to risks like long-term supply chain disruption, propagations, and high uncertainty [271]. India has been on a world manufacturing scenario in recent years with the announcement of 'Make in India' in 2014. In the current pandemic situation, many business houses will be looking for the least resistance alternatives. India stands a chance to grab this big opportunity, undertaking broad-based structural reforms, despite its lockdowns and economic challenges [272]. Resilience, strategic agility, and entrepreneurship will be of prime importance in the current pandemic situation [273] and India needs to focus on these aspects.

7.1.2 Political, economic, social, technological, legal and environmental challenges

Though the pandemic can work as an advantage to India, the country has its challenges. The major areas of focus identified are land, labour, liquidity, and laws as per the recent announcement by Prime Minister Shri. Narendra Modi for stabilizing the economy and inviting foreign investor partners for 'Make in India' progress as reported in Business Today [274]. In the previous chapter, fifty-seven factors affecting facility location are identified using PESTLE analysis which is the major strategic decision in supply chain network design. The potential based ranking of sectors identified in 'Make in India' needs to be done on PESTLE identified factors that goes in line with the second objective of the research.

7.1.3 Identification of potential in the announced sectors

The Indian government has identified twenty-five manufacturing sectors for the 'Make in India' initiative. Secondly, amongst these twenty-five, superstar sectors are also identified. However, amidst the challenges, analysis leading to the identification of the potential for manufacturing and future growth in each sector needs to be carried out.

7.1.4 Decision making by academicians and industry professionals

It is seen that most of the research in the decision-making field is carried out in academic institutions. Often, the decision making by academicians does not guarantee optimal results as their viewpoints are mostly based on theories, whereas the industry professionals make judgments' based on practical aspects. In many research applications, the decisions are directly taken based on the experts' opinions not accounting for the decision-makers' field i.e. either academic or industry. Many times, it is a mix of both. The viewpoints of academicians and professionals should be considered separately for gap identification and then analyzed as a mix for better understanding.

The above sections indicate that there is a need to identify the potential for manufacturing and future growth in the twenty-five sectors. In this part of research, fuzzy AHP is used to rank the sectors identified by 'Make in India' based on the views of academicians and industry professionals and the results are compared with proposed method ranking results.

7.2 Literature Background

A background for the case study is presented in the following subsections referring to the literature available.

7. 2.1 Indian manufacturing scenario

There have been mainly two breakthroughs in the Indian industrial policies, the first being in 1965-66 which emphasized heavy industries and the second in 1984-85 for major changes concerning liberalization [217]. After the 1984-85 deregulations, there was no proper product-wise categorization in various parts of the country despite the expected growth of industries concerning the products [218]. Indian manufacturing sectors have to overcome major hurdles like poor policy decisions, lack of protection from foreign competition, absence of competitive domestic industries, and several other regional factors for growth and productivity improvements [219]. In recent years, new land and labour laws along with infrastructure improvement have given a boost to the manufacturing sector in India [220]. Sharma and Kodali [221] have proposed various frameworks that include elements like leadership, manufacturing strategy, supply chain management, world-class maintenance systems, etc. and initiatives like knowledge management, flexible processes, and innovative product planning to account for the changing manufacturing scenario. The manufacturing sector has the potential to enhance its share in the economic development of the country [222].

7.2.2 'Make in India'

'Make in India' is an initiative to make the country world's largest manufacturing center [275]. In the present pandemic conditions, India has a chance to lure low-end manufacturers that are planning to move their businesses overseas from other countries. India is at the cradle stage in the manufacturing sector and has plans for elementary manufacturing over the decade. However, Indian industry authorities have emphasized the need of implementing technology and digitalization to the manufacturing domain rather than depend entirely on cheap labour to make the initiative successful [223]. India has cross-cultural issues [224] which need to be sorted. The potentially high impact of an acceleration of formal-sector manufacturing should serve as motivation for the Indian government at all levels to push hard toward the goal [276]. Within all the advantages and limitations, the Government of India is thriving hard to rebuild the manufacturing sector through the 'Make in India' initiative. The twenty-five sectors recognized in 'Make in India' are Automobiles, Auto components, Aviation, Biotechnology, Chemicals, Construction, Defence manufacturing, Electrical machinery, Electronic system design and manufacturing, Food processing, IT and BPM, Leather, Media and Entertainment, Mining, Oil and Gas, Pharmaceuticals, Ports, Railways, Renewable energy, Roads and highways, Space, Textiles, Thermal power, Tourism &

Hospitality, and Wellness. Amongst these, Pharmaceuticals, Renewable energy, Roads and highways, Electronic system design and manufacturing, Food processing, and Automobiles are mentioned as superstar sectors [268].

7.2.3 Research perspectives of academicians and industry professionals

Academicians should work hand in hand with government and industry professionals for innovative solutions. The Collective research will lead to resilient societal outcomes that will benefit mankind [225]. Researchers have proved using forecasting methods case study that there is a similarity in the responses given by academicians and industry professionals. But, although the general outcome of this survey is that the same criteria are used by both groups, a certain lack of agreement still exists within each group [226]. An Apparel industry case study carried out by Wright et al. [227] represents the disparity of thought in the decision making of academicians and industry professionals. The gap in decision making between members of Industry and academia has been addressed on several occasions. While some think it is expanding, others consider it important for insightful research and speculations [228].

7.3 Case Study

The twenty-five sectors identified in the 'Make in India' initiative, if ranked will provide a better picture to the investors in terms of potential. In this case study, fuzzy AHP has been used along with proposed method for the ranking of these sectors. The decision makers are either academicians and/or industry professionals in research problems. The academicians are strong in theories whereas industry professionals are practical oriented. Literature states that there exists a gap in the decision making of the two fraternities. This shows there is a strong need to identify this gap and minimize its effect in decision making. In the first part of the case study, analysis is carried out using fuzzy AHP as three sub cases i.e., one with academicians, second with industry professionals and the third case is a mix of decisions of both. Results are further analyzed for correlation.

7.4 Calculations

Table 7.1 shows the summary of responses along with the details of the experts. In theory for best consistency, the Consistency Ratio (CR) has to be less than 0.1 [258]. But it is seen in literature that CR up to 0.2 is also tolerable for higher-order matrices [263]. As the matrix is of higher order, the expert responses with CR's of less than 0.2 are considered for further

analysis. The literature reviewed for this case in case of number of experts [19, 277-287] shows that the number of experts vary from a minimum of one expert to as many as forty two. As fuzzy AHP is not a statistical method, the sample size is not standardized [288]. Also, there is no mention of the number of experts and/or their respective fields in some fuzzy AHP applications [289-292]. In this part of case study, thirty responses from academicians and thirty-five responses from industry professionals were received and checked for consistency. Alonso and Lamata (2006) have proposed Random Index (RI) for calculating CRs up to matrix size of thirty nine and further proposed an equation for calculating RI for matrices of order size higher than thirty nine [260]. As twenty-five sectors need to be ranked, the size of the matrix will be twenty-five. The value of the Random Index (RI) used for calculating the CR for a matrix order size of twenty-five is taken as 1.6624 from the Random Index Table of Alonso and Lamata (2006). In total forty responses, i.e., twenty academicians and twenty industry professionals with CR below 0.2 are taken for the analysis. Appendix 4 shows the data for 40 respondents. Table 7.2 shows the CRs of the chosen responses. Tables 7.3 and 7.4 show a sample paired comparison matrix of academician and industry professionals respectively. Tables 7.5 and 7.6 show a sample calculation of weights of academicians and industry professionals respectively.

Table 7.1: Summary of responses for pairwise comparisons

Respondents Category	Pair wise Comparisons received	Pair wise Comparisons with CR<0.2	Work Experience		Industry/Field
			Years	Number of experts	
Industry Professionals	35	20	10-19	2	Mining, Air Conditioning, Hospitality, Agro chemicals, Oil & Gas, IT, Defence, Pharmaceuticals, Nuclear Power, Packaging, Healthcare, Food processing, Chemical, Ship building, Textiles
			20-29	9	
			30-39	5	
			40 & above	4	
Academicians	30	20	10-19	4	Mechanical, Metallurgy, Maritime, Electrical, Computer Science, IT
			20-29	11	
			30-39	4	
			40 & above	1	

Table 7.2: CRs of responses

Academicians				Industry Professionals			
Sr no.	CR	Sr no.	CR	Sr no.	CR	Sr no.	CR
1	0.0896	11	0.0501	1	0.0872	11	0.0501
2	0.1093	12	0.0712	2	0.1529	12	0.1183
3	0.0772	13	0.1383	3	0.1007	13	0.0632
4	0.1564	14	0.1243	4	0.1551	14	0.0942
5	0.0638	15	0.1420	5	0.0752	15	0.1293
6	0.1383	16	0.1798	6	0.0331	16	0.1059
7	0.1250	17	0.0896	7	0.0896	17	0.1250
8	0.1759	18	0.0939	8	0.1013	18	0.1305
9	0.1688	19	0.1653	9	0.1644	19	0.1250
10	0.0983	20	0.1731	10	0.1661	20	0.1886

Table 7.3: Sample paired comparison matrix of an academician

	Automobiles	Auto Components	Aviation	Biotechnology	Chemicals
Automobiles	1, 1, 1	1, 1, 3	1, 3, 5	1, 1, 3	1, 1, 3
Auto Components	1, 1, 3	1, 1, 1	1, 3, 5	1, 1, 3	1, 1, 3
Aviation	0.2, 0.3333, 1	0.2, 0.3333, 1	1, 1, 1	0.2, 0.3333, 1	0.2, 0.3333, 1
Biotechnology	1, 1, 3	1, 1, 3	1, 3, 5	1, 1, 1	1, 1, 3
Chemicals	1, 1, 3	1, 1, 3	1, 3, 5	1, 1, 3	1, 1, 1

Table 7.4: Sample paired comparison matrix of an industry professional

	Automobiles	Auto Components	Aviation	Biotechnology	Chemicals
Automobiles	1, 1, 1	1, 1, 3	1, 1, 3	0.2, 0.3333, 1	1, 1, 3
Auto Components	1, 1, 3	1, 1, 1	1, 1, 3	0.2, 0.3333, 1	1, 1, 3

Aviation	1, 1, 3	1, 1, 3	1, 1, 1	0.2, 0.3333, 1	1, 1, 3
Biotechnology	1, 3, 5	1, 3, 5	1, 3, 5	1, 1, 1	1, 3, 5
Chemicals	1, 1, 3	1, 1, 3	1, 1, 3	0.2, 0.3333, 1	1, 1, 1

Table 7.5: Sample calculation of weights of academicians

Academician	Automobiles	Auto Components	Aviation	Biotechnology	Chemicals
1	0.051806	0.051806	0.020429	0.051806	0.051806
2	0.045883	0.045883	0.045883	0.045883	0.045883
3	0.067131	0.067131	0.032554	0.032554	0.032554
4	0.086424	0.048144	0.020324	0.048144	0.007907
5	0.024613	0.024613	0.057718	0.057718	0.057718

Table 7.6: Sample calculation of weights of industry professionals

Professional	Automobiles	Auto Components	Aviation	Biotechnology	Chemicals
1	0.028567	0.028567	0.028567	0.06238	0.028567
2	0.045883	0.045883	0.016469	0.016469	0.045883
3	0.028494	0.062632	0.028494	0.062632	0.062632
4	0.018183	0.048484	0.018183	0.048484	0.048484
5	0.024842	0.024842	0.057744	0.024842	0.024842

Table 7.7 shows the final ranking of sectors based on the sum of weights of respondents for all three cases.

Table 7.7: FAHP ranking of sectors (academicians, professionals and combined)

Sector	Academicians		Professionals		Combined	
	Normalized weights	Rank	Normalized weights	Rank	Normalized weights	Rank
Automobiles	0.04324	10	0.0373	18	0.0402731	15
Auto Components	0.04322	11	0.0393	14	0.04127	13
Aviation	0.0298	22	0.0232	25	0.0265	24
Biotechnology	0.04313	12	0.0395	13	0.04132	12
Chemicals	0.03133	20	0.0437	10	0.0375	17
Construction	0.0484	4	0.0390	15	0.0437	10
Defence manufacturing	0.0426	14	0.0379	17	0.04032736	14
Electrical machinery	0.0455	7	0.0406	12	0.0431	11
Electronic system design and manufacturing	0.0444	9	0.0440	9	0.0442	9
Food processing	0.04309	13	0.0486	5	0.0458	6
IT and BPM	0.0453	8	0.0461	7	0.0457	7
Leather	0.0216	25	0.0238	24	0.0227	25
Media and Entertainment	0.0331	19	0.0328	21	0.0329	20
Mining	0.03130	21	0.0331	20	0.0322	21
Oil and Gas	0.0266	23	0.0272	23	0.0269	23
Pharmaceuticals	0.0557	1	0.0541	1	0.0549	1
Ports	0.0364	17	0.0389	16	0.0377	16
Railways	0.0471	6	0.0465	6	0.0468	4
Renewable energy	0.0536	2	0.0506	3	0.0521	2
Roads and highways	0.0474	5	0.0459	8	0.0466	5
Space	0.0373	16	0.0296	22	0.0334	19

Textiles	0.0336	18	0.0410	11	0.0373	18
Thermal power	0.0263	24	0.0362	19	0.0312	22
Tourism & Hospitality	0.0412	15	0.0493	4	0.0452	8
Wellness	0.0488	3	0.0519	2	0.0504	3

7.5 Data Ranking

The respondents who satisfy CR criteria have been considered for data analysis. The ranking of the data is as per the calculations in fuzzy AHP based on expert's weights, as shown in Table 7.7. The ranking will provide an insight on investment opportunities in potential sectors. One of the goals of this paper is to identify the gap between the decision making of academicians and industry professionals. It is seen that there is not much difference of opinion in ranking between academicians and industry professionals for almost one-third of the sectors. There is the highest level of agreement for ranking of sectors like Biotechnology, Electronic system design and manufacturing, IT and BPM, Leather, Mining, Oil & Gas, Pharmaceuticals, Ports, Renewable energy and Wellness. On the contrary, rankings of sectors like Construction, Chemicals, and Tourism and hospitality show a high level of disagreement. The top five sectors according to industry professionals are Wellness, Pharmaceuticals, Renewable energy, Tourism & Hospitality, and Food processing whereas Renewable energy, Pharmaceutical, Construction, Wellness, and Roads and Highways are ranked as top five sectors by the academicians. Therefore, we can observe there is an agreement in the importance of the three out of the top five factors. The top five sectors according to the combined Opinions are Pharmaceuticals; Renewable energy, Wellness, Railways, and Road and highways. It is observed that three of the five factors are similar to those given by academicians and industry professionals. This is because the construction sector has been given less importance by the professionals as compared to Food Processing and Tourism & Hospitality sector by the academicians. Railways sector makes it to top five in combined decision as in both the individual ranking it is placed at sixth position.

7.6 Data Correlation

To quantify the gap between decisions by the academicians and the industry professionals we evaluate the Spearman's correlation coefficient and Kendall's tau as shown in Table 7.8. The value of Spearman's correlation coefficient between academicians and professionals is 0.7492

whereas Kendall's tau is 0.5533, suggesting a strong correlation [265, 266]. To strengthen the fact that the combined decision of both the groups is a better choice than considering the decision from any one of the two fraternities, we evaluate the correlation coefficients between combined fraternities and single fraternities. The Spearman's coefficient and Kendall's tau between Professionals and Combined are 0.9238 and 0.7733 respectively whereas those between Academicians and Combined are 0.9184 and 0.7799. All these values correspond to a strong correlation, thereby endorsing combined decision as the best option.

Table 7.8: Spearman's correlation coefficient and Kendall's tau

	Academicians and Professionals	Professionals and Combined	Academicians and Combined
Spearman's correlation coefficient	0.7492	0.9238	0.9184
Kendall's tau	0.5533	0.7733	0.7799

7.7 Comparison with Superstar Sectors

The Government of India has identified six superstar sectors viz. Automotive, Electronics system design and manufacturing, Renewable energy, Roads & Highways, Pharmaceuticals and, Food processing to boost the 'Make in India' campaign. Amongst the six superstar sectors, Pharmaceuticals and Renewable energy are ranked in the top five in all the three cases analyzed as seen in Table 7.7. Whereas, Roads & Highways and Electronics system design and manufacturing find a place in the top ten ranks in all the three cases. An important point to note is that the Wellness sector has been given a spot in the top three rankings in all the cases, but the Government has not identified it as one of the superstar sectors.

7.8 Comparison with Proposed Method

The analysis for the present case study is done using Fuzzy AHP. The ranking is then done using proposed method and the results are compared and validated as shown in further sections for 2 cases of forty (considering twenty academicians and twenty industry professionals i.e., 1:1 ratio) and one hundred and fifty (considering fifty academicians and one hundred industry professionals i.e., 2:3 ratio) responses.

7.8.1 Analysis for academicians and industry professionals for 1:1 ratio

The ranking results obtained using Fuzzy AHP (Table 7.7 of section 7.4) for the case of industry professionals and academicians combined data is compared with ranking results of proposed algorithm for forty combined responses (considering 1:1 ratio) of ranking devised during the ongoing research work. The ranking results are as shown in the Table 7.9 below.

Table 7.9: Comparison of ranking by fuzzy AHP and proposed method with 1:1 ratio

SECTOR	FAHP RANK	PROPOSED METHOD RANK
Pharmaceuticals	1	1
Renewable energy	2	2
Wellness	3	3
Railways	4	4
Roads and highways	5	6
Food processing	6	7
Information Technology and Business Process Management (IT and BPM)	7	5
Tourism & Hospitality	8	8
Electronic system design and manufacturing	9	9
Construction	10	11
Electrical machinery	11	10
Biotechnology	12	12
Auto Components	13	13
Defence manufacturing	14	14
Automobiles	15	15
Ports	16	16
Chemicals	17	18
Textiles	18	17
Space	19	21
Media and entertainment	20	19
Mining	21	20
Thermal power	22	22
Oil and gas	23	24
Aviation	24	23
Leather	25	25

7.8.1.1 Data validation for 1:1 case

To validate the correlation between the ranking of proposed algorithm and fuzzy AHP, Spearman rank correlation and Kendall's Tau is calculated. The value of Spearman rank correlation for the data is 0.9940 and Kendall's tau is 0.9583 which indicates a very strong correlation between two results. The results indicate that the proposed method that is simple in implementation with additional advantages of space and time complexity along with comparison difficulties can be used for ranking.

7.8.2 Analysis for academicians and industry professionals for 2:3 ratio

Table 7.10 shows sample data and Cronbach's Alfa calculations for the data set of one hundred and fifty responses with fifty academicians and one hundred industry professionals in ratio of 2:3. The complete data is enclosed as Appendix 5. Cronbach's Alfa test is performed on the incoming data and is found to be 0.8735 which proves the data to be reliable [250].

Table 7.10: Sample data set of one hundred and fifty responses for Cronbach's Alfa

	1. Automobiles	2. Auto Components	3. Aviation	4. Biotechnology	5. Chemicals
1	0.777282	0.924211	0.540062	0.540062	0.777282
2	0.777282	0.777282	0.777282	0.924211	0.777282
3	0.777282	0.924211	0.924211	0.777282	0.777282
4	0.924211	0.924211	0.777282	0.777282	0.777282
5	0.924211	0.924211	0.777282	0.924211	0.924211
6	0.777282	0.777282	0.924211	0.924211	0.777282
7	0.777282	0.924211	0.540062	0.777282	0.924211
8	0.777282	0.777282	0.777282	0.777282	0.777282
9	0.777282	0.777282	0.540062	0.777282	0.540062
10	0.924211	0.924211	0.924211	0.777282	0.540062
---	--	--	--	--	--
146	0.924211	0.924211	0.322749	0.540062	0.777282
147	0.777282	0.777282	0.540062	0.777282	0.777282
148	0.777282	0.777282	0.540062	0.777282	0.777282
149	0.777282	0.777282	0.777282	0.777282	0.777282
150	0.924211	0.924211	0.540062	0.540062	0.924211
	0.022694	0.019366	0.023384	0.016617	0.024551
K	25				
sigvar	0.550412				
Var	3.410771				
α	0.873568				

The ranking results obtained using fuzzy AHP is compared with ranking results of proposed algorithm of ranking devised during the ongoing research work for the combined data with 2:3 ratio. The ranking results are as shown in the Table 7.9 below.

Table 7.11: Comparison of ranking by fuzzy AHP and proposed algorithm with 2:3 ratio

SECTOR	FAHP RANK	PROPOSED METHOD RANK
Pharmaceuticals	1	1
Renewable energy	2	2
Food processing	3	3
Roads and highways	4	4
Information Technology and Business Process Management (IT and BPM)	5	5
Electronic system design and manufacturing	6	6
Auto Components	7	7
Electrical machinery	12	8
Wellness	8	9
Tourism & Hospitality	9	10
Biotechnology	14	11
Railways	11	12
Defence manufacturing	13	13
Construction	10	14
Ports	16	15
Automobiles	15	16
Chemicals	17	17
Media and entertainment	18	18
Textiles	20	19
Space	19	20
Thermal power	21	21
Aviation	23	22
Mining	22	23
Oil and gas	24	24
Leather	25	25

7.8.2.1 Data validation for 2:3 case

To validate the correlation between the ranking of proposed algorithm and fuzzy AHP, Spearman rank correlation and Kendall's Tau is calculated. The value of Spearman rank

correlation is 0.9807 and Kendall's Tau is 0.9199 which indicates, there is a strong correlation between two results.

7.9 Summary

Post-Independence of India, the service sector has been the major contributor to the growth of GDP and has overshadowed the manufacturing sector. The 'Make in India' campaign has been initiated by the government with a prime focus on boosting the manufacturing sector. In the current pandemic situation, it is critical to focus on the potential sectors for increasing GDP share through manufacturing; therefore ranking the sectors is the primary objective of this research. In this research, ranking of the sectors identified in the 'Make in India' initiative is done using fuzzy AHP and proposed method. The ranking will help the investors to choose right sectors for investments. The sectors have been ranked in three different cases of expert classification, i.e., academicians, industry professionals, and using combinations to identify whether there is a gap in decision making. Observing the gap in decision making between the academicians and industry professionals it is obvious that the combined decision of both the fraternities is a better choice than relying on either academicians or industry professionals. According to the combined ranking with a data set of forty experts i.e. twenty academicians and twenty industry professionals, it is observed that the six superstar sectors identified by the government can be ranked in the order as, Pharmaceuticals, Renewable energy, Roads & Highways, Food processing, Electronics system design and manufacturing and Automotive. A comparison of results obtained by fuzzy AHP is done with proposed method for ranking for the combined data of academicians and industry professionals for two cases. The first case considers a equal ration of academicians and industry professionals with total of forty responses and the second case considers fifty academicians with one hundred industry professionals (2:3) for one hundred and fifty total responses. The correlation proves the new method to be equally good to fuzzy AHP using Spearman rank correlation and Kendall's Tau where the spearman coefficient and Kendall's tau is found to be 0.9940 and 0.9583, respectively, in first case, and Spearman rank correlation and Kendall's tau is found to be 0.9807 and 0.9199, respectively, in the second case proving very strong correlation. It is interesting to note that in case of the one hundred and fifty responses analysis, the top seven positions for both the methods remain unchanged, proving the need of higher number of responses for better decision making. Further the rankings show that the six superstar sectors identified by the government can be ranked in the order as, Pharmaceuticals, Renewable energy, Food Processing, Roads & Highways, Electronics system design and manufacturing

and Automotive out of which four sectors are ranked at top four positions as seen in ranking results by both methods. One interesting observation is the wellness sector has achieved a rank of 8 in fuzzy AHP ranking and 9 in proposed method with the analysis of one hundred and fifty experts. In the analysis of 40 experts the Wellness sector is ranked at 3. This can be an interesting future scope for analysing the results and experts' attributes in terms of correlation. The results indicate that the proposed method that is simple in implementation with additional advantages of space and time complexity along with comparison difficulties can be used for ranking. In the next chapter, a case study in the area of renewable energy is carried out that is the need of the hour with current power shortage situations in most of the developing countries. A solar power plant location is identified amongst given alternatives using the proposed method and the results are compared with fuzzy AHP for validation. A combination of proposed method with fuzzy TOPSIS and fuzzy AHP – fuzzy TOPSIS is also evaluated.

Chapter 8

Locating Solar Power Plant in Goa: A Case Study

8.1 General

India has been on global map with recent push in manufacturing sectors through its 'Make in India' initiative. Power is one of the major drives of industrialization. However, India has its own existing energy issues. The government is proposing renewable energy and is inviting investors all across globe for investing in renewable energy sector along with others. Raghuvanshi and Arya (2019) in their recent review paper have emphasized the potential of renewable energy systems (RESs) and region-wise installed capacity in India [230]. Kumar and Majid (2020) have presented the vital achievements, prospects, projections, generation of electricity, as well as challenges and investment and employment opportunities due to the growth of renewable energy in India [231]. India has a great potential in setting up of solar power plants as the country has a favourable geographical position. However, the policies for the development of solar energy in India and the barriers for successful policy development and deployment need to be considered [233]. Tropical geography, a large market base, attractive policy incentives, and huge educational and research facilities make India a prime contender to be a leader in the global energy market. Gupta and Anand (2013) have conducted study of various national and state-level schemes, incentives, packages, and various mechanisms to promote solar photovoltaic and its effectiveness with a conclusion that solar capacity development has gained a greater height under state policies than others[234]. In the previous chapters, factors affecting facility location are identified, ranked with a propose method and the method is validated against the existing fuzzy AHP with modifications. In this chapter an attempt has been made to choose best alternative amongst given alternatives based on selected criteria.

8.1.1 Case study motivation

The government of India has identified twenty-five sectors for investments in India. The ranking of these sectors is carried out in chapter 6 and it is observed that renewable energy is ranked in top three sectors for investments. The renewable energy sector is chosen for

applying the proposed method as the energy crisis in India has been on the rise over the years. There is a strong need to identify alternate energy sources for domestic as well as industrial use. India has abundant solar power owing to its tropical location advantage and hence solar power plants can be set up to counter the growing energy crisis. With the Goa government's new solar policy expected soon, Goa's solar power sector is due for action. The government feels that the policy will modify the power supply scenario in the state by fast-tracking projects and create clean energy. The Goa Energy Development Agency (GEDA), the promoter for the use of non-conventional and renewable energy in Goa, states that the number of solar projects in the state is estimated to be around 90 systems with a total capacity in the region of four MW. A chunk of the capacity is 5 kwh to 50 kwh owned by individual and commercial consumers such as hotels. Large plants of about one MW or more have yet to come upas per GEDA [293]. This forms the major motivation of conducting the case study. The proposed fuzzy method is further extended as an MCDM approach to identify best suitable location for a solar power plant in Goa, India. This case study takes care of the final objective of choosing the best location for a particular business.

8.2 Criteria Selection

The solar power plant location selection problem has been a wide area for research since decades and there have been many approaches listed by authors depending upon the complexity of the problem. The present research has identified fifty-seven general factors based on literature and expert inputs that affect the facility location decision making using PESTLE tool. These factors are further ranked to account for their importance. However, it is interesting to note that these factors will come into force when the decision making amongst locations is done across borders or across states of a particular country as there will be variation amongst the factors. However, when these factors are considered for a particular type of business as criteria, some of them might not be important and some specific factors may have to be selected. Secondly when the decision making is to be done amongst locations that are not far, majority of the factors may be on par at all locations. Hence for the present case study, an online meeting was organised amongst experts from solar industry and academicians who have expertise in renewable energy in general and solar energy in particular. All fifty-seven factors were discussed in this meeting in brief and the experts were of the opinion that majority of the factors need not be considered as they are common across all the locations. Hence a new set of solar plant location specific criteria was suggested for consideration that differs within the given alternative locations. Some of the specific criteria

identified by various researchers for locating solar power plant are shown in Table 8.1. In total nine specific criteria are identified through the brainstorming session viz. availability of land (4 acres), surface slope, distance from load centres, location of nearest substation, environmental clearance issues (forest/CRZ/bird migration land/protected sites nearby), dust accumulation (module soiling), interference of locals, access to potential site (ease of transportation) and distance from residential areas. These nine criteria are considered to be of prime importance for the functioning of solar power plant in Goa and are used for further analysis. The solar radiation across Goa is uniform hence the criterion is not considered in the present analysis as seen in Figure 8.1. The cell temperature and climatic conditions are not considered as they are on same levels all across Goa. The choices for alternatives identified are Valpoi, Vagheri; Pernem, Terekhol; Canacona, Gaondongri and Ponda, Keri, Bhootkhamb being the better options identified through experts' opinions. In total seventeen experts belonging to different solar power industries in Goa, Government departments, Academicians, Goa Energy Development Agency employees in the field of renewable energy are chosen as decision makers (DM). The problem is formulated as a fuzzy Multi criteria decision making problem with nine criteria and four alternatives and the analysis is carried out as shown.

Table 8.1: Review of criteria for location selection of solar power plant

Author & Year	Criteria
Saracoglu et al. (2018) [294]	1. Global horizontal irradiation, 2. Government's super grid integration policy 3. Super grid business climate and conditions, 4.High Voltage Direct Current (HVDC) and High Voltage Alternating Current (HVAC) electrification grid infrastructure, 5. Land use, allocation and availability, 6. Geological conditions, 7. Political, war, terror & security, 8. Topographical conditions, 9. Climatic conditions, 10. Water availability conditions, 11. Natural disaster/hazard conditions
Khan and Rathi(2014) [295]	1. Availability of solar radiation 2. Availability of vacant land 3. Distance from highways and existing transmission lines, 4. Variations of local climate 5. Module soiling 6. Topography of site
Ozdemir and Sahin (2018) [296]	1. Potential energy production (Solar energy potential of the location, daily and monthly irradiation), 2. Environmental factors (Climate conditions, the existence of many clear days per year, Distance to bird migration locations), 3. Safety (Protecting infrastructure and equipment from hazards) 4. Distance from existing transmission line (number of lines, capacities of the transformer) 5. Topographical properties (flat or slightly south facing slopes, modules soiled, geological structure and land type)
Yousefi et al. (2018)	1. Economic Criteria (distance to faults, distance to roads, distance to urban and rural areas, slope and elevation, proximity of power plants to urban and industrial areas, accessibility to the transport network, build power stations near the residential areas and transmission lines)

[297]	2.Environmental Criteria (Land use, distance to protected areas, and distance to rivers and water resources, Land availability) 3. Technical Criteria (Climatic factors: temperature, precipitation, humidity and sunshine hours, Rainfall characteristics (rainy and snowy days show the amount of particular matters in the atmosphere), moisture factor)
Uyan(2017) [298]	1. Distance from residential areas, 2. Land use, 3.Slope (%), 4.Distance from transmission lines (m), 5. Distance from roads
Kereush and Perovych (2017) [299]	1. Abundant solar irradiation, 2. Certain slope & aspect, 3. Transmission lines adjusted to capacity located nearby, 4. Proximity to populated area, 5. Proximity to enterprises,6. Proximity to road network, 7. Average air temperature in July (north hemisphere), 8. Proximity to multi-storey houses, 9. Proximity to residential areas, 10. Land cover free like mountains, forests, 11. Protected areas, 12.Shoreline,13. High altitude areas
Sharma and Singh (2018) [300]	1. Availability of solar radiation, 2.Availability of vacant land, 3.Distance from existing transmission line, 4.Topography of site, 5.Variation in local climate, 6. Use of nearby land, 7. Consideration of geopolitical sites, 8.Module soiling
Krpan et al. (2012) [301]	1. Spatial attractiveness data, 2.Solar plant positioning, 3. Areas with unfavorable inclination (mountain ridges and hilltops), 4. Considerable shading or restricted space (canyons), 5. Special purpose spaces like protected coastal areas, 6. National borders, 7.Nature localities protected by law, 8. Cultural heritage sites specified by law, 9. Areas in which protected sources of drinking water located, 10.First protection zones, 11. Built-up areas, 12.Infrastructure zones, 13. Areas under the sea/water

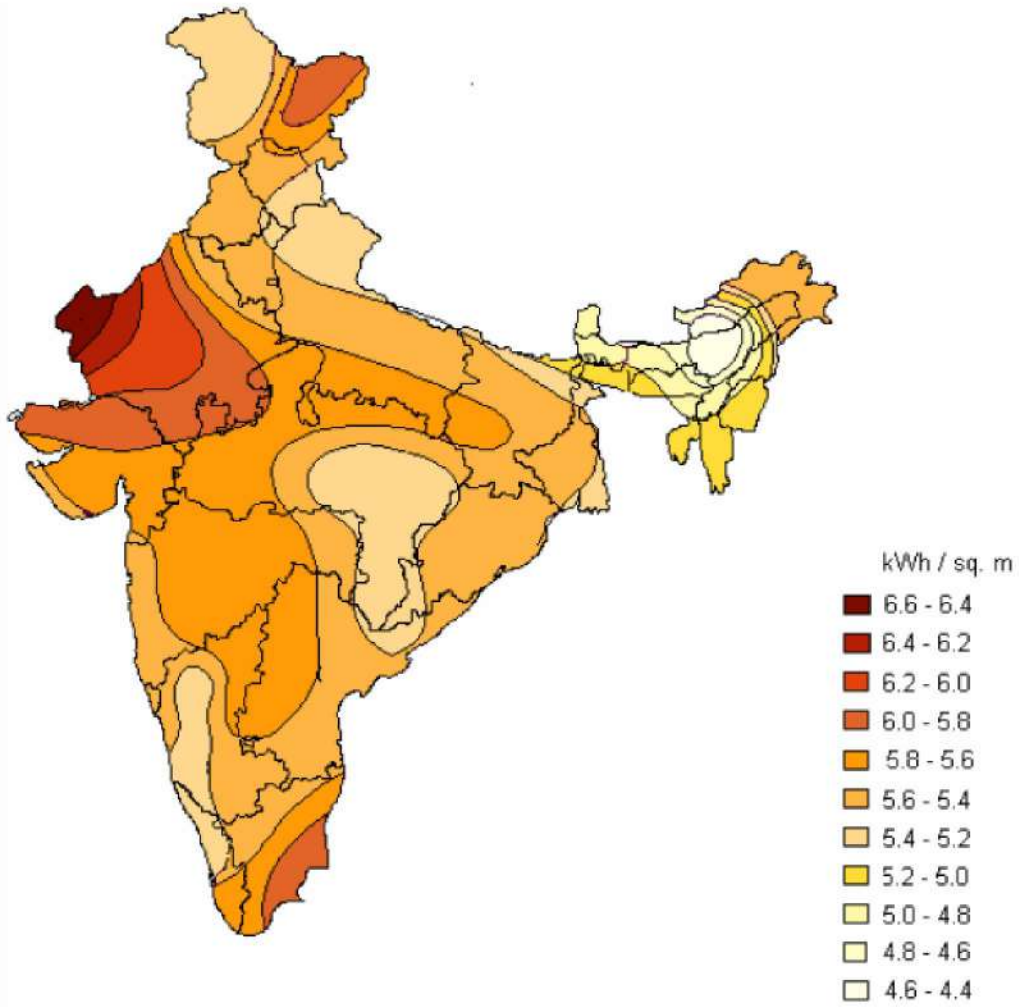

Figure 8.1: Solar radiation on India [302]

8.3 General Aspects of MCDM Methods

The multi-criteria decision-making problem addresses the issue of finding best alternative among given alternatives with respect to a set of criteria. The criteria generally conflict with each other. The criteria are generally of two types. The "benefit" type of criteria needs to be maximized and the "cost type" of criteria needs to be minimized. The qualitative variables i.e., the linguistic judgments of the decision makers are converted into crisp/fuzzy numbers and the criteria weights are calculated. Qualitative criteria are often involved in the decision process. Once the criteria weights are identified, responses of alternatives based on criteria taken from decision makers are evaluated for finding out the best alternative.

8.4 Case Analysis

Seventeen decision makers are asked to give their linguistic inputs for ranking of nine criteria and ranking of four chosen alternatives versus various criteria. The criteria importance data is

enclosed in Appendix 6. The alternatives importance data for respective criteria is enclosed in Appendix 7 to 10. Amongst the nine identified criteria, availability of land, surface slope and access to potential site (ease of transportation) are identified to be "benefit type" whereas environmental clearance issues (forest/CRZ/bird migration land/protected sites nearby), dust accumulation (module soiling), location of nearest substation, distance from load centers, interference of locals and distance from residential areas are identified to be "cost type". Akkas et al. have worked on a similar Photo Voltaic Power System (PVPS) establishment site selection problem to identify best location amongst five cities in the central Anatolian region of Turkey [232]. In the study, the problem is solved with crisp numbers. However, qualitative data is better represented by triangular fuzzy numbers and proposed fuzzy MCDM method for identifying the best location amongst the given alternatives in this study. In most of the multi criteria decision making applications seen in literature, fuzzy AHP is commonly used for ranking and best alternative selection. However, in some applications; fuzzy AHP is used for ranking of criteria and further some other methods like fuzzy TOPSIS are used for alternative selection. To validate the proposed method against a known method, the analysis is carried out in two ways. In first approach, the proposed method is extended on similar lines to fuzzy AHP approach for ranking and finding the best alternative. In the second approach, the criteria are ranked in the same manner as in the first approach, but the alternative ranking is done by a fuzzy TOPSIS.

8.4.1 Analysis with proposed method and Fuzzy AHP for ranking of criteria and alternatives

The proposed method as shown in chapter 5 is extended further for choosing of best alternative as required in analysis. The initial steps (up to step 7 as seen below) of the method are common as the criteria have to be ranked and the respective weights have to be obtained as shown. Once the ranking is done for criteria and criteria weights are obtained, the alternatives are compared for each criterion to get the relative weights of alternatives against each criterion. Finally, the ranking of alternatives is done based on the alternative weights and criteria weights. The steps are as follows:

Step 1: The average or aggregate influence importance values of criteria are in the matrix A given by

$$A = [a, b, c]_{1xn} \tag{8.1}$$

Step 2: Generate the Dominance matrix B

$$X_{ij} = [p, q, r]_{ij} = [a, b, c]_i - [a, b, c]_j \qquad \forall \text{ i:1 to n;} \qquad \text{j: (i+1) to n;} \tag{8.2}$$

Step 3: Generate the centroid matrix C

$$X_{ij} = \frac{[p,q,r]}{3_{ij}} \quad \forall \text{ i:1 to n;} \quad \text{j: (i+1) to n;} \tag{8.3}$$

Step 4: Scan along all the rows (i) to get positive sums of centroids

$$\text{sump(i)} = \sum_{j=i+1}^{n} (X_{ij}); \quad \forall X_{ij} > 0 \tag{8.4}$$

Step 5: Scan along all the columns (j) to get negative sums of centroids

$$\text{sumn(j)} = \sum_{i=j+1}^{n} (X_{ij}); \quad \forall X_{ij} < 0 \tag{8.5}$$

Step 6: Get the summation of positive sums and negative sums of centroids

$$\text{summation(i)} = \text{sump(i)} + [-1 \times \text{sumn(i)}]; \quad \forall \text{ i: 1 to n} \tag{8.6}$$

Step 7: Rank the criteria based on descending order of Summation (i)

Step 8: Calculate weights for the criteria based on summation using assumption as mentioned in section 8.4.1.1

Step 9: Multiply the weights of criteria and alternatives to rank the alternatives

8.4.1.1 Assigning weights for proposed method

The proposed method gives ranking on the basis of positive and negative sums. In this method, it is but obvious that one factor will be overpowered by all other factors and will be at the last position. Therefore, this factor will have a sum of zero. In case we normalize the sums to calculate weights, this factor will still have a zero weight. This problem will also exist in alternative comparisons wherein the last alternative will always have zero sum and zero weight. To counter such situation, the weights are rounded up to six digits and then subtracted from 1 i.e. the sum total of weights. The difference obtained after adding the weights of other factors and subtracting it from the actual sum total of weights i.e., 1, post rounding, is taken as the weight for the last factor for mathematical calculation purpose. The value of this weight is almost zero, but not zero. This is done to take care of the further non-zero mathematical calculations especially multiplications as non-zero weights need to be multiplied for the final ranking of alternatives. Further, in case more than one criterion takes the last position, which also is possible as the aggregate fuzzy numbers for more than one criterion can be same, the residual sum post roundup of weights can be shared by the criteria on last position equally.

8.4.1.2 Ranking of criteria using fuzzy AHP and proposed method

The responses received for ranking of criteria from experts are shown in linguistic terms in Table 8.2 along with counts of each variable. The Cronbach's Alfa test is carried out on the

data and the value of Alfa is 0.7785 proving the data to be reliable. The criteria ranking using fuzzy AHP and proposed method is as shown in Table 8.4 and 8.5 respectively.

Table 8.2: Responses along with counts

Resp.	Availability of Land	Surface slope	Distance from load centres	Location of nearest substation	Environmental clearance issues	Dust accumulation	Interference of locals	Access to potential site	Distance from residential areas
1	High	High	High	M	High	M	M	High	Low
2	Low	VL	VL	Low	Low	VL	Low	VL	Low
3	VH	High	M	High	VH	Low	Low	VH	Low
4	High	M	M	Low	High	High	High	M	Low
5	High	High	High	High	VL	VL	VL	High	Low
6	VH	M	M	M	Low	High	High	High	Low
7	High	High	M	M	High	Low	M	M	M
8	VH	M	Low	Low	VH	M	Low	M	M
9	VH	M	High	High	High	M	M	M	M
10	High	M	M	M	High	Low	M	High	High
11	M	Low	Low	Low	M	VL	M	Low	VL
12	High	VH	High	VH	Low	High	Low	VH	Low
13	M	High	Low	M	VL	VL	VL	VL	M
14	VH	High	VH	VH	High	M	High	VH	M
15	VH	M	M	M	Low	M	Low	M	Low
16	High	High	High	VH	M	M	M	Low	Low
17	VH	M	High	High	VH	Low	VH	M	VL
TOTAL COUNTS OF EACH VARIABLE FOR EACH CRITERIA									
VH	7	1	1	3	3	0	1	3	0
High	7	7	6	4	6	3	3	4	1
M	2	7	6	6	2	6	6	6	5
Low	1	1	3	4	4	4	5	2	9
VL	0	1	1	0	2	4	2	2	2

Table 8.3: Cronbach's Alfa test results

Respondent	Availability of Land	Surface slope	Distance from load centres	Location of nearest substation	Environmental clearance issues	Dust accumulation	Distance from residential areas	
1	0.777282	0.777282	0.777282	0.540062	0.777282	0.540062	0.322749	5.829342
2	0.322749	0.144338	0.144338	0.322749	0.322749	0.144338	0.322749	2.191095
3	0.924211	0.777282	0.540062	0.777282	0.924211	0.322749	0.322749	5.835505
4	0.777282	0.540062	0.540062	0.322749	0.777282	0.777282	0.322749	5.374809
5	0.777282	0.777282	0.777282	0.777282	0.144338	0.144338	0.322749	4.642171
6	0.924211	0.540062	0.540062	0.540062	0.322749	0.777282	0.322749	5.521739
7	0.777282	0.777282	0.540062	0.540062	0.777282	0.322749	0.540062	5.354902
8	0.924211	0.540062	0.322749	0.322749	0.924211	0.540062	0.540062	4.976915
9	0.924211	0.540062	0.777282	0.777282	0.777282	0.540062	0.540062	5.956365

10	0.777282	0.540062	0.540062	0.540062	0.777282	0.322749	0.777282	5.592122
11	0.540062	0.322749	0.322749	0.322749	0.540062	0.144338	0.144338	3.199856
12	0.777282	0.924211	0.777282	0.924211	0.322749	0.777282	0.322749	6.072725
13	0.540062	0.777282	0.322749	0.540062	0.144338	0.144338	0.540062	3.297567
14	0.924211	0.777282	0.924211	0.924211	0.777282	0.540062	0.540062	7.108814
15	0.924211	0.540062	0.540062	0.540062	0.322749	0.540062	0.322749	4.592766
16	0.777282	0.777282	0.777282	0.924211	0.540062	0.540062	0.322749	5.521739
17	0.924211	0.540062	0.777282	0.777282	0.924211	0.322749	0.144338	5.874407
	0.029355	0.039046	0.046845	0.047963	0.077074	0.05037	0.026493	0.433403
k	9							
sigvar	0.433403							
var	1.407384							
α	0.778557							

Table 8.4: Ranking of criteria using Fuzzy AHP

RANK	CRITERIA	NORMALISED WEIGHTS
1	AVAILABILITY OF LAND (AOL)	0.196435
2	ENVIRONMENTAL CLEARANCE ISSUES (ECI)	0.128029
3	LOCATION OF NEAREST SUBSTATION (LONS)	0.121653
4	SURFACE SLOPE (SS)	0.119186
5	ACCESS TO POTENTIAL SITE (ATPS)	0.114398
6	DISTANCE FROM LOAD CENTRES (DFL)	0.103459
7	INTERFERENCE OF LOCALS (IOL)	0.088991
8	DUST ACCUMULATION (DA)	0.066136
9	DISTANCE FROM RESIDENTIAL AREAS (DFRA)	0.061713

Table 8.5: Ranking of criteria using proposed method

RANK	CRITERIA	SUM	NORMALISED WEIGHT	R/O WEIGHTS
1	AVAILABILITY OF LAND	2.098039	0.407618833	0.407619
2	SURFACE SLOPE	0.725491	0.140952478	0.140952
3	LOCATION OF NEAREST SUBSTATION	0.62255	0.12095252	0.120952
4	ACCESS TO POTENTIAL SITE	0.504902	0.098095204	0.098095
4	ENVIRONMENTAL CLEARANCE ISSUES	0.504902	0.098095204	0.098095

5	DISTANCE FROM LOAD CENTRES	0.465686	0.090476099	0.090476
6	INTERFERENCE OF LOCALS	0.171569	0.033333392	0.033333
7	DUST ACCUMULATION	0.053922	0.01047627	0.010476
8	DISTANCE FROM RESIDENTIAL AREAS	0	0	0.000002

As seen from Table 8.3 and Table 8.4, there is a difference in ranking of criteria. In both, proposed method as well as fuzzy AHP, availability of land ranks on top position whereas surface slope is on 2nd position in proposed method and 4th in fuzzy AHP. This definitely raises a question on difference in ranks. However, if the data is examined carefully with number of counts, it is seen that availability of land and surface slope should be on higher position with higher number that is seen clearly. This is a major drawback of the fuzzy AHP method as the experts compare the criteria with each other on the basis of their individual decisions only. The data is not considered in totality. Secondly the weights obtained using proposed method give a clear-cut picture of the actual weightage given to each criterion that is but obvious by looking at raw data received. In traditional fuzzy AHP, each expert gives his own paired comparison matrix hence the individual criteria comparison does not happen. The proposed method takes care of individual criteria comparison, considers all the individual criteria importance together and finally carries out paired comparison. Further, on the given data, Cronbach's Alfa test is done as seen in Table 8.3. The value of Alfa is 0.778557. As per Taber (2018), the linguistic terms given to the data for such a value of Alfa is acceptable, satisfactory, sufficient, fairly high, high, good, reasonable and adequate. Such a value of Alfa means that the data is not excellent, reliable and robust. This gives another cutting-edge advantage for proposed method over fuzzy AHP. For the proposed method entire data can be tested for reliability and if not reliable can be changed as input required from experts is in simple format. Secondly as per fuzzy AHP, only consistency of paired comparison is checked of individual expert. So even if the data is unreliable, the data is taken for further study as individual expert comparisons with only a consistency check. The advantages of proposed method over fuzzy AHP through this case study can be proposed as follows. The entire data is checked for reliability and robustness in case of proposed method. The conclusions are based on complete set of data in proposed method as against individual paired comparisons in Fuzzy AHP. Consistency of paired comparison need not be checked in proposed method as the method takes care of paired comparisons. The input data required for analysis can be t aken in simple form for analysis by proposed method as against paired comparisons in fuzzy AHP thereby saving time of experts. The spearman coefficient of correlation value is 0.9121 and

Kendall's tau is 0.8170, proving the ranking results of both the methods having a strong correlation.

8.4.1.3 Ranking of alternatives using fuzzy AHP and proposed method

As seen in Section 8.4.1.2, once the ranking is done for criteria and criteria weights are obtained, the alternatives are compared for each criterion to get the relative weights of alternatives against each criterion. Finally, the ranking of alternatives is done based on the alternative weights and criteria weights. The calculations are shown in Table 8.6 and 8.7 for proposed method and fuzzy AHP respectively.

Table 8.6: Final weights for ranking of alternatives by proposed method

	AOL	ATPS	DA	DFL	DFRA
PONDA, KERI, BHOOTKHAMB	0.288842	0.073244	$1.05X10^{-08}$	0.07964	$4.00\ X10^{-12}$
CANACONA, GAONDONGRI	0.070186	0.00654	0.003895	$1.81\ X10^{-7}$	$6.88\ X10^{-7}$
VALPOI, VAGHERI	0.04859	$9.81\ X10^{-8}$	0.00591	0.006501	$8.79\ X10^{-7}$
PERNEM, TEREKHOL	$8.15X10^{-7}$	0.018311	0.000672	0.004334	$4.33\ X10^{-7}$
	ECI	IOL	LONS	SS	TOTALWT
PONDA, KERI, BHOOTKHAMB	0.068013	0.005769	0.118379	0.087058	0.720946
CANACONA, GAONDONGRI	0.001308	0.000641	$6.05\ X10^{-8}$	0.043529	0.1261
VALPOI, VAGHERI	$9.81X10^{-8}$	0.026923	0.002573	0.010364	0.100862
PERNEM, TEREKHOL	$6.67X10^{-8}$	$6.05X10^{-8}$	$1.41X10^{-7}$	$1.41X10^{-7}$	0.052093

Table 8.7: Final weights for ranking of alternatives by fuzzy AHP

	AOL	ATPS	DA	DFL	DFRA
PONDA, KERI, BHOOTKHAMB	0.072132	0.04279	0.013901	0.041479	0.009808
VALPOI, VAGHERI	0.047417	0.021161	0.018531	0.02138	0.019708
CANACONA, GAONDONGRI	0.045746	0.024065	0.018174	0.018287	0.017062
PERNEM, TEREKHOL	0.031141	0.026382	0.01553	0.022313	0.015135
	ECI	IOL	LONS	SS	TOTALWT
PONDA KERI, BHOOTKHAMB	0.045688	0.022994	0.043159	0.041201	0.333152
VALPOI, VAGHERI	0.024516	0.026311	0.02618	0.025194	0.230399

CANACONA, GAONDONGRI	0.024363	0.019163	0.026392	0.031791	0.225041
PERNEM, TEREKHOL	0.033463	0.020523	0.025921	0.021	0.211408

Table 8.8: Final ranking by proposed method and Fuzzy AHP

	PROPOSED METHOD		FUZZY AHP	
	TOTAL WEIGHT	FINAL RANK	TOTAL WEIGHT	FINAL RANK
PONDA, KERI, BHOOTKHAMB	0.720946	1	0.333152	1
CANACONA, GAONDONGRI	0.1261	2	0.225041	3
VALPOI, VAGHERI	0.100862	3	0.230399	2
PERNEM, TEREKHOL	0.052093	4	0.211408	4

8.4.1.4 Results and discussions

As seen from Table 8.8, the results clearly indicate that Ponda, Keri, Bhootkhamb is the best alternative to setup the solar power plant in Goa. However, the remaining positions are changed in both the methods. Canacona, Gaondongri is placed at 2 by proposed method whereas it occupies 3rd position in fuzzy AHP method. Similarly, Valpoi, Vagheri is at 3rd position in proposed method and is in 2nd position in fuzzy AHP method. Pernem, Terekhol occupies last position in proposed method as well as in fuzzy AHP method. If we look at the weights of Canacona, Valpoi and Pernem in fuzzy AHP method, there is hardly any difference in the weights, whereas a clear-cut distinction in weights is noticed in proposed method for all the three options. It is evident that whenever comparisons are made, there should be some noticeable difference. The data received is sufficient but not robust as per Cronbach's Alfa test. This proves that despite the data not being robust, the proposed method works very well to give better clarity in the weights. The spearman coefficient of correlation of ranking of alternatives comes to 0.80 and Kendall's tau as 0.667 proving strong correlation thereby validating the proposed method ranking results with Fuzzy AHP ranking results.

8.4.2 Analysis with proposed method –fuzzy TOPSIS and fuzzy AHP- Fuzzy TOPSIS combinations for ranking of criteria and alternatives

The criteria weights calculated using proposed method and fuzzy AHP are used to rank alternatives with Fuzzy TOPSIS [18, 229, 303], a well-known method in MCDM for ranking of alternatives and finding the best alternative.

8.4.2.1 Fuzzy TOPSIS

The steps in Fuzzy TOPSIS are as follows:

Step 1: Feasible alternatives should be generated; evaluation criteria should be decided and the decision makers are to be identified. Let say there are 'm' alternatives, 'n' criteria and 'k' decision makers.

Step 2: Allow the decision makers to choose the appropriate linguistic variables to decide about the weightage for the criteria's ($\tilde{\omega}_j$). Similarly make the decision makers to choose the linguistic variables for each alternative with respect to each criterion ($\tilde{x}_j$). The linguistic scale is associated with the standard fuzzy scale in terms of TFN

Step 3: Get the average weights of criteria and ratings of alternatives given by the k decision makers, using Equation 8.7 and 8.8.

$$\tilde{w}_j = \frac{1}{3}\left[\tilde{w}_j^1 + \tilde{w}_j^2 + \ldots + \tilde{w}_j^k\right] \tag{8.7}$$

$$\tilde{x}_j = \frac{1}{3}\left[\tilde{x}_j^1 + \tilde{x}_j^2 + \ldots + \tilde{x}_j^k\right] \tag{8.8}$$

where $\tilde{\omega}_j$ stands for the weight of criteria and $\tilde{x}_j$ stands for the rating of alternative given by k^{th} decision maker.

Step 4: Next step is to make the fuzzy decision matrix of the alternatives (D). This will give the subjective ratings given by a set of decision makers as shown in Equation 8.9

$$D = \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \ldots & \tilde{x}_{1m} \\ \vdots & \vdots & \vdots & \\ \tilde{x}_{n1} & \tilde{x}_{n2} & \ldots & \tilde{x}_{nm} \end{bmatrix} \tag{8.9}$$

where $\tilde{x}_{ij}$, j = 1, 2,…….m, are linguistic variables. The variables are represented by triangular fuzzy numbers, $\tilde{x}_{ij}$= (aij ,bij , cij).

Step 5: Normalized fuzzy decision matrix should be constructed using matrix (D). The various criteria scales are transformed to comparable scale using linear scale transformation. The normalized fuzzy decision matrix is given by Equations 8.10 and 8.11.

$$\tilde{r_{ij}} = \left(\frac{a_{ij}}{c_j^+}, \frac{b_{ij}}{c_j^+}, \frac{c_{ij}}{c_j^+}\right), c_j^+ = \max_i c_{ij} \text{ (benefit criteria)} \tag{8.10}$$

$$\tilde{r_{ij}} = \left(\frac{a_j^+}{c_{ij}}, \frac{a_j^+}{b_{ij}}, \frac{a_j^+}{a_{ij}}\right), a_j^+ = \min_i a_{ij} \text{ (cost criteria)} \tag{8.11}$$

Step 6: Calculate the weighted normalized decision matrix ($\tilde{v}_{ij}$) by multiplying the criteria weights ($\tilde{w}_j$) to the elements ($\tilde{r}_{ij}$) of the normalized fuzzy decision matrix as shown in Equation 8.12

$$\tilde{v}_{ij} = \tilde{r_{ij}} \times \tilde{w_j} \tag{8.12}$$

Step 7: Determine the Fuzzy Positive Ideal Solution (FPIS) and the Fuzzy Negative Ideal Solution (FNIS).

Calculate the separation measures for each alternative. The separation from the positive ideal solution (S^+) is given by Equation 8.13

$$S_i^+ = \sum_{j=1}^{n} d_v(\tilde{v}_{ij}, \tilde{v}_j^+) \quad (8.13)$$

Similarly, the separation from the negative ideal solution (S^-) is given by Equation 8.14.

$$S_i^- = \sum_{i=1}^{n} d_v(\tilde{v}_{ij}, \tilde{v}_j^-) \quad (8.14)$$

Here d_v (.,.) represents the distance between two fuzzy numbers using the vertex method. According to the vertex method, the distance between two triangular fuzzy numbers A1 (l_1, m_1, u_1) and A2 (l_2, m_2, u_2) is calculated using Equation 8.15

$$d(A_1, A_2) = \sqrt{\frac{1}{3}[(l_1 - l_2)^2 + (m_1 - m_2)^2 + (u_1 - u_2)^2]} \quad (8.15)$$

Step 8: Calculate the relative closeness to the ideal solution C_i^* using Equation 8.16 and select the option with C_i^* closest to 1.

$$C_i^* = \frac{S_i^-}{S_i^+ + S_i^-} \quad (8.16)$$

8.4.2.2 Fuzzy AHP – fuzzy TOPSIS combination approach

The criteria weights obtained in Fuzzy AHP before normalising are used for analysis for ranking of alternatives by fuzzy TOPSIS as the criteria weights are required as triangular fuzzy numbers. The final ranking of alternatives is as shown in Table 8.9. It is seen that Ponda, Keri, Bhootkhamb is ranked at 1.

Table 8.9: Ranking of alternatives with fuzzy AHP - fuzzy TOPSIS combination

ALTERNATIVE	FPIS	FNIS	CC	RANK
VALPOI, VAGHERI	0.092038	0.119901	0.565735	2
PERNEM, TEREKHOL	0.130222	0.080272	0.381351	3
CANACONA, GAONDONGRI	0.150359	0.048907	0.245435	4
PONDA, KERI, BHOOTKHAMB	0.031444	0.167198	0.841704	1

8.4.2.3 Proposed method – fuzzy TOPSIS combination approach

In fuzzy TOPSIS, the criteria weights are required as triangular fuzzy numbers. However, in proposed method, the final weights are calculated based on the centroid positive and negative sums which are crisp numbers. A new approach of mapping is presented in this research, to address this issue. In literature, there are many methods where, a fuzzy number can be defuzzified and can be used as a crisp number. There are a few methods mentioned in literature that use statistics to convert crisp numbers to triangular fuzzy numbers [304]. A new approach to map the crisp numbers to known TFN's is used in the present context. In this

approach, the TFNs (0, 0.25, 0.25), (0.25, 0.25, 0.5), (0.25, 0.5, 0.5), (0.5, 0.5, 0.75), (0.5, 0.75, 0.75) and (0.75, 0.75, 1) are added to the known TFNs i.e. (0, 0, 0.25), (0, 0.25, 0.5), (0.25, 0.5, 0.75), (0.5, 0.75, 1) and (0.75, 1, 1). This is done as many of the values map with two TFNs, for eg. the mapped value of 0.22196 for distance from load centres can fall in upper half of (0, 0, 0.25) whose aggregate value is 0.1443 and lower half of (0, 0.25, 0.5) whose aggregate value is 0.32274. However, if we introduce one more TFN i.e. (0, 0.25, 0.25) whose aggregate value is 0.2041 and comes close to the mapped value of 0.22196. The aggregate values of the new range of TFNs are calculated and the crisp numbers are mapped to the aggregate values base on the closeness. Table 8.10 shows the TFNs and the aggregate values. The Table 8.11 shows the crisp numbers mapped to TFN's.

Table 8.10: Aggregate values of new range of TFNs

TFN			Aggregate
0	0	0.25	0.144337567
0	0.25	0.25	0.204124145
0	0.25	0.5	0.322748612
0.25	0.25	0.5	0.353553391
0.25	0.5	0.5	0.433012702
0.25	0.5	0.75	0.5400
0.5	0.5	0.75	0.595119036
0.5	0.75	0.75	0.6770032
0.5	0.75	1	0.777281588
0.75	0.75	1	0.841625412
0.75	1	1	0.924211376

Table 8.11: Crisp weights of proposed method mapped to TFNs

Criteria	Weight	Percentile	Map value	TFN
Availability of land	0.407619	100	1	0.75, 1, 1
Surface slope	0.140952	34.57934983	0.345793498	0.25, 0.25, 0.5
Location of nearest substation	0.120952	29.6728072	0.296728072	0, 0.25, 0.5
Access to potential site	0.098095	24.06536496	0.24065365	0, 0.25, 0.25
Environmental clearance issues	0.098095	24.06536496	0.24065365	0, 0.25, 0.25
Distance from load centres	0.090476	22.19621755	0.221962175	0, 0.25, 0.25
Interference of locals	0.033333	8.177489273	0.081774893	0, 0, 0.25
Dust accumulation	0.010476	2.570047029	0.02570047	0, 0, 0.25
Distance from residential areas	0.000002	0.000490654	$4.90654X10^{-06}$	0, 0, 0.25

The TFNs from Table 8.11 are used as criteria weights for further calculations in fuzzy TOPSIS. The final ranking of alternatives is as shown in Table 8.12. It is seen that Ponda, Keri, Bhootkhamb is ranked at 1.

Table 8.12: Ranking of alternatives with proposed method - fuzzy TOPSIS combination

ALTERNATIVE	FPIS	FNIS	CC	RANK
VALPOI, VAGHERI	0.301487	0.176734	0.369566	2
PERNEM, TEREKHOL	0.378379	0.068172	0.152664	4
CANACONA, GAONDONGRI	0.347233	0.09764	0.219479	3
PONDA, KERI, BHOOTKHAMB	0	0.42825	1	1

8.4.2.4 Results and discussions

As seen from Table 8.9 and Table 8.12, the results clearly indicate that Ponda, Keri, Bhootkhamb is the best alternative to setup the solar power plant in Goa. Valpoi, Vagheri is also on 2nd position in both approaches. However, the remaining positions are changed in both the approaches. Canacona, Gaondongri is placed at 3 by proposed method – fuzzy TOPSIS combination whereas it occupies 4thposition in fuzzy AHP –fuzzy TOPSIS combination. Similarly, Pernem, Terekhol is at 4th position in proposed method– fuzzy TOPSIS combination and is in 3rd position in fuzzy AHP –fuzzy TOPSIS combination. Comparing the present combination with the previous results i.e., for criteria and alternative ranking both by proposed method and fuzzy AHP as obtained in section 8.4.1.2 and 8.4.1.3, it is seen that the 1st and 4th position is retained in the direct case and 1st and 2nd position is retained in the combination case. The spearman coefficient is calculated as 0.7999 and Kendall's tau is calculated as 0.6666 proving a strong correlation between both the approaches thereby validating the proposed method – fuzzy TOPSIS combination ranking results with fuzzy AHP – fuzzy TOPSIS combination ranking results.

8.5 Summary

The energy crisis has been always a major challenge in developing countries. In countries like India, some of the houses in villages in remote areas still continue to live in dark post seven decades of independence. One strong reason for this is the infrastructure that does not reach the remote areas. The second reason is that there is already a shortfall in the amount of electricity produced for supplying in the cities and industrial zones. Renewable energy has always been in focus to counter such a challenge. The final objective of this research is to identify the best location amongst given alternatives for a particular type of business. As

renewable energy is ranked high by the academicians and industry professionals including the Government of India identifying it as a superstar sector, a case study on locating a solar power plant is presented in this chapter. Amongst four alternatives identified through brain storming and expert opinions, Ponda, Keri, Bhookhamb is identified as the best choice. The location selection analysis is carried out with four approaches. The first approach uses fuzzy AHP to rank the criteria and the alternatives. The second approach uses the proposed method to rank the criteria and alternatives. In the third approach, fuzzy AHP is used for criteria rankings and then the alternatives are ranked using fuzzy TOPSIS. In the fourth approach, the criteria ranks of proposed method are used to rank the alternatives using fuzzy TOPSIS. A new fuzzification method is proposed to convert crisp weights into fuzzy weights as the proposed method gives weights in terms of crisp numbers. The results comparison shows that Ponda, Keri, Bhootkhamb is identified as the best location in all the cases. To conclude, fuzzy AHP and proposed method is used for location planning of solar power plant in Goa, India under a fuzzy environment to rank criteria and alternatives and is further both methods are combined with fuzzy TOPSIS respectively for alternative ranking. The combinatorial approaches prove better as the top two ranks remain unchanged in both the cases.

Chapter 9

Summary and Conclusions

9.1 Conclusions

Location decision making includes investment decisions with constraints on the quantity of production and distribution of goods. Location decision making is a complex problem and depends on a number of known and unknown factors that are of unique nature that influence the behaviour of entire supply chain. These factors are of quantitative and qualitative nature and have a major impact on location choices. While deciding on location choices, it is an extremely difficult task to achieve optimal trade-offs among those factors. Moreover, managing global supply chains is a herculean task due to the numerous uncertainty sources and intricate interrelationships at different echelons amidst the diverse elements. Such situations make it very difficult to decide the supply chain configuration and associated total cost simultaneously. Considering developing countries like India, locating a facility has been a challenging issue. From the cases in India like the Tata Nano plant shift to Gujarat from Singur, West Bengal or the Goa nylon 66 plant agitation, it is obvious that location decisions in developing countries is a difficult task. The integration of location decisions with supply chain network design decisions has been discussed over years and recent research has been moving towards achieving the aim. This suggests that the supply chain performance measures affecting the strategic and operational decisions making need to be integrated in facility location decisions. It is seen that the factors that affect facility location decisions have a direct or indirect effect on the performance measures. For example, non-availability of the required transportation facility affects the on-time delivery. Similarly, the inventory levels can be managed optimally with proper use of information technology. Such dependency proves that supply chain performance has a strong connect to the factors considered for facility location. Therefore, there is a strong need to consider the factors that directly or indirectly affect the supply chain performance.

In developing countries, it is mostly observed that the policies are not firm hence there are many loopholes that can work towards benefits of those who like to take undue advantage of the system. In developing countries, a major influence is the political system of the country in its industrial growth. Underlying factors like maturity of political leadership, blind belief in leadership, bureaucratic hurdles, internal turbulence, internal threats, role of parallel economy have not been considered yet in facility location decision making and can cause a lot of issues

and pose lot of challenges during location tracking for a facility. This research work is carried out with an aim of locating a facility that will ensure all such deliverables at optimum levels. Many a times, even after the location is finalized and structure is built, some of these factors may lead to closure of work in such advanced stages that might cause a lot of losses to the investors i. e. the business houses. Identifying such factors is a need of the hour for supply chains to run smoothly post location decisions. A thorough literature review concerning all relevant areas of research problem has been carried out to identify the literature gap in the initial stage of the research. It is observed that in majority of the research papers reviewed, there is no due weight age given supply chain performance measures in location decisions. Fifty-seven factors including the known factors through past research that affect facility location decisions have been identified through literature and brain storming and have been classified in terms of strategic and operational factors using PESTLE tool. The factors identified using PESTLE need to be ranked for their importance. An innovative fuzzy method is proposed to take care of large data matrix. Two case studies have been presented for data analysis with the proposed method. In the first case study, the proposed method has been used for a data set of twenty responses using average and aggregate fuzzy numbers for analysis. The results show that the use of aggregate fuzzy numbers in analysis yield better results. For the distinct clarity in ranking, the sample size is increased to fifty-six in the second case study and analysis has been carried out using aggregate fuzzy numbers. The data is also validated for reliability using Cronbach's Alfa test that has been used for the first time for fuzzy data in this research. The proposed method has been validated against this existing fuzzy AHP method. As fuzzy AHP has a limitation of solving large data matrix on a single level, a novel mapping approach has been proposed to solve the large data matrix problems using fuzzy AHP. The results are checked for correlation and the correlation proves to be very strong with the spearman coefficient value of 0.99924 and Kendall's tau value of 0.9374 proving the rank results obtained by both the methods to be similar. Further, randomly generated data sets are used for three cases of 100 data sets with 50,100 and 300 experts give on an average value around 0.94 proving the results of proposed method and fuzzy AHP are very strongly correlated. It is observed that, the proposed method has an upper hand over fuzzy AHP in terms of time and space complexity. The distinct advantage of the proposed method is that the reliability of incoming data can be checked as the data is considered in totality for obtaining final solution. In case for particular criteria, the opinions are totally different, the aggregation of those criteria will be of average value. For eg. if we have only five respondents, and all give different responses, the aggregation will be average thus getting response for that criteria to be average. In fuzzy AHP, the criteria are compared to each other

on individual expert basis. Thereby, we get weights of criteria against each other for each expert. These weights are added in the end. The response of each expert for each criterion is not considered and such situation can lead to misleading results. The proposed method takes care of considering response of each expert for a given criteria and aggregates the response gaining a major advantage over fuzzy AHP.

The proposed method has been further extended as a risk based ranking application to address the dynamic nature of the dormant factors like maturity of political leadership, blind belief in leadership, bureaucratic hurdles, internal turbulence, internal threats, role of parallel economy that are not considered for facility location selection till now. These factors show an upward trend of movement in ranking with risk based ranking approach. Disaster risks factor too shows a noticeable change with risk based ranking approach. To identify the various business investment opportunities, ranking of sectors identified through 'Make in India' has been done using the proposed method and fuzzy AHP with validation. The sectors have been ranked in three different cases of expert classification, i.e., academicians, industry professionals, and using combinations to identify whether there is a gap in decision making. Observing the gap in decision making between the academicians and industry professionals it is obvious that the combined decision of both the fraternities is a better choice than relying on either academicians or industry professionals. According to the combined ranking with a data set of forty experts i.e., twenty academicians and twenty industry professionals, it is observed that the six superstar sectors identified by the government can be ranked in the order as, Pharmaceuticals, Renewable energy, Roads & Highways, Food processing, Electronics system design and manufacturing and Automotive. A comparison of results obtained by fuzzy AHP is done with proposed method for ranking for the combined data of academicians and industry professionals for two cases. The first case considers a equal ration of academicians and industry professionals with total of forty responses and the second case considers fifty academicians with one hundred industry professionals (2:3) for one hundred and fifty total responses. The correlation proves the new method to be equally good to fuzzy AHP using Spearman rank correlation and Kendall's Tau where the spearman coefficient and Kendall's tau is found to be 0.9940 and 0.9583, respectively, in first case, and Spearman rank correlation and Kendall's Tau is found to be 0.9807 and 0.9199, respectively, in the second case proving very strong correlation. It is interesting to note that in case of the one hundred and fifty responses, the top seven positions for both the methods remain unchanged, proving the need of higher number of responses for better decision making. Further the rankings show that the six superstar sectors identified by the government can be ranked in the order as, Pharmaceuticals, Renewable energy, Food Processing, Roads & Highways, Electronics

system design and manufacturing and Automotive out of which four sectors are ranked at top four positions as seen in ranking results by both methods. One interesting observation is the wellness sector has achieved a rank of 8 in fuzzy AHP ranking and 9 in proposed method with the analysis of one hundred and fifty experts. In the analysis of 40 experts the Wellness sector is ranked at 3. This can be an interesting future scope for analysing the results and experts' attributes in terms of correlation. The results indicate that the proposed method that is simple in implementation with additional advantages of space and time complexity along with comparison difficulties can be used for ranking. To conclude the research objectives, case studies have been carried out for finding out the best location for a solar power plant in Goa, India. The first case study uses the proposed method and the results are compared with existing fuzzy AHP approach for MCDM. The second case study uses combinatorial approach of proposed method – fuzzy TOPSIS and the results are compared against the existing combination of fuzzy AHP and fuzzy TOPSIS approach for ranking of criteria and alternatives respectively. The combinatorial approaches prove to be better as the top two positions amongst four alternatives. In all the four approaches, Ponda Keri, Bhootkhamb results in the best alternative for setting up a solar power plant in Goa. To summarise, the research work has identified various issues in location decisions in developing country like India. The issue of dynamic behaviour of the dormant factors has been identified. Secondly potential based investment decision making for 'Make in India' initiative has been taken up to rank the sectors that will work towards investors' advantage. A major mathematical issue of solving large matrix problems for ranking has been taken up as a challenge and an innovative method & a modified fuzzy AHP approach has been proposed to overcome the analytical issues. The decision making by experts (academicians and industry professionals) is also taken up as an issue and a combined decision-making approach is proposed. Finally, best alternative for setting up a solar power plant is identified using existing and proposed method and combinations.

9.2 Contributions

The dormant factors affecting facility location decisions and supply chain performance during supply chain network design are identified in this research. A mapping approach has been suggested to take care of ranking by paired comparison for large data in the existing fuzzy AHP method. A new fuzzy ranking by paired comparison method with advantages over fuzzy AHP has been proposed. In the traditional fuzzy AHP method, the ranking by paired comparison is done by experts. This is a tedious and time-consuming affair. Therefore, in

both the methods i.e., modified fuzzy AHP and proposed method, the response input requirement is modified in such a way that the experts spend less time in responding to the requests and more experts can be utilised for analysis. The advantages of proposed method over fuzzy AHP in terms of time and space complexities are a major contribution to the research. The proposed method is further extended for risk-based ranking to address dormant factors. The incoming data is validated with Cronbach's Alfa test for reliability of data. For the first time, the Cronbach's Alfa test has been administered on fuzzy data. Lastly two methods in line with fuzzy AHP and fuzzy AHP-fuzzy TOPSIS combination have been proposed for Multi Criteria Decision Making. A new fuzzification method is suggested to convert the crisp criteria weights to fuzzy weights as the proposed method gives weights in terms of crisp numbers and fuzzy TOPSIS requires fuzzy weights as input criteria weights.

9.3 Limitations

In the research, the factors are identified using exiting research and brainstorming. Brainstorming sessions were held with academicians and industry professionals who are based in Goa. The respondents for the case studies on ranking of factors, ranking of sectors are from India. The respondents for solar power plant location case are from Goa, India. Therefore, all the case studies are carried out considering India as a developed country. As the ranking of factors case is in general for developing countries, the data needs to be collected from majority of developing countries to understand the issues faced on a general scale. This is a major limitation of the research.

9.4 Future scope

The present area of research has a wide scope. The following areas of future research are identified:

1. The research is carried out in India. Similar case studies can be conducted in other developing countries and compared with the existing results.
2. The ranking of factors can be generalised for developing countries with mixed responses from different developed countries.
3. The Consistency Ratio (CR) acceptance limit proposed by Thomas Saaty for AHP is 0.1. This limit has been taken up to 0.2 for larger matrices in research. However, size of the matrix is not known. CRs are calculated to identify human error in paired comparisons. The proposed mapping approach takes care of these errors. However, the CR values also depend on the matrix order size and the increments in defuzzified values for CR calculations. An

investigation on CR needs to be done to propose acceptance limits based on different sizes of matrix thus leading to a new problem in research.

4. The analysis of CRs is carried out as per AHP. In present analysis, the data is defuzzified and the CR calculation approach of AHP is used. For Fuzzy AHP, a new approach for CR calculations may be developed.

5. Presently a case study for identifying best location for solar power plant in Goa is done. The alternatives can be extended state-wise and a case study for identifying best location in India can be carried out. Case studies on other important sectors identified through 'Make in India' intiative can be carried out using the proposed MCDM method.

6. Different sectors having common location decision making factors can be grouped together for presenting a group wise framework.

Appendix 1

Data of 57 factors (criteria)/56 respondents

F/R	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	VH	VH	H	H	H	M	H	H	H	H	M	M	M	H	H	H	H	H	H
2	VH	VH	H	H	H	H	H	VH	H	H	M	M	H	H	M	M	H	H	M
3	H	H	M	H	H	H	H	H	H	H	H	H	M	H	H	H	H	H	M
4	VH	VH	VH	H	H	H	H	H	H	VH	VH	VH	H	H	H	H	H	H	H
5	H	H	H	VH	H	H	H	H	H	H	H	H	M	H	H	H	VH	H	H
6	H	H	H	VH	H	H	H	H	H	H	H	H	M	H	H	H	VH	H	H
7	H	H	M	VH	H	VH	VH	H	VH	VH	H	H	M	H	M	H	H	H	M
8	VH	H	VH	H	H	H	H	M	M	H	M	H	M	H	M	H	H	H	H
9	H	H	H	VH	H	H	H	H	VH	VH	H	H	H	H	M	H	M	H	H
10	VH	VH	H	M	H	H	M	H	H	H	M	H	M	H	H	M	H	H	VH
11	VH	H	H	H	H	H	VH	H	H	H	M	M	M	H	H	H	VH	M	H
12	VH	H	H	VH	VH	M	H	VH	VH	VH	M	M	M	H	M	M	M	H	M
13	H	H	VH	H	M	VL	M	H	L	M	L	L	H	H	L	L	M	VL	L
14	VH	VH	VH	H	M	H	VH	VH	H	VH	VH	H	VH	M	VH	M	M	H	VH
15	H	H	M	M	M	M	M	M	H	M	M	M	L	L	L	L	L	M	M
16	VH	H	H	L	H	L	VH	H	VH	M	M	L	M	H	L	VL	L	M	M
17	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH
18	VH	H	H	VH	H	H	H	H	VH	H	M	M	H	VH	H	VH	VH	H	H
19	VH	VH	H	H	H	H	VH	VH	H	H	H	H	M	M	H	M	VH	H	VH
20	H	M	H	M	H	H	VH	H	M	M	M	M	H	M	M	H	VH	H	M
21	H	M	H	M	H	H	VH	H	M	M	M	M	H	M	M	H	VH	H	M
22	VH	H	M	H	H	M	H	H	H	M	M	M	H	H	VH	H	H	VH	H
23	VH	VH	M	H	H	M	H	H	H	M	L	M	M	H	VH	H	H	M	M
24	VH	VH	VH	VH	M	M	H	H	M	VH	M	M	M	H	M	M	H	H	H
25	VH	VH	H	H	VH	H	L	VH	VH	VH	M	M	M	H	M	H	H	VH	H
26	VH	VH	H	H	VH	M	H	H	M	H	L	H	M	H	H	H	H	H	VH
27	VH	H	H	M	H	H	M	H	VH	VH	H	VH	H	VH	M	VH	H	H	M
28	H	H	VH	M	H	M	H	VH	M	M	L	H	L	M	L	L	VH	VH	M
29	M	VH	M	VH	M	M	L	M	M	H	H	H	M	M	M	M	VH	VH	VH
30	H	VH	H	VH	VH	H	VH	VH	H	H	H	H	VH	VH	M	H	VH	H	H
31	VH	H	H	VH	H	H	M	H	M	H	H	H	M	M	M	M	M	H	H
32	VH	VH	VH	VH	H	H	H	H	H	H	H	H	H	H	H	H	H	VH	VH
33	VH	VH	VH	VH	VH	VH	H	VH	M	H	VH	VH	H	VH	H	VH	VH	H	H
34	VH	VH	VH	M	M	H	VH	M	VH	L	L	M	H	M	M	M	H	M	M
35	H	VH	VH	H	VH	H	H	VH	H	H	M	H	H	VH	VH	H	H	H	H
36	M	H	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
37	VH	VH	H	H	H	H	H	VH	VH	VH	VH	VH	VH	VH	H	H	VH	H	H
38	H	M	VH	H	M	M	M	M	H	H	H	M	H	M	H	H	M	M	M
39	H	H	H	M	M	VH	VH	VH	VH	VH	VH	H	H	H	M	M	M	M	H
40	H	VH	H	H	H	VH	H	H	H	H	M	H	H	H	M	H	H	M	H
41	VH	VH	VL	M	M	VL	L	H	VL	H	VL	M	M	H	L	L	L	M	M

42	H	H	H	VH	H	H	VH	H	H	H	H	H	M	H	M	M	H	H	H
43	H	H	M	M	VL	L	VH	VH	VH	VL	VL	M	M	H	M	M	VH	H	M
44	VH	H	H	M	H	M	H	H	H	H	M	M	H	H	L	M	M	H	H
45	VH	VH	H	H	M	H	M	M	H	H	M	VH	H	VH	M	H	VH	H	H
46	H	H	M	H	H	H	M	VH	H	H	M	H	H	M	H	H	H	H	M
47	VH	H	H	H	H	H	M	H	H	H	M	M	M	VH	H	VH	H	H	M
48	H	M	H	H	H	H	H	H	H	VH	H	VH	H	H	H	H	VH	VH	H
49	H	H	H	H	M	M	M	VH	M	M	M	VH	M	H	L	M	VH	VH	L
50	H	M	M	H	M	M	M	H	H	VH	M	M	M	H	VL	M	M	VH	M
51	H	M	H	VH	M	H	H	VH	M	M	M	M	M	H	M	H	M	M	M
52	H	H	M	M	H	H	VH	H	M	L	H	H	H	H	H	H	VH	VH	VH
53	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH
54	VH	H	H	VH	H	H	M	H	H	H	VH	H	VH	M	M	L	L	L	H
55	VH	VH	M	H	H	M	H	H	M	H	M	M	M	M	M	M	M	M	M
56	H	VH	M	M	L	M	M	H	H	H	L	L	M	M	VL	VL	M	M	M
F/R	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1	H	H	M	VH	H	VL	VL	M	H	VH	H	H	H	H	H	H	H	H	M
2	H	M	M	M	H	M	H	M	H	H	H	H	H	H	H	H	H	H	H
3	H	M	M	H	H	M	VL	H	H	H	H	H	H	H	M	H	H	H	H
4	H	H	M	H	H	M	M	H	H	H	H	H	VH	VH	VH	VH	VH	H	VH
5	H	M	M	H	M	M	M	M	M	H	H	VH	VH	H	H	H	H	H	M
6	H	M	M	H	M	M	M	M	M	H	H	VH	VH	H	H	H	H	H	M
7	M	M	M	M	H	VL	VL	M	VH	VH	VH	H	H	H	H	H	VH	H	H
8	H	H	H	VH	M	VL	VL	VL	M	H	M	H	H	H	H	H	H	VH	M
9	H	M	M	VH	VH	M	M	H	H	VH	H	H	M	H	H	VH	H	H	H
10	M	L	L	L	L	VL	M	M	M	VH	VL	H	VH	M	M	VH	M	H	M
11	H	H	H	H	H	M	H	H	H	VH	M	VH	VH	H	VH	VH	VH	VH	H
12	L	L	M	M	H	L	L	M	H	VH	H	VH	VH	VH	M	H	M	H	H
13	VL	L	M	L	VL	M	L	L	M	H	M	L	H	M	L	VH	H	L	L
14	L	M	L	M	M	H	H	L	H	VH	M	VH	VH	H	M	H	M	H	H
15	M	L	L	M	L	VL	L	L	H	H	M	L	M	M	M	M	M	M	M
16	H	H	M	H	VH	VL	L	M	VH	VH	H	M	VH	M	M	VH	VH	H	H
17	VH	VH	VH	VH	VH	M	M	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH
18	H	H	VH	H	H	M	M	VH	VH	VH	H	H	VH	VH	M	VH	VH	VH	VH
19	M	M	H	M	H	L	M	H	H	H	M	VH	VH	H	H	VH	VH	H	H
20	H	M	M	H	M	H	M	H	H	VH	H	VH	VH	H	M	VH	H	VH	VH
21	H	M	M	H	M	H	M	H	H	VH	H	VH	VH	H	M	VH	H	VH	VH
22	H	H	M	M	VH	L	M	H	H	VH	H	VH	VH	H	VH	VH	H	H	H
23	H	H	M	H	H	VL	L	H	H	VH	H	VH	VH	H	H	VH	H	H	M
24	H	M	M	VH	H	M	M	M	VH	VH	VH	VH	VH	VH	M	H	H	H	M
25	H	M	M	H	H	L	L	M	VH	VH	VH	VH	VH	H	L	H	H	VH	H
26	VH	H	H	H	H	L	M	H	H	VH	VH	VH	VH	H	H	H	H	H	H
27	H	M	M	H	H	L	H	M	H	VH	M	H	VH	H	M	VH	M	M	H
28	L	L	H	L	L	L	L	L	H	VH	H	VH	VH	H	M	VH	M	VH	L
29	M	M	M	H	VH	M	M	M	H	H	M	VH	VH	VH	M	H	VH	H	H
30	H	H	M	H	H	VL	VL	M	VH	VH	H	VH	H	H	H	H	H	VH	H

31	VH	H	H	H	H	M	M	M	M	H	VH	H	H	H	M	H	H	H	H
32	VH	VH	M	VH	H	M	H	H	H	VH	VH	VH	VH	VH	VH	VH	H	VH	H
33	H	VH	H	VH	VH	L	L	L	VH	VH	VH	VH	VH	VH	M	VH	VH	VH	H
34	L	L	M	L	L	VL	VL	M	VH	VH	VH	H	VH	H	M	VH	M	M	M
35	VH	H	M	H	VH	H	M	H	VH	VH	VH	VH	VH	VH	H	VH	VH	VH	VH
36	M	M	M	M	H	M	M	H	M	M	M	M	M	M	M	H	H	M	M
37	VH	H	H	H	VH	M	M	H	VH	H	H	VH	VH	H	H	H	VH	H	H
38	L	L	M	L	L	M	M	H	H	H	H	M	M	M	M	M	M	M	H
39	H	H	H	H	H	M	H	H	H	H	H	H	VH	VH	VH	VH	VH	VH	VH
40	H	H	M	H	H	M	H	M	H	H	M	H	H	H	H	H	M	H	M
41	H	M	M	VH	H	VL	VL	VL	H	VH	VH	VH	VH	H	L	VH	H	VH	VH
42	H	H	H	H	M	M	M	M	H	H	M	H	H	H	H	H	H	H	H
43	L	H	H	H	M	VL	VL	H	VH	VH	H	H	VH	VH	L	VH	M	VH	H
44	M	M	L	M	H	VL	VL	L	H	VH	H	H	H	H	M	H	H	H	M
45	H	M	M	VL	H	VL	VL	L	H	VH	H	H	VH	VH	M	H	H	H	M
46	VH	H	M	H	H	M	M	L	VH	VH	H	H	H	H	H	VH	H	H	H
47	H	H	M	VH	VH	M	M	H	H	H	VH	H	H	H	H	H	H	H	M
48	H	H	H	VH	VH	M	M	H	H	VH	H	H	H	VH	H	H	H	VH	H
49	M	H	L	M	H	VL	VL	L	VH	VH	VH	VH	VH	VH	L	H	M	H	H
50	M	M	M	H	M	M	VL	M	VH	H	VL	H	M	M	M	M	M	H	H
51	H	H	M	H	M	VH	M	M	M	M	M	VH	VH	H	H	H	H	H	M
52	VH	H	M	H	H	VL	L	H	VH	VH	H	VH	VH	VH	H	H	VH	H	H
53	VH	VH	VH	VH	VH	VL	VL	VL	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH
54	M	H	M	M	VL	L	L	L	H	VH	VL	H	H	M	L	H	L	L	H
55	M	M	M	M	VH	L	M	M	H	M	M	M	VH	M	H	M	VH	M	H
56	M	VL	L	M	M	L	L	L	H	VH	VH	H	H	H	M	VH	H	M	H
F/R	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
1	M	H	H	H	M	H	H	M	H	M	H	M	H	H	M	M	H	H	H
2	M	M	M	M	M	M	H	M	H	M	M	M	M	M	M	M	M	H	H
3	H	H	H	H	H	L	M	M	H	L	M	H	H	M	M	H	M	H	H
4	VH	VH	VH	H	H	VH	VH	VH	H	VH	H	H	VH	M	H	VH	VH	VH	VH
5	M	H	H	H	M	H	H	M	M	M	M	H	M	H	M	M	M	M	H
6	M	H	H	H	M	H	H	M	M	M	M	H	M	H	M	M	M	M	H
7	M	M	M	M	M	M	M	M	M	M	M	M	VH	H	VH	VH	H	M	M
8	M	H	H	M	M	H	H	M	M	M	M	M	H	M	M	M	H	M	H
9	H	H	H	VH	H	VH	VH	H	H	H	H	VH	H	H	H	H	H	H	H
10	H	H	H	H	M	H	VH	H	M	H	VH	H	H	M	H	H	H	M	H
11	H	VH	H	H	H	H	H	H	VH	H	H	M	H	H	H	H	H	H	H
12	H	H	M	H	M	M	H	M	H	M	VH	M	VH	VH	M	H	H	H	VH
13	L	M	H	M	M	M	H	L	VL	VL	VL	L	H	M	L	H	H	M	M
14	H	H	H	M	M	VH	VH	M	M	M	M	M	H	VH	M	M	M	VH	VH
15	VL	L	L	M	M	H	H	M	M	M	L	L	L	M	M	M	M	M	M
16	M	VL	L	M	M	M	H	M	H	M	M	M	H	H	H	H	H	L	H
17	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH
18	VH	H	H	H	H	M	H	M	L	L	H	H	H	M	H	H	H	M	H
19	M	H	H	H	H	H	VH	H	H	M	M	H	VH	H	H	H	H	VH	VH

20	H	M	M	M	M	M	M	M	H	M	M	H	VH	H	M	M	VH	M	VH
21	H	M	M	M	M	M	M	M	H	M	M	H	VH	H	M	M	VH	M	VH
22	H	H	M	M	L	M	H	H	H	H	M	H	M	H	H	H	M	VH	H
23	H	M	H	M	L	VL	H	M	H	M	H	H	M	M	H	H	M	H	H
24	M	H	H	M	H	H	H	M	H	M	M	M	H	H	H	M	M	H	H
25	H	VH	VH	M	H	VH	H	H	H	L	M	H	VH	H	M	H	H	H	H
26	VH	H	H	M	M	VH	VH	M	M	M	M	M	H	H	M	M	M	M	VH
27	H	VH	H	M	M	H	H	M	M	M	H	H	H	H	M	VH	H	H	VH
28	L	M	L	L	M	H	H	M	M	M	M	M	M	M	M	M	M	L	H
29	M	H	M	M	M	H	H	M	VH	H	M	M	H	H	M	H	H	VH	H
30	M	H	H	H	H	VH	VH	H	VH	H	H	L	M	H	M	M	H	H	H
31	L	H	H	M	H	VH	H	M	H	H	H	L	M	M	M	M	M	H	H
32	H	VH	VH	VH	VH	VH	VH	H	H	H	VH	H	H	H	H	H	H	H	H
33	H	VH	VH	VH	VH	H	VH	H	VH	H	VH	H	H	H	H	VH	H	VH	VH
34	M	H	VH	H	H	H	H	H	H	M	H	H	VH	M	H	H	H	VH	H
35	VH	VH	H	M	H	H	H	H	H	H	M	H	VH	H	H	VH	H	VH	H
36	M	M	M	M	M	M	M	M	H	M	M	M	M	M	M	M	M	H	M
37	H	M	M	H	H	H	M	H	H	H	H	M	H	H	M	M	M	H	H
38	H	VH	VH	H	H	VH	H	H	M	M	M	L	M	M	H	H	H	H	H
39	VH	VH	VH	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
40	H	H	M	H	H	H	H	M	H	M	M	M	H	M	H	H	H	M	H
41	H	VL	VL	VL	VL	L	L	VL	L	VL	VL	L	M	M	VL	M	H	H	H
42	H	H	H	H	H	VH	VH	H	H	M	H	H	H	H	H	H	H	H	H
43	M	L	L	H	M	H	VH	M	L	M	M	M	H	H	H	H	H	L	VH
44	M	H	H	M	M	M	H	M	H	M	H	M	M	M	M	M	L	L	M
45	M	H	H	H	H	M	H	H	H	L	M	H	H	H	H	H	VH	VH	H
46	M	H	H	M	M	M	M	M	H	M	H	H	H	M	M	M	H	H	H
47	M	M	H	M	H	H	H	H	H	M	M	M	M	M	M	M	H	H	H
48	H	VH	VH	H	VH	VH	H	M	H	L	M	H	VH	M	M	M	H	M	H
49	H	M	M	M	M	H	H	M	H	M	M	M	H	H	VL	L	M	M	VH
50	M	M	H	M	M	H	H	M	M	M	M	H	H	M	M	M	H	M	M
51	M	H	M	H	M	VH	H	M	H	M	H	M	M	M	M	H	M	H	H
52	H	VH	VH	VH	H	M	H	M	H	M	H	VH	H	M	H	H	H	VH	VH
53	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	M	VH	VH	VH	VH
54	M	H	H	H	L	H	H	M	VL	H	H	M	M	M	M	H	M	M	H
55	H	M	M	H	M	H	VH	M	VH	M	M	H	H	M	M	M	M	H	H
56	H	H	M	H	M	H	VH	M	H	M	M	M	H	M	M	M	H	H	M

Appendix 2

Criteria Weights of 56 Respondents for Fuzzy AHP

R/C	1	2	3	4	5	6	7	8	9
1	0.036195167	0.036195167	0.020090756	0.020090756	0.020090756	0.007736369	0.020090756	0.020090756	0.020090756
2	0.030982203	0.01550582	0.01550582	0.01550582	0.01550582	0.01550582	0.030982203	0.01550582	0.01550582
3	0.034690505	0.018159043	0.018159043	0.034690505	0.034690505	0.007806276	0.018159043	0.034690505	0.034690505
4	0.032963676	0.032963676	0.050183782	0.032963676	0.017206219	0.003422293	0.017206219	0.032963676	0.007715857
5	0.032655397	0.032655397	0.032655397	0.016378762	0.007047487	0.016378762	0.032655397	0.032655397	0.016378762
6	0.035710091	0.035710091	0.019414522	0.019414522	0.019414522	0.019414522	0.019414522	0.019414522	0.035710091
7	0.039121702	0.022291284	0.022291284	0.004359167	0.022291284	0.004359167	0.039121702	0.022291284	0.039121702
8	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686
9	0.030304158	0.01479357	0.01479357	0.030304158	0.01479357	0.01479357	0.01479357	0.01479357	0.030304158
10	0.031509426	0.031509426	0.015811827	0.015811827	0.015811827	0.015811827	0.031509426	0.031509426	0.015811827
11	0.019364387	0.008300613	0.019364387	0.008300613	0.019364387	0.019364387	0.036081483	0.019364387	0.008300613
12	0.039172553	0.039172553	0.022427373	0.022427373	0.022427373	0.022427373	0.022427373	0.039172553	0.022427373
13	0.019364387	0.008300613	0.019364387	0.008300613	0.019364387	0.019364387	0.036081483	0.019364387	0.008300613
14	0.034020597	0.017929868	0.00701323	0.017929868	0.017929868	0.00701323	0.017929868	0.017929868	0.017929868
15	0.036788983	0.036788983	0.008424083	0.020467611	0.020467611	0.008424083	0.020467611	0.020467611	0.020467611
16	0.034878048	0.034878048	0.034878048	0.034878048	0.007688734	0.007688734	0.018391934	0.018391934	0.007688734
17	0.031381041	0.031381041	0.01560003	0.01560003	0.031381041	0.01560003	0.002826212	0.031381041	0.031381041
18	0.033145604	0.033145604	0.017082592	0.017082592	0.033145604	0.006809355	0.017082592	0.017082592	0.006809355
19	0.033694195	0.017538462	0.017538462	0.007014244	0.017538462	0.017538462	0.007014244	0.017538462	0.033694195
20	0.024579239	0.024579239	0.042268458	0.012039364	0.024579239	0.012039364	0.024579239	0.042268458	0.012039364
21	0.008380106	0.036024521	0.008380106	0.036024521	0.008380106	0.008380106	0.003341215	0.008380106	0.008380106
22	0.015371899	0.030768492	0.015371899	0.030768492	0.030768492	0.015371899	0.030768492	0.030768492	0.015371899
23	0.021593097	0.021593097	0.008193647	0.021593097	0.021593097	0.021593097	0.021593097	0.021593097	0.021593097
24	0.037374438	0.020859601	0.020859601	0.037374438	0.020859601	0.020859601	0.008418605	0.020859601	0.008418605
25	0.026263105	0.026263105	0.026263105	0.026263105	0.011657739	0.011657739	0.011657739	0.011657739	0.011657739
26	0.023839334	0.023839334	0.023839334	0.023839334	0.023839334	0.023839334	0.009769554	0.023839334	0.003764556
27	0.036032079	0.036032079	0.036032079	0.008628045	0.008628045	0.01943193	0.036032079	0.008628045	0.036032079
28	0.012240267	0.027073921	0.027073921	0.012240267	0.027073921	0.012240267	0.012240267	0.027073921	0.012240267
29	0.015650157	0.03107031	0.015650157	0.015650157	0.015650157	0.015650157	0.015650157	0.015650157	0.015650157
30	0.030098129	0.030098129	0.01467162	0.01467162	0.01467162	0.01467162	0.01467162	0.030098129	0.030098129
31	0.023958495	0.010582394	0.04103675	0.023958495	0.010582394	0.010582394	0.010582394	0.010582394	0.023958495
32	0.01437065	0.01437065	0.01437065	0.005226067	0.005226067	0.029675965	0.029675965	0.029675965	0.029675965
33	0.020554966	0.036932207	0.020554966	0.020554966	0.020554966	0.036932207	0.020554966	0.020554966	0.020554966
34	0.02659614	0.02659614	0.02659614	0.011878007	0.011878007	0.011878007	0.011878007	0.011878007	0.011878007
35	0.042582118	0.042582118	0.003479818	0.013483742	0.013483742	0.003479818	0.006698306	0.026114635	0.003479818
36	0.018279072	0.018279072	0.018279072	0.034261098	0.018279072	0.018279072	0.034261098	0.018279072	0.018279072
37	0.020662538	0.020662538	0.009406347	0.009406347	0.002256691	0.004241273	0.037167228	0.037167228	0.037167228
38	0.042165948	0.025282902	0.025282902	0.011201859	0.025282902	0.011201859	0.025282902	0.025282902	0.025282902
39	0.034422584	0.034422584	0.018495872	0.018495872	0.007418668	0.018495872	0.007418668	0.007418668	0.018495872
40	0.020283091	0.020283091	0.008008453	0.020283091	0.020283091	0.020283091	0.008008453	0.036681284	0.020283091
41	0.036182342	0.019817913	0.019817913	0.019817913	0.019817913	0.019817913	0.007828038	0.019817913	0.019817913

42	0.015479049	0.005774068	0.015479049	0.015479049	0.015479049	0.015479049	0.015479049	0.015479049	0.015479049
43	0.021347713	0.021347713	0.021347713	0.021347713	0.009826474	0.009826474	0.009826474	0.038223637	0.009826474
44	0.026478273	0.012530919	0.012530919	0.026478273	0.012530919	0.012530919	0.012530919	0.026478273	0.026478273
45	0.020794111	0.020794111	0.020794111	0.037264073	0.020794111	0.020794111	0.020794111	0.020794111	0.020794111
46	0.022131866	0.00960371	0.022131866	0.039098556	0.00960371	0.022131866	0.022131866	0.039098556	0.00960371
47	0.014890248	0.014890248	0.00571031	0.00571031	0.014890248	0.014890248	0.030337366	0.014890248	0.00571031
48	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682
49	0.040929421	0.024170626	0.024170626	0.040929421	0.024170626	0.024170626	0.010823352	0.024170626	0.024170626
50	0.040594023	0.040594023	0.010698914	0.023206859	0.023206859	0.010698914	0.023206859	0.023206859	0.010698914
51	0.025488292	0.042616214	0.011970793	0.011970793	0.00482954	0.011970793	0.011970793	0.025488292	0.025488292
52	0.020794111	0.020794111	0.020794111	0.037264073	0.020794111	0.020794111	0.020794111	0.020794111	0.020794111
53	0.01905322	0.01905322	0.008204361	0.035546961	0.01905322	0.035546961	0.035546961	0.01905322	0.035546961
54	0.038649118	0.022227251	0.038649118	0.022227251	0.022227251	0.022227251	0.022227251	0.009283369	0.009283369
55	0.015793863	0.015793863	0.015793863	0.031313156	0.015793863	0.015793863	0.015793863	0.015793863	0.031313156
56	0.037092843	0.037092843	0.020646794	0.008714443	0.020646794	0.020646794	0.008714443	0.020646794	0.020646794
R/C	10	11	12	13	14	15	16	17	18
1	0.020090756	0.007736369	0.007736369	0.007736369	0.020090756	0.020090756	0.020090756	0.020090756	0.020090756
2	0.01550582	0.005570343	0.005570343	0.005570343	0.01550582	0.01550582	0.01550582	0.030982203	0.005570343
3	0.034690505	0.007806276	0.007806276	0.007806276	0.018159043	0.007806276	0.007806276	0.007806276	0.018159043
4	0.017206219	0.007715857	0.007715857	0.032963676	0.032963676	0.007715857	0.007715857	0.017206219	0.003422293
5	0.032655397	0.032655397	0.016378762	0.032655397	0.007047487	0.032655397	0.007047487	0.007047487	0.016378762
6	0.019414522	0.019414522	0.019414522	0.007665567	0.007665567	0.007665567	0.007665567	0.007665567	0.019414522
7	0.010156941	0.010156941	0.004359167	0.010156941	0.022291284	0.004359167	0.002224002	0.004359167	0.010156941
8	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686
9	0.01479357	0.005641665	0.005641665	0.01479357	0.030304158	0.01479357	0.030304158	0.030304158	0.01479357
10	0.015811827	0.015811827	0.015811827	0.00601103	0.00601103	0.015811827	0.00601103	0.031509426	0.015811827
11	0.008300613	0.008300613	0.008300613	0.019364387	0.008300613	0.008300613	0.019364387	0.036081483	0.019364387
12	0.022427373	0.009283541	0.009283541	0.022427373	0.022427373	0.009283541	0.009283541	0.022427373	0.022427373
13	0.008300613	0.008300613	0.008300613	0.019364387	0.008300613	0.008300613	0.019364387	0.036081483	0.019364387
14	0.00701323	0.00701323	0.00701323	0.017929868	0.017929868	0.034020597	0.017929868	0.017929868	0.034020597
15	0.008424083	0.003444704	0.008424083	0.008424083	0.020467611	0.036788983	0.020467611	0.020467611	0.008424083
16	0.034878048	0.007688734	0.007688734	0.007688734	0.018391934	0.007688734	0.007688734	0.018391934	0.018391934
17	0.031381041	0.006239049	0.006239049	0.006239049	0.01560003	0.006239049	0.01560003	0.01560003	0.031381041
18	0.017082592	0.002868421	0.017082592	0.006809355	0.017082592	0.017082592	0.017082592	0.017082592	0.017082592
19	0.033694195	0.017538462	0.033694195	0.017538462	0.033694195	0.007014244	0.033694195	0.017538462	0.017538462
20	0.012039364	0.005240359	0.024579239	0.005240359	0.012039364	0.005240359	0.005240359	0.042268458	0.042268458
21	0.019248988	0.019248988	0.019248988	0.008380106	0.008380106	0.008380106	0.008380106	0.036024521	0.036024521
22	0.015371899	0.015371899	0.015371899	0.030768492	0.030768492	0.005815436	0.015371899	0.030768492	0.015371899
23	0.021593097	0.021593097	0.021593097	0.008193647	0.021593097	0.021593097	0.021593097	0.021593097	0.021593097
24	0.020859601	0.020859601	0.020859601	0.008418605	0.008418605	0.008418605	0.008418605	0.008418605	0.020859601
25	0.011657739	0.011657739	0.011657739	0.011657739	0.011657739	0.011657739	0.011657739	0.011657739	0.026263105
26	0.009769554	0.023839334	0.023839334	0.009769554	0.023839334	0.009769554	0.023839334	0.023839334	0.009769554
27	0.003752378	0.003752378	0.008628045	0.01943193	0.008628045	0.008628045	0.008628045	0.01943193	0.008628045
28	0.012240267	0.004466415	0.012240267	0.012240267	0.027073921	0.027073921	0.012240267	0.012240267	0.012240267
29	0.015650157	0.015650157	0.015650157	0.015650157	0.015650157	0.015650157	0.015650157	0.015650157	0.015650157
30	0.030098129	0.030098129	0.030098129	0.030098129	0.030098129	0.01467162	0.01467162	0.030098129	0.01467162

31	0.023958495	0.023958495	0.010582394	0.023958495	0.010582394	0.023958495	0.023958495	0.010582394	0.010582394
32	0.029675965	0.029675965	0.01437065	0.01437065	0.01437065	0.005226067	0.005226067	0.005226067	0.005226067
33	0.020554966	0.007780743	0.020554966	0.020554966	0.020554966	0.007780743	0.020554966	0.020554966	0.007780743
34	0.02659614	0.02659614	0.02659614	0.011878007	0.011878007	0.011878007	0.011878007	0.011878007	0.011878007
35	0.026114635	0.003479818	0.013483742	0.013483742	0.026114635	0.006698306	0.006698306	0.006698306	0.013483742
36	0.018279072	0.018279072	0.018279072	0.006519605	0.018279072	0.006519605	0.006519605	0.018279072	0.018279072
37	0.002256691	0.002256691	0.009406347	0.009406347	0.020662538	0.009406347	0.009406347	0.037167228	0.020662538
38	0.025282902	0.011201859	0.011201859	0.025282902	0.025282902	0.004327342	0.011201859	0.011201859	0.025282902
39	0.018495872	0.007418668	0.034422584	0.018495872	0.034422584	0.007418668	0.018495872	0.034422584	0.018495872
40	0.020283091	0.008008453	0.020283091	0.020283091	0.008008453	0.020283091	0.020283091	0.020283091	0.020283091
41	0.019817913	0.007828038	0.007828038	0.007828038	0.036182342	0.019817913	0.036182342	0.019817913	0.019817913
42	0.031051799	0.015479049	0.031051799	0.015479049	0.015479049	0.015479049	0.015479049	0.031051799	0.031051799
43	0.009826474	0.009826474	0.038223637	0.009826474	0.021347713	0.004192833	0.009826474	0.038223637	0.038223637
44	0.043718145	0.012530919	0.012530919	0.012530919	0.026478273	0.002203675	0.012530919	0.012530919	0.043718145
45	0.020794111	0.020794111	0.020794111	0.008236903	0.020794111	0.020794111	0.020794111	0.037264073	0.020794111
46	0.00960371	0.00960371	0.00960371	0.00960371	0.022131866	0.00960371	0.022131866	0.00960371	0.00960371
47	0.002586408	0.014890248	0.014890248	0.014890248	0.014890248	0.014890248	0.014890248	0.030337366	0.030337366
48	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682
49	0.024170626	0.040929421	0.024170626	0.040929421	0.010823352	0.010823352	0.00459553	0.00459553	0.00459553
50	0.023206859	0.010698914	0.010698914	0.010698914	0.010698914	0.010698914	0.010698914	0.010698914	0.010698914
51	0.025488292	0.00482954	0.00482954	0.011970793	0.011970793	0.002341287	0.002341287	0.011970793	0.011970793
52	0.020794111	0.020794111	0.020794111	0.008236903	0.020794111	0.020794111	0.020794111	0.037264073	0.020794111
53	0.035546961	0.01905322	0.01905322	0.008204361	0.01905322	0.008204361	0.01905322	0.01905322	0.01905322
54	0.022227251	0.009283369	0.022227251	0.009283369	0.022227251	0.009283369	0.022227251	0.022227251	0.022227251
55	0.031313156	0.015793863	0.015793863	0.015793863	0.015793863	0.005656377	0.015793863	0.005656377	0.015793863
56	0.020646794	0.008714443	0.020646794	0.008714443	0.020646794	0.020646794	0.008714443	0.020646794	0.020646794
R/C	19	20	21	22	23	24	25	26	27
1	0.020090756	0.020090756	0.020090756	0.007736369	0.036195167	0.020090756	0.001776096	0.001776096	0.007736369
2	0.01550582	0.01550582	0.01550582	0.01550582	0.01550582	0.01550582	0.005570343	0.01550582	0.01550582
3	0.007806276	0.003296399	0.003296399	0.007806276	0.007806276	0.018159043	0.003296399	0.003296399	0.007806276
4	0.007715857	0.003422293	0.007715857	0.017206219	0.007715857	0.003422293	0.017206219	0.007715857	0.007715857
5	0.032655397	0.00306431	0.007047487	0.00306431	0.007047487	0.007047487	0.016378762	0.016378762	0.00306431
6	0.019414522	0.019414522	0.007665567	0.007665567	0.019414522	0.007665567	0.003057791	0.007665567	0.007665567
7	0.010156941	0.022291284	0.022291284	0.010156941	0.022291284	0.039121702	0.002224002	0.004359167	0.010156941
8	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686	0.002506135	0.002506135	0.018090686
9	0.01479357	0.01479357	0.01479357	0.030304158	0.01479357	0.01479357	0.005641665	0.005641665	0.030304158
10	0.031509426	0.00601103	0.00601103	0.015811827	0.00601103	0.015811827	0.002580059	0.00601103	0.015811827
11	0.008300613	0.019364387	0.008300613	0.008300613	0.019364387	0.008300613	0.019364387	0.008300613	0.019364387
12	0.009283541	0.022427373	0.009283541	0.009283541	0.009283541	0.022427373	0.009283541	0.022427373	0.009283541
13	0.008300613	0.019364387	0.008300613	0.008300613	0.019364387	0.008300613	0.019364387	0.008300613	0.019364387
14	0.017929868	0.017929868	0.017929868	0.00701323	0.00701323	0.034020597	0.002891443	0.00701323	0.017929868
15	0.008424083	0.020467611	0.020467611	0.008424083	0.020467611	0.020467611	0.001898482	0.003444704	0.020467611
16	0.018391934	0.018391934	0.007688734	0.007688734	0.034878048	0.018391934	0.007688734	0.007688734	0.007688734
17	0.01560003	0.01560003	0.006239049	0.006239049	0.01560003	0.01560003	0.002826212	0.002826212	0.006239049
18	0.033145604	0.033145604	0.017082592	0.017082592	0.017082592	0.017082592	0.002868421	0.006809355	0.017082592
19	0.007014244	0.017538462	0.007014244	0.007014244	0.017538462	0.017538462	0.002889049	0.017538462	0.007014244

20	0.012039364	0.005240359	0.005240359	0.024579239	0.005240359	0.005240359	0.005240359	0.005240359	0.005240359
21	0.036024521	0.008380106	0.008380106	0.008380106	0.019248988	0.036024521	0.008380106	0.008380106	0.008380106
22	0.015371899	0.015371899	0.015371899	0.005815436	0.015371899	0.015371899	0.001626617	0.001626617	0.005815436
23	0.008193647	0.021593097	0.008193647	0.008193647	0.021593097	0.021593097	0.008193647	0.001805145	0.021593097
24	0.020859601	0.037374438	0.020859601	0.020859601	0.020859601	0.020859601	0.008418605	0.008418605	0.008418605
25	0.026263105	0.026263105	0.026263105	0.004147792	0.026263105	0.011657739	0.004147792	0.011657739	0.011657739
26	0.009769554	0.009769554	0.023839334	0.009769554	0.023839334	0.023839334	0.002027188	0.002027188	0.002027188
27	0.008628045	0.003752378	0.003752378	0.008628045	0.003752378	0.003752378	0.001994574	0.001994574	0.008628045
28	0.012240267	0.027073921	0.012240267	0.004466415	0.012240267	0.027073921	0.012240267	0.004466415	0.012240267
29	0.015650157	0.015650157	0.015650157	0.015650157	0.015650157	0.03107031	0.015650157	0.015650157	0.03107031
30	0.01467162	0.030098129	0.01467162	0.01467162	0.01467162	0.030098129	0.005437565	0.005437565	0.01467162
31	0.010582394	0.004049553	0.004049553	0.010582394	0.004049553	0.004049553	0.010582394	0.010582394	0.023958495
32	0.01437065	0.01437065	0.01437065	0.01437065	0.01437065	0.01437065	0.005226067	0.01437065	0.01437065
33	0.020554966	0.020554966	0.020554966	0.007780743	0.020554966	0.020554966	0.007780743	0.020554966	0.007780743
34	0.011878007	0.011878007	0.011878007	0.004307615	0.011878007	0.011878007	0.004307615	0.004307615	0.011878007
35	0.013483742	0.026114635	0.013483742	0.013483742	0.042582118	0.026114635	0.003479818	0.003479818	0.003479818
36	0.018279072	0.018279072	0.018279072	0.018279072	0.018279072	0.006519605	0.006519605	0.006519605	0.006519605
37	0.009406347	0.004241273	0.020662538	0.020662538	0.020662538	0.009406347	0.002256691	0.002256691	0.020662538
38	0.025282902	0.011201859	0.011201859	0.004327342	0.011201859	0.025282902	0.002158041	0.002158041	0.004327342
39	0.018495872	0.018495872	0.007418668	0.007418668	0.001842201	0.018495872	0.001842201	0.001842201	0.00317369
40	0.008008453	0.036681284	0.020283091	0.008008453	0.020283091	0.020283091	0.008008453	0.008008453	0.003099404
41	0.007828038	0.019817913	0.019817913	0.007828038	0.036182342	0.036182342	0.007828038	0.007828038	0.019817913
42	0.015479049	0.015479049	0.015479049	0.015479049	0.031051799	0.031051799	0.005774068	0.005774068	0.015479049
43	0.004192833	0.009826474	0.021347713	0.004192833	0.009826474	0.021347713	0.002154546	0.002154546	0.004192833
44	0.012530919	0.012530919	0.012530919	0.012530919	0.026478273	0.012530919	0.012530919	0.002203675	0.012530919
45	0.020794111	0.020794111	0.008236903	0.008236903	0.020794111	0.008236903	0.008236903	0.008236903	0.008236903
46	0.00960371	0.022131866	0.022131866	0.00960371	0.022131866	0.00960371	0.039098556	0.00960371	0.00960371
47	0.030337366	0.030337366	0.014890248	0.00571031	0.014890248	0.014890248	0.001592284	0.002586408	0.014890248
48	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682	0.001335975	0.001335975	0.001335975
49	0.024170626	0.010823352	0.024170626	0.010823352	0.010823352	0.002317435	0.00459553	0.00459553	0.00459553
50	0.010698914	0.010698914	0.010698914	0.010698914	0.010698914	0.040594023	0.003975864	0.010698914	0.010698914
51	0.011970793	0.011970793	0.002341287	0.00482954	0.011970793	0.011970793	0.00482954	0.00482954	0.00482954
52	0.020794111	0.020794111	0.008236903	0.008236903	0.020794111	0.008236903	0.008236903	0.008236903	0.008236903
53	0.008204361	0.008204361	0.008204361	0.008204361	0.008204361	0.01905322	0.001835882	0.001835882	0.008204361
54	0.022227251	0.022227251	0.022227251	0.022227251	0.038649118	0.009283369	0.001954164	0.001954164	0.001954164
55	0.015793863	0.015793863	0.005656377	0.005656377	0.031313156	0.031313156	0.005656377	0.005656377	0.015793863
56	0.037092843	0.008714443	0.003600043	0.003600043	0.003600043	0.003600043	0.001947451	0.008714443	0.008714443
R/C	28	29	30	31	32	33	34	35	36
1	0.020090756	0.036195167	0.020090756	0.020090756	0.020090756	0.020090756	0.020090756	0.020090756	0.020090756
2	0.01550582	0.030982203	0.005570343	0.030982203	0.030982203	0.01550582	0.030982203	0.030982203	0.030982203
3	0.018159043	0.034690505	0.018159043	0.034690505	0.034690505	0.034690505	0.007806276	0.018159043	0.007806276
4	0.017206219	0.032963676	0.017206219	0.007715857	0.032963676	0.017206219	0.007715857	0.050183782	0.032963676
5	0.016378762	0.032655397	0.007047487	0.032655397	0.032655397	0.016378762	0.007047487	0.016378762	0.007047487
6	0.035710091	0.035710091	0.019414522	0.007665567	0.019414522	0.019414522	0.019414522	0.019414522	0.019414522
7	0.039121702	0.039121702	0.022291284	0.010156941	0.039121702	0.010156941	0.010156941	0.039121702	0.039121702
8	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686

9	0.030304158	0.030304158	0.01479357	0.01479357	0.030304158	0.030304158	0.005641665	0.030304158	0.030304158
10	0.015811827	0.015811827	0.00601103	0.031509426	0.031509426	0.015811827	0.015811827	0.031509426	0.031509426
11	0.019364387	0.036081483	0.019364387	0.036081483	0.036081483	0.019364387	0.008300613	0.036081483	0.019364387
12	0.022427373	0.022427373	0.022427373	0.022427373	0.022427373	0.022427373	0.022427373	0.022427373	0.022427373
13	0.019364387	0.036081483	0.019364387	0.036081483	0.036081483	0.019364387	0.008300613	0.036081483	0.019364387
14	0.017929868	0.034020597	0.017929868	0.034020597	0.034020597	0.017929868	0.034020597	0.034020597	0.017929868
15	0.020467611	0.036788983	0.020467611	0.036788983	0.036788983	0.020467611	0.020467611	0.036788983	0.020467611
16	0.034878048	0.034878048	0.034878048	0.034878048	0.034878048	0.034878048	0.007688734	0.018391934	0.018391934
17	0.031381041	0.031381041	0.031381041	0.031381041	0.031381041	0.01560003	0.002826212	0.01560003	0.01560003
18	0.017082592	0.033145604	0.033145604	0.033145604	0.033145604	0.017082592	0.017082592	0.017082592	0.017082592
19	0.017538462	0.033694195	0.007014244	0.017538462	0.033694195	0.017538462	0.007014244	0.033694195	0.007014244
20	0.024579239	0.042268458	0.024579239	0.042268458	0.042268458	0.024579239	0.012039364	0.042268458	0.012039364
21	0.019248988	0.019248988	0.008380106	0.036024521	0.036024521	0.036024521	0.008380106	0.019248988	0.036024521
22	0.030768492	0.030768492	0.015371899	0.030768492	0.015371899	0.015371899	0.015371899	0.015371899	0.015371899
23	0.021593097	0.021593097	0.021593097	0.021593097	0.021593097	0.021593097	0.008193647	0.021593097	0.021593097
24	0.008418605	0.020859601	0.037374438	0.020859601	0.020859601	0.020859601	0.008418605	0.020859601	0.020859601
25	0.011657739	0.026263105	0.026263105	0.026263105	0.026263105	0.026263105	0.026263105	0.026263105	0.011657739
26	0.023839334	0.023839334	0.023839334	0.023839334	0.023839334	0.023839334	0.003764556	0.023839334	0.023839334
27	0.036032079	0.036032079	0.036032079	0.01943193	0.036032079	0.01943193	0.008628045	0.036032079	0.008628045
28	0.027073921	0.027073921	0.027073921	0.027073921	0.027073921	0.027073921	0.012240267	0.027073921	0.027073921
29	0.015650157	0.015650157	0.015650157	0.015650157	0.015650157	0.015650157	0.015650157	0.03107031	0.03107031
30	0.030098129	0.01467162	0.01467162	0.030098129	0.030098129	0.01467162	0.01467162	0.01467162	0.030098129
31	0.023958495	0.023958495	0.023958495	0.010582394	0.010582394	0.010582394	0.010582394	0.010582394	0.010582394
32	0.01437065	0.01437065	0.01437065	0.01437065	0.029675965	0.029675965	0.029675965	0.029675965	0.029675965
33	0.020554966	0.020554966	0.007780743	0.020554966	0.020554966	0.020554966	0.020554966	0.020554966	0.007780743
34	0.011878007	0.011878007	0.011878007	0.011878007	0.02659614	0.02659614	0.02659614	0.02659614	0.02659614
35	0.026114635	0.042582118	0.042582118	0.042582118	0.042582118	0.026114635	0.006698306	0.042582118	0.026114635
36	0.018279072	0.018279072	0.006519605	0.018279072	0.018279072	0.018279072	0.018279072	0.018279072	0.018279072
37	0.037167228	0.037167228	0.020662538	0.020662538	0.037167228	0.037167228	0.004241273	0.037167228	0.009406347
38	0.025282902	0.042165948	0.025282902	0.025282902	0.025282902	0.025282902	0.011201859	0.025282902	0.025282902
39	0.018495872	0.034422584	0.018495872	0.018495872	0.034422584	0.034422584	0.007418668	0.018495872	0.018495872
40	0.036681284	0.036681284	0.020283091	0.020283091	0.020283091	0.020283091	0.020283091	0.036681284	0.020283091
41	0.019817913	0.019817913	0.036182342	0.019817913	0.019817913	0.019817913	0.019817913	0.019817913	0.019817913
42	0.015479049	0.031051799	0.015479049	0.015479049	0.015479049	0.031051799	0.015479049	0.015479049	0.015479049
43	0.038223637	0.038223637	0.038223637	0.038223637	0.038223637	0.038223637	0.004192833	0.021347713	0.009826474
44	0.043718145	0.026478273	0.002203675	0.026478273	0.012530919	0.012530919	0.012530919	0.012530919	0.012530919
45	0.008236903	0.020794111	0.020794111	0.037264073	0.037264073	0.020794111	0.020794111	0.020794111	0.020794111
46	0.00960371	0.00960371	0.00960371	0.039098556	0.039098556	0.022131866	0.022131866	0.022131866	0.022131866
47	0.030337366	0.030337366	0.014890248	0.030337366	0.030337366	0.030337366	0.014890248	0.014890248	0.030337366
48	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682
49	0.024170626	0.040929421	0.002317435	0.024170626	0.024170626	0.010823352	0.00459553	0.024170626	0.00459553
50	0.023206859	0.010698914	0.010698914	0.010698914	0.040594023	0.010698914	0.023206859	0.010698914	0.040594023
51	0.025488292	0.042616214	0.042616214	0.025488292	0.025488292	0.025488292	0.011970793	0.042616214	0.025488292
52	0.008236903	0.020794111	0.020794111	0.037264073	0.037264073	0.020794111	0.020794111	0.020794111	0.020794111
53	0.035546961	0.035546961	0.035546961	0.01905322	0.01905322	0.01905322	0.01905322	0.01905322	0.035546961
54	0.009283369	0.022227251	0.009283369	0.022227251	0.022227251	0.022227251	0.022227251	0.022227251	0.022227251

55	0.015793863	0.031313156	0.015793863	0.015793863	0.005656377	0.015793863	0.015793863	0.031313156	0.015793863
56	0.008714443	0.037092843	0.001947451	0.020646794	0.037092843	0.008714443	0.008714443	0.037092843	0.008714443
R/C	37	38	39	40	41	42	43	44	45
1	0.020090756	0.007736369	0.007736369	0.020090756	0.020090756	0.020090756	0.007736369	0.020090756	0.020090756
2	0.030982203	0.01550582	0.01550582	0.030982203	0.01550582	0.01550582	0.01550582	0.01550582	0.01550582
3	0.018159043	0.018159043	0.018159043	0.018159043	0.007806276	0.018159043	0.007806276	0.007806276	0.018159043
4	0.007715857	0.007715857	0.007715857	0.017206219	0.032963676	0.017206219	0.017206219	0.017206219	0.032963676
5	0.016378762	0.016378762	0.016378762	0.016378762	0.016378762	0.007047487	0.007047487	0.032655397	0.032655397
6	0.019414522	0.019414522	0.003057791	0.007665567	0.007665567	0.019414522	0.019414522	0.035710091	0.035710091
7	0.022291284	0.022291284	0.010156941	0.002224002	0.004359167	0.010156941	0.010156941	0.010156941	0.022291284
8	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686
9	0.030304158	0.030304158	0.030304158	0.01479357	0.01479357	0.01479357	0.01479357	0.005641665	0.01479357
10	0.015811827	0.015811827	0.00601103	0.015811827	0.015811827	0.015811827	0.015811827	0.015811827	0.031509426
11	0.036081483	0.036081483	0.019364387	0.008300613	0.008300613	0.008300613	0.008300613	0.008300613	0.008300613
12	0.022427373	0.022427373	0.009283541	0.009283541	0.009283541	0.009283541	0.009283541	0.009283541	0.022427373
13	0.036081483	0.036081483	0.019364387	0.008300613	0.008300613	0.008300613	0.008300613	0.008300613	0.008300613
14	0.017929868	0.017929868	0.017929868	0.017929868	0.00701323	0.00701323	0.002891443	0.00701323	0.017929868
15	0.020467611	0.008424083	0.020467611	0.008424083	0.020467611	0.008424083	0.003444704	0.001898482	0.020467611
16	0.018391934	0.007688734	0.007688734	0.018391934	0.018391934	0.007688734	0.018391934	0.018391934	0.018391934
17	0.031381041	0.01560003	0.01560003	0.031381041	0.031381041	0.006239049	0.01560003	0.031381041	0.01560003
18	0.017082592	0.017082592	0.033145604	0.017082592	0.017082592	0.006809355	0.006809355	0.033145604	0.033145604
19	0.007014244	0.017538462	0.017538462	0.033694195	0.017538462	0.007014244	0.007014244	0.017538462	0.017538462
20	0.042268458	0.005240359	0.005240359	0.012039364	0.005240359	0.005240359	0.012039364	0.024579239	0.024579239
21	0.019248988	0.019248988	0.008380106	0.019248988	0.008380106	0.008380106	0.008380106	0.019248988	0.019248988
22	0.030768492	0.015371899	0.005815436	0.015371899	0.015371899	0.015371899	0.015371899	0.030768492	0.030768492
23	0.021593097	0.021593097	0.021593097	0.021593097	0.021593097	0.021593097	0.021593097	0.003180231	0.008193647
24	0.020859601	0.020859601	0.003263344	0.020859601	0.020859601	0.008418605	0.020859601	0.037374438	0.020859601
25	0.026263105	0.011657739	0.011657739	0.026263105	0.026263105	0.026263105	0.026263105	0.026263105	0.026263105
26	0.023839334	0.009769554	0.009769554	0.023839334	0.023839334	0.023839334	0.023839334	0.009769554	0.023839334
27	0.008628045	0.008628045	0.008628045	0.01943193	0.036032079	0.01943193	0.01943193	0.01943193	0.01943193
28	0.027073921	0.027073921	0.027073921	0.027073921	0.012240267	0.004466415	0.012240267	0.012240267	0.012240267
29	0.015650157	0.015650157	0.015650157	0.015650157	0.015650157	0.015650157	0.015650157	0.015650157	0.015650157
30	0.01467162	0.01467162	0.01467162	0.005437565	0.005437565	0.01467162	0.01467162	0.01467162	0.005437565
31	0.010582394	0.023958495	0.023958495	0.04103675	0.04103675	0.023958495	0.023958495	0.04103675	0.023958495
32	0.029675965	0.029675965	0.029675965	0.029675965	0.029675965	0.01437065	0.01437065	0.01437065	0.01437065
33	0.020554966	0.007780743	0.020554966	0.020554966	0.007780743	0.020554966	0.020554966	0.020554966	0.020554966
34	0.011878007	0.02659614	0.02659614	0.02659614	0.02659614	0.011878007	0.011878007	0.02659614	0.02659614
35	0.042582118	0.042582118	0.026114635	0.003479818	0.003479818	0.003479818	0.003479818	0.006698306	0.006698306
36	0.018279072	0.018279072	0.018279072	0.018279072	0.018279072	0.018279072	0.018279072	0.034261098	0.034261098
37	0.037167228	0.020662538	0.009406347	0.004241273	0.004241273	0.020662538	0.009406347	0.020662538	0.037167228
38	0.025282902	0.011201859	0.011201859	0.025282902	0.025282902	0.011201859	0.011201859	0.011201859	0.025282902
39	0.018495872	0.007418668	0.007418668	0.018495872	0.018495872	0.018495872	0.018495872	0.007418668	0.018495872
40	0.020283091	0.020283091	0.008008453	0.020283091	0.020283091	0.008008453	0.008008453	0.008008453	0.008008453
41	0.019817913	0.007828038	0.007828038	0.007828038	0.019817913	0.007828038	0.019817913	0.019817913	0.019817913
42	0.031051799	0.015479049	0.015479049	0.031051799	0.031051799	0.015479049	0.031051799	0.031051799	0.015479049
43	0.021347713	0.021347713	0.021347713	0.009826474	0.009826474	0.009826474	0.009826474	0.021347713	0.021347713

44	0.026478273	0.026478273	0.012530919	0.012530919	0.026478273	0.012530919	0.012530919	0.026478273	0.026478273
45	0.020794111	0.008236903	0.008236903	0.020794111	0.020794111	0.020794111	0.008236903	0.020794111	0.020794111
46	0.022131866	0.00960371	0.00960371	0.022131866	0.00960371	0.022131866	0.00960371	0.039098556	0.022131866
47	0.014890248	0.014890248	0.014890248	0.030337366	0.030337366	0.030337366	0.014890248	0.00571031	0.014890248
48	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682
49	0.00459553	0.024170626	0.010823352	0.024170626	0.024170626	0.024170626	0.00459553	0.024170626	0.024170626
50	0.010698914	0.023206859	0.023206859	0.010698914	0.010698914	0.023206859	0.010698914	0.023206859	0.040594023
51	0.011970793	0.025488292	0.025488292	0.025488292	0.011970793	0.025488292	0.011970793	0.025488292	0.042616214
52	0.020794111	0.008236903	0.008236903	0.020794111	0.020794111	0.020794111	0.008236903	0.020794111	0.020794111
53	0.01905322	0.01905322	0.008204361	0.008204361	0.008204361	0.008204361	0.008204361	0.008204361	0.008204361
54	0.038649118	0.009283369	0.009283369	0.022227251	0.022227251	0.009283369	0.009283369	0.022227251	0.022227251
55	0.015793863	0.015793863	0.015793863	0.015793863	0.015793863	0.031313156	0.015793863	0.031313156	0.031313156
56	0.020646794	0.008714443	0.020646794	0.020646794	0.020646794	0.020646794	0.008714443	0.020646794	0.037092843

R/C	46	47	48	49	50	51	52	53	54
1	0.007736369	0.020090756	0.007736369	0.020090756	0.007736369	0.020090756	0.020090756	0.007736369	0.007736369
2	0.01550582	0.030982203	0.01550582	0.01550582	0.005570343	0.01550582	0.01550582	0.01550582	0.01550582
3	0.007806276	0.018159043	0.007806276	0.034690505	0.007806276	0.034690505	0.034690505	0.007806276	0.018159043
4	0.007715857	0.003422293	0.003422293	0.003422293	0.007715857	0.032963676	0.017206219	0.007715857	0.032963676
5	0.007047487	0.007047487	0.007047487	0.007047487	0.007047487	0.016378762	0.032655397	0.007047487	0.007047487
6	0.019414522	0.019414522	0.019414522	0.007665567	0.007665567	0.007665567	0.019414522	0.019414522	0.019414522
7	0.010156941	0.022291284	0.010156941	0.010156941	0.010156941	0.022291284	0.022291284	0.022291284	0.022291284
8	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686	0.018090686
9	0.005641665	0.002520401	0.002520401	0.01479357	0.01479357	0.01479357	0.005641665	0.01479357	0.01479357
10	0.015811827	0.015811827	0.00601103	0.00601103	0.015811827	0.031509426	0.015811827	0.015811827	0.015811827
11	0.008300613	0.019364387	0.008300613	0.008300613	0.019364387	0.036081483	0.019364387	0.008300613	0.008300613
12	0.009283541	0.022427373	0.009283541	0.009283541	0.009283541	0.009283541	0.009283541	0.009283541	0.009283541
13	0.008300613	0.019364387	0.008300613	0.008300613	0.019364387	0.036081483	0.019364387	0.008300613	0.008300613
14	0.017929868	0.017929868	0.017929868	0.00701323	0.017929868	0.00701323	0.017929868	0.017929868	0.017929868
15	0.008424083	0.020467611	0.008424083	0.020467611	0.020467611	0.008424083	0.008424083	0.020467611	0.020467611
16	0.007688734	0.018391934	0.007688734	0.007688734	0.007688734	0.018391934	0.018391934	0.018391934	0.007688734
17	0.01560003	0.01560003	0.002826212	0.006239049	0.01560003	0.031381041	0.01560003	0.006239049	0.01560003
18	0.006809355	0.006809355	0.006809355	0.006809355	0.006809355	0.017082592	0.017082592	0.006809355	0.006809355
19	0.007014244	0.007014244	0.007014244	0.017538462	0.017538462	0.017538462	0.017538462	0.007014244	0.033694195
20	0.012039364	0.012039364	0.012039364	0.012039364	0.012039364	0.012039364	0.012039364	0.012039364	0.012039364
21	0.008380106	0.036024521	0.019248988	0.008380106	0.008380106	0.019248988	0.019248988	0.008380106	0.019248988
22	0.015371899	0.030768492	0.015371899	0.015371899	0.002610555	0.005815436	0.015371899	0.005815436	0.005815436
23	0.008193647	0.021593097	0.003180231	0.008193647	0.021593097	0.021593097	0.008193647	0.008193647	0.021593097
24	0.008418605	0.020859601	0.020859601	0.020859601	0.003263344	0.008418605	0.008418605	0.008418605	0.008418605
25	0.011657739	0.011657739	0.011657739	0.026263105	0.011657739	0.011657739	0.011657739	0.011657739	0.011657739
26	0.009769554	0.023839334	0.009769554	0.023839334	0.009769554	0.009769554	0.009769554	0.009769554	0.023839334
27	0.01943193	0.01943193	0.008628045	0.01943193	0.01943193	0.036032079	0.008628045	0.01943193	0.01943193
28	0.012240267	0.012240267	0.012240267	0.004466415	0.012240267	0.027073921	0.012240267	0.012240267	0.027073921
29	0.015650157	0.03107031	0.015650157	0.015650157	0.015650157	0.015650157	0.015650157	0.015650157	0.015650157
30	0.01467162	0.01467162	0.01467162	0.01467162	0.005437565	0.01467162	0.01467162	0.005437565	0.005437565
31	0.023958495	0.010582394	0.010582394	0.010582394	0.004049553	0.010582394	0.010582394	0.023958495	0.023958495
32	0.01437065	0.01437065	0.01437065	0.01437065	0.01437065	0.01437065	0.01437065	0.01437065	0.01437065

33	0.007780743	0.020554966	0.007780743	0.007780743	0.007780743	0.020554966	0.007780743	0.020554966	0.020554966
34	0.02659614	0.011878007	0.02659614	0.011878007	0.011878007	0.02659614	0.004307615	0.011878007	0.02659614
35	0.003479818	0.006698306	0.003479818	0.003479818	0.006698306	0.013483742	0.013483742	0.003479818	0.013483742
36	0.018279072	0.018279072	0.006519605	0.018279072	0.018279072	0.018279072	0.018279072	0.018279072	0.018279072
37	0.009406347	0.004241273	0.009406347	0.009406347	0.009406347	0.020662538	0.020662538	0.020662538	0.020662538
38	0.011201859	0.025282902	0.011201859	0.025282902	0.011201859	0.011201859	0.011201859	0.011201859	0.011201859
39	0.018495872	0.018495872	0.00317369	0.007418668	0.018495872	0.018495872	0.018495872	0.018495872	0.018495872
40	0.008008453	0.020283091	0.008008453	0.020283091	0.020283091	0.020283091	0.008008453	0.008008453	0.008008453
41	0.019817913	0.019817913	0.007828038	0.007828038	0.007828038	0.007828038	0.007828038	0.007828038	0.007828038
42	0.005774068	0.015479049	0.002499597	0.005774068	0.015479049	0.031051799	0.005774068	0.005774068	0.005774068
43	0.009826474	0.021347713	0.009826474	0.009826474	0.009826474	0.021347713	0.021347713	0.002154546	0.004192833
44	0.012530919	0.012530919	0.012530919	0.012530919	0.026478273	0.026478273	0.012530919	0.012530919	0.012530919
45	0.008236903	0.008236903	0.008236903	0.008236903	0.020794111	0.008236903	0.020794111	0.008236903	0.008236903
46	0.00960371	0.022131866	0.00960371	0.022131866	0.00960371	0.00960371	0.00960371	0.00960371	0.022131866
47	0.00571031	0.014890248	0.00571031	0.014890248	0.030337366	0.014890248	0.00571031	0.014890248	0.014890248
48	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682	0.018739682	0.002788922	0.018739682
49	0.010823352	0.002317435	0.024170626	0.024170626	0.010823352	0.010823352	0.010823352	0.010823352	0.024170626
50	0.010698914	0.040594023	0.010698914	0.010698914	0.023206859	0.023206859	0.010698914	0.010698914	0.010698914
51	0.011970793	0.025488292	0.011970793	0.011970793	0.011970793	0.025488292	0.011970793	0.011970793	0.011970793
52	0.008236903	0.008236903	0.008236903	0.008236903	0.020794111	0.008236903	0.020794111	0.008236903	0.008236903
53	0.008204361	0.008204361	0.008204361	0.008204361	0.008204361	0.035546961	0.01905322	0.035546961	0.035546961
54	0.009283369	0.009283369	0.009283369	0.009283369	0.009283369	0.022227251	0.009283369	0.009283369	0.009283369
55	0.015793863	0.015793863	0.015793863	0.015793863	0.031313156	0.015793863	0.015793863	0.015793863	0.015793863
56	0.020646794	0.008714443	0.020646794	0.037092843	0.020646794	0.020646794	0.008714443	0.020646794	0.020646794

R/C	55	56	57
1	0.020090756	0.020090756	0.020090756
2	0.01550582	0.01550582	0.01550582
3	0.018159043	0.018159043	0.034690505
4	0.032963676	0.017206219	0.017206219
5	0.007047487	0.032655397	0.032655397
6	0.019414522	0.019414522	0.019414522
7	0.022291284	0.004359167	0.022291284
8	0.018090686	0.018090686	0.018090686
9	0.01479357	0.005641665	0.01479357
10	0.015811827	0.031509426	0.031509426
11	0.036081483	0.008300613	0.036081483
12	0.009283541	0.022427373	0.022427373
13	0.036081483	0.008300613	0.036081483
14	0.00701323	0.034020597	0.017929868
15	0.008424083	0.020467611	0.020467611
16	0.007688734	0.018391934	0.018391934
17	0.01560003	0.01560003	0.01560003
18	0.006809355	0.006809355	0.033145604
19	0.017538462	0.017538462	0.033694195
20	0.012039364	0.005240359	0.024579239
21	0.019248988	0.036024521	0.019248988

22	0.015371899	0.015371899	0.015371899
23	0.008193647	0.021593097	0.021593097
24	0.008418605	0.020859601	0.020859601
25	0.011657739	0.011657739	0.011657739
26	0.009769554	0.023839334	0.023839334
27	0.01943193	0.036032079	0.01943193
28	0.012240267	0.027073921	0.012240267
29	0.015650157	0.03107031	0.015650157
30	0.005437565	0.01467162	0.01467162
31	0.023958495	0.023958495	0.023958495
32	0.01437065	0.01437065	0.01437065
33	0.020554966	0.007780743	0.020554966
34	0.02659614	0.02659614	0.02659614
35	0.026114635	0.026114635	0.026114635
36	0.018279072	0.018279072	0.018279072
37	0.020662538	0.004241273	0.037167228
38	0.004327342	0.004327342	0.011201859
39	0.034422584	0.034422584	0.018495872
40	0.020283091	0.020283091	0.020283091
41	0.019817913	0.019817913	0.019817913
42	0.015479049	0.005774068	0.015479049
43	0.009826474	0.009826474	0.038223637
44	0.026478273	0.012530919	0.012530919
45	0.008236903	0.008236903	0.020794111
46	0.00960371	0.022131866	0.022131866
47	0.014890248	0.030337366	0.030337366
48	0.018739682	0.018739682	0.018739682
49	0.010823352	0.010823352	0.024170626
50	0.010698914	0.023206859	0.023206859
51	0.025488292	0.025488292	0.011970793
52	0.008236903	0.008236903	0.020794111
53	0.01905322	0.008204361	0.008204361
54	0.022227251	0.009283369	0.022227251
55	0.015793863	0.015793863	0.015793863
56	0.020646794	0.008714443	0.020646794

Appendix 3

Data for Risk Based Ranking

	GOVERNMENT POLICIES FOR INDUSTRY									GOVERNMENT LAWS AND REGULATIONS FOR INDUSTRIES								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75	0.25	0.5	0.75	0.5	0.75	1	0.25	0.5	0.75
2	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1
3	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75
4	0.5	0.75	1	0.75	1	1	0.75	1	1	0.5	0.75	1	0.75	1	1	0	0	0.25
5	0.25	0.5	0.75	0.5	0.75	1	0.25	0.5	0.75	0.5	0.75	1	0.25	0.5	0.75	0.25	0.5	0.75
6	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75	0.75	1	1	0.75	1	1	0	0.25	0.75
	POLITICAL SYSTEM									SCOPE FOR EXPANSION OPPORTUNITIES FOR INDUSTRIES								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.25	0.5	0.75	0.25	0.5	1	0	0.25	0.75	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75
2	0.25	0.5	0.75	0.25	0.5	1	0	0.25	0.75	0.25	0.5	0.75	0.25	0.5	0.75	0	0.25	0.75
3	0.25	0.5	0.75	0.5	0.75	1	0.5	0.5	1	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1
4	0.75	1	1	0.5	0.75	1	0	0	0.25	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75
5	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75	0	0.25	0.75	0.75	1	1	0	0.25	0.75
6	0	0.25	0.75	0.5	0.75	1	0.25	0.5	0.75	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75
	INDUSTRY COMPETITIVE SCENARIO									IMPACT OF PRESENT INDUSTRY STATUS								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.5	0.75	1	0.5	0.75	1	0	0	0.25	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75
2	0.25	0.5	0.75	0.25	0.5	1	0	0.25	0.75	0	0.25	0.75	0	0.25	0.75	0.25	0.5	0.75
3	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1
4	0.5	0.75	1	0.5	0.75	1	0	0	0.25	0	0.25	0.75	0.5	0.75	1	0.5	0.75	1
5	0.5	0.75	1	0.5	0.75	1	0	0	0.25	0.25	0.5	0.75	0	0.25	0.75	0.25	0.5	0.75
6	0.75	1	1	0.75	1	1	0.25	0.5	0.75	0.75	1	1	0.75	1	1	0.25	0.5	0.75
	MARKET CHARACTERISTICS (CUSTOMER PROXIMITY/PURCHASING POWER)									SUPPLIER CHARACTERISTICS (QUALITY/RELIABILITY)								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.25	0.5	0.75	0.25	0.5	1	0	0.25	0.75	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75
2	0.5	0.75	1	0.25	0.5	1	0.25	0.5	0.75	0.25	0.5	0.75	0.25	0.5	0.75	0.5	0.75	1
3	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75
4	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75
5	0.5	0.75	1	0	0.25	1	0.25	0.5	0.75	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75
6	0.75	1	1	0.75	1	1	0.25	0.5	0.75	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75
	FINANCIAL INCENTIVES									TAX STRUCTURE								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.5	0.75	1	0.25	0.5	1	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0	0.25	0.75
2	0.25	0.5	0.75	0.25	0.5	1	0.5	0.75	1	0.25	0.5	0.75	0	0.25	0.75	0	0.25	0.75
3	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75
4	0.5	0.75	1	0.25	0.5	1	0	0.25	0.75	0	0.25	0.75	0.25	0.5	0.75	0	0.25	0.75
5	0	0.25	0.75	0.5	0.75	1	0.25	0.5	0.75	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75
6	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75	0.75	1	1	0.75	1	1	0	0.25	0.75
	TREND OF CURRENCY STRENGTH AGAINST U. S. DOLLAR OF THE COUNTRY OF LOCATION CHOICE									ECONOMIC STANDING OF THE COUNTRY OF LOCATION CHOICE								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.25	0.5	0.75	0.25	0.5	1	0	0	0.25	0.25	0.5	0.75	0.25	0.5	0.75	0	0	0.25
2	0.25	0.5	0.75	0	0.25	1	0	0.25	0.75	0.25	0.5	0.75	0	0.25	0.75	0	0.25	0.75
3	0.25	0.5	0.75	0.5	0.75	1	0	0.25	0.75	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75
4	0.25	0.5	0.75	0	0.25	1	0.25	0.5	0.75	0.5	0.75	1	0.25	0.5	0.75	0	0.25	0.75
5	0.25	0.5	0.75	0.25	0.5	1	0	0.25	0.75	0	0.25	0.75	0.5	0.75	1	0	0.25	0.75
6	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.25	0.5	0.75	0.25	0.5	0.75	0.5	0.75	1
	INFLATION TREND									KNOWLEDGE BASE								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75	0.5	0.75	1	0.25	0.5	0.75	0	0.25	0.75
2	0.25	0.5	0.75	0.25	0.5	1	0.25	0.5	0.75	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75
3	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75
4	0.5	0.75	1	0.25	0.5	1	0.5	0.75	1	0.25	0.5	0.75	0.5	0.75	1	0	0.25	0.75
5	0.75	1	1	0.5	0.75	1	0.25	0.5	0.75	0.5	0.75	1	0.25	0.5	0.75	0	0.25	0.75
6	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75	0.75	1	1	0.25	0.5	0.75	0	0.25	0.75
	MEDICAL FACILITIES									EDUCATION SYSTEM AND AVENUES								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.25	0.5	0.75	0.25	0.5	1	0	0.25	0.75	0.25	0.5	0.75	0.25	0.5	0.75	0	0.25	0.75

2	0.25	0.5	0.75	0.25	0.5	1	0	0.25	0.75	0.25	0.5	0.75	0	0.25	0.75	0	0	0.25
3	0	0.25	0.75	0	0.25	1	0	0	0.25	0.5	0.75	1	0.25	0.5	0.75	0.25	0.5	0.75
4	0.5	0.75	1	0.5	0.75	1	0	0	0.25	0.75	1	1	0.5	0.75	1	0	0.25	0.75
5	0.25	0.5	0.75	0.75	1	1	0	0	0.25	0.25	0.5	0.75	0.5	0.75	1	0	0.25	0.75
6	0.25	0.5	0.75	0.5	0.75	1	0	0.25	0.75	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75
	LABOR CHARACTERISTICS (EDUCATION/TRAINING FACILITIES)									EMPLOYABILITY								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.25	0.5	0.75	0.25	0.5	0.75	0	0.25	0.75
2	0.25	0.5	0.75	0	0.25	1	0	0	0.25	0.25	0.5	0.75	0	0.25	0.75	0	0.25	0.75
3	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75
4	0.5	0.75	1	0	0.25	1	0.25	0.5	0.75	0.5	0.75	1	0.25	0.5	0.75	0	0.25	0.75
5	0	0.25	0.75	0.5	0.75	1	0	0.25	0.75	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75
6	0.75	1	1	0.75	1	1	0	0.25	0.75	0.75	1	1	0.75	1	1	0	0	0.25
	UNION FLEXIBILITY									MOTIVATION & ENTHUSIASM OF EMPLOYEES								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.25	0.5	0.75
2	0.25	0.5	0.75	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.5	0.75	1
3	0.25	0.5	0.75	0.5	0.75	1	0.25	0.5	0.75	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75
4	0.5	0.75	1	0.25	0.5	1	0.25	0.5	0.75	0.25	0.5	0.75	0.5	0.75	1	0	0.25	0.75
5	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.25	0.5	0.75	0.25	0.5	0.75	0.25	0.5	0.75
6	0.25	0.5	0.75	0.25	0.5	1	0	0.25	0.75	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75
	SOCIAL ETHOS (PRIDE IN WORK OF ANY TYPE IN THE LOCATION OF CHOICE)									LINGUISTIC BARRIERS								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.25	0.5	0.75	0.25	0.5	1	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75
2	0	0.25	0.75	0	0.25	1	0	0.25	0.75	0	0.25	0.75	0	0.25	0.75	0	0	0.25
3	0.25	0.5	0.75	0	0.25	1	0	0	0.25	0.25	0.5	0.75	0.25	0.5	0.75	0	0.25	0.75
4	0	0.25	0.75	0.25	0.5	1	0	0.25	0.75	0.5	0.75	1	0.25	0.5	0.75	0	0.25	0.75
5	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0	0.25	0.75	0.5	0.75	1	0	0	0.25
6	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.75	1	1	0.75	1	1	0	0	0.25
	EMPLOYEE INTEGRITY & ETHICS									AFFECT ON HEALTH OF PEOPLE DUE TO INDUSTRIES								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.25	0.5	0.75	0	0.25	1	0	0.25	0.75	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75
2	0	0.25	0.75	0.25	0.5	1	0.25	0.5	0.75	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75
3	0.25	0.5	0.75	0.25	0.5	1	0	0.25	0.75	0.5	0.75	1	0.5	0.75	1	0.75	1	1
4	0.5	0.75	1	0.25	0.5	1	0	0.25	0.75	0.75	1	1	0.5	0.75	1	0	0.25	0.75
5	0.25	0.5	0.75	0.25	0.5	1	0	0.25	0.75	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75
6	0.25	0.5	0.75	0.25	0.5	1	0	0.25	0.75	0.75	1	1	0.75	1	1	0.25	0.5	0.75
	USE OF VASTUSHASTRA									RELIGIOUS BELIEFS								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.5	0.75	1	0	0.25	1	0	0	0.25	0.25	0.5	0.75	0	0.25	0.75	0	0	0.25
2	0.25	0.5	0.75	0	0.25	1	0	0.25	0.75	0.25	0.5	0.75	0.5	0.75	1	0.25	0.5	0.75
3	0	0.25	0.75	0	0.25	1	0.75	1	1	0	0	0.25	0	0	0.25	0.75	1	1
4	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.75	1	1	0.5	0.75	1	0.25	0.5	0.75
5	0	0.25	0.75	0	0.25	1	0.5	0.75	1	0	0.25	0.75	0	0.25	0.75	0.25	0.5	0.75
6	0	0	0.25	0	0	0	0	0.25	0.75	0	0	0.25	0	0	0.25	0	0.25	0.75
	STANDARD OF LIVING OF PEOPLE IN LOCATION CHOICE									TECHNOLOGY COST								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.25	0.5	0.75	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.5	0.75	1	0.5	0.75	1
2	0.25	0.5	0.75	0.5	0.75	1	0	0	0.25	0.5	0.75	1	0	0.25	0.75	0	0	0.25
3	0.25	0.5	0.75	0	0.25	1	0.25	0.5	0.75	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75
4	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.25	0.5	0.75	0.5	0.75	1	0.25	0.5	0.75
5	0.5	0.75	1	0.75	1	1	0	0.25	0.75	0.5	0.75	1	0.75	1	1	0	0	0.25
6	0.25	0.5	0.75	0.5	0.75	1	0	0.25	0.75	0.75	1	1	0.75	1	1	0	0.25	0.75
	POWER SUPPLY									ALTERNATE ENERGY SOURCES AND BACKUP								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.75	1	1	0.75	1	1	0	0.25	0.75	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75
2	0.75	1	1	0.75	1	1	0	0.25	0.75	0.5	0.75	1	0.25	0.5	0.75	0	0	0.25
3	0.75	1	1	0.5	0.75	1	0.25	0.5	0.75	0.25	0.5	0.75	0.25	0.5	0.75	0.75	1	1
4	0.5	0.75	1	0.75	1	1	0	0	0.25	0.75	1	1	0.5	0.75	1	0.25	0.5	0.75
5	0.75	1	1	0.75	1	1	0.25	0.5	0.75	0	0.25	0.75	0.5	0.75	1	0.25	0.5	0.75
6	0.75	1	1	0.75	1	1	0	0	0.25	0.5	0.75	1	0.5	0.75	1	0	0	0.25
	INFRASTRUCTURE AVAILABILITY									AVAILABILITY OF TRANSPORTATION FACILITY (ROAD/RAIL/PORTS/AIR)								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.5	0.75	1	0.75	1	1	0.25	0.5	0.75	0.75	1	1	0.75	1	1	0	0.25	0.75
2	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75	0.5	0.75	1	0.75	1	1	0	0	0.25

3	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75	0.75	1	1	0.5	0.75	1	0	0.25	0.75
4	0.5	0.75	1	0.25	0.5	1	0	0.25	0.75	0.5	0.75	1	0.75	1	1	0	0.25	0.75
5	0.5	0.75	1	0.75	1	1	0	0.25	0.75	0.75	1	1	0.75	1	1	0	0.25	0.75
6	0.75	1	1	0.75	1	1	0.25	0.5	0.75	0.75	1	1	0.75	1	1	0	0.25	0.75
	AVAILABILITY OF UTILITY SERVICES (ASSISTANCE TO MAIN SERVICES)									CLIMATIC CONDITIONS								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.25	0.5	0.75	0.25	0.5	1	0	0.25	0.75	0.25	0.5	0.75	0	0.25	0.75	0	0.25	0.75
2	0.5	0.75	1	0.25	0.5	1	0	0	0.25	0.25	0.5	0.75	0.5	0.75	1	0	0	0.25
3	0.25	0.5	0.75	0.25	0.5	1	0	0.25	0.75	0	0.25	0.75	0	0.25	0.75	0.75	1	1
4	0.75	1	1	0.25	0.5	1	0	0.25	0.75	0.75	1	1	0	0.25	0.75	0	0	0.25
5	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75
6	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75	0.5	0.75	1	0.25	0.5	0.75	0	0.25	0.75
	WATER AVAILABILITY									IMPACT OF INDUSTRIALIZATION ON ENVIRONMENT								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.75	1	1	0.5	0.75	1	0	0.25	0.75	0.75	1	1	0.5	0.75	1	0.25	0.5	0.75
2	0.5	0.75	1	0.5	0.75	1	0	0	0.25	0.25	0.5	0.75	0.25	0.5	0.75	0.25	0.5	0.75
3	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1
4	0.75	1	1	0.75	1	1	0	0.25	0.75	0.25	0.5	0.75	0.25	0.5	0.75	0.25	0.5	0.75
5	0.5	0.75	1	0.5	0.75	1	0	0	0.25	0.5	0.75	1	0.75	1	1	0.25	0.5	0.75
6	0.75	1	1	0.75	1	1	0	0.25	0.75	0.75	1	1	0.75	1	1	0.25	0.5	0.75
	AVAILABILITY OF SKILLED LABOUR									SALES & MARKETING COSTS								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.75	1	1	0.5	0.75	1	0.25	0.5	0.75	0.5	0.75	1	0.25	0.5	0.75	0.25	0.5	0.75
2	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.25	0.5	0.75	0.5	0.75	1	0.25	0.5	0.75
3	0.75	1	1	0.75	1	1	0.25	0.5	0.75	0.5	0.75	1	0.5	0.75	1	0	0	0.25
4	0.5	0.75	1	0.75	1	1	0.25	0.5	0.75	0.25	0.5	0.75	0.25	0.5	0.75	0.25	0.5	0.75
5	0.75	1	1	0.75	1	1	0	0	0.25	0.5	0.75	1	0.75	1	1	0	0	0.25
6	0.75	1	1	0.75	1	1	0.25	0.5	0.75	0.25	0.5	0.75	0.75	1	1	0.25	0.5	0.75
	I. T. COSTS									POLITICAL STABILITY								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.5	0.75	1	0.25	0.5	1	0	0	0.25	0.5	0.75	1	0.75	1	1	0.5	0.75	1
2	0.25	0.5	0.75	0.25	0.5	1	0	0	0.25	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75
3	0.5	0.75	1	0.25	0.5	1	0.75	1	1	0.75	1	1	0.25	0.5	0.75	0	0.25	0.75
4	0	0.25	0.75	0.5	0.75	1	0.25	0.5	0.75	0.75	1	1	0.5	0.75	1	0	0.25	0.75
5	0.5	0.75	1	0.25	0.5	1	0.25	0.5	0.75	0.25	0.5	0.75	0.25	0.5	0.75	0.5	0.75	1
6	0.75	1	1	0.75	1	1	0.25	0.5	0.75	0.75	1	1	0.75	1	1	0	0.25	0.75
	MATURITY OF POLITICAL LEADERSHIP									INTERNAL THREATS								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.5	0.75	1
2	0.5	0.75	1	0.5	0.75	1	0	0	0.25	0.25	0.5	0.75	0.5	0.75	1	0.75	1	1
3	0.25	0.5	0.75	0.25	0.5	1	0.25	0.5	0.75	0.25	0.5	0.75	0.25	0.5	0.75	0	0.25	0.75
4	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75	0.5	0.75	1	0.75	1	1	0	0.25	0.75
5	0.5	0.75	1	0.25	0.5	1	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.5	0.75	1
6	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1
	NEIGHBORHOOD STABILITY									BUREAUCRATIC HURDLES								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.5	0.75	1	0.25	0.5	1	0.75	1	1	0.5	0.75	1	0.25	0.5	0.75	0.75	1	1
2	0.25	0.5	0.75	0.5	0.75	1	0	0.25	0.75	0.5	0.75	1	0.75	1	1	0.25	0.5	0.75
3	0	0.25	0.75	0.25	0.5	1	0.75	1	1	0.5	0.75	1	0.5	0.75	1	0.75	1	1
4	0.75	1	1	0.25	0.5	1	0	0.25	0.75	0.75	1	1	0.25	0.5	0.75	0	0.25	0.75
5	0.25	0.5	0.75	0.25	0.5	1	0	0.25	0.75	0.25	0.5	0.75	0.5	0.75	1	0	0.25	0.75
6	0.5	0.75	1	0.25	0.5	1	0	0.25	0.75	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75
	GOVERNMENT INTERVENTION									ROLE OF PARALLEL ECONOMY								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.25	0.5	0.75	0.25	0.5	1	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.5	0.75	1
2	0.5	0.75	1	0.5	0.75	1	0.75	1	1	0.25	0.5	0.75	0.25	0.5	0.75	0.25	0.5	0.75
3	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75	0.25	0.5	0.75	0.25	0.5	0.75	0.75	1	1
4	0.75	1	1	0.5	0.75	1	0.25	0.5	0.75	0.75	1	1	0.5	0.75	1	0.25	0.5	0.75
5	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.5	0.75	1	0.25	0.5	0.75	0.5	0.75	1
6	0.5	0.75	1	0.25	0.5	1	0.25	0.5	0.75	0.5	0.75	1	0.75	1	1	0	0.25	0.75
	HAZARDS DUE TO INDUSTRIALIZATION									BLIND BELIEF IN LEADERSHIP								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.5	0.75	1	0.75	1	1	0	0.25	0.75	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1
2	0.25	0.5	0.75	0.5	0.75	1	0.25	0.5	0.75	0.25	0.5	0.75	0.75	1	1	0	0	0.25
3	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.25	0.5	0.75	0.75	1	1	0.5	0.75	1
4	0.75	1	1	0.5	0.75	1	0.25	0.5	0.75	0.5	0.75	1	0.5	0.75	1	0.75	1	1

5	0.5	0.75	1	0.25	0.5	1	0	0.25	0.75	0.25	0.5	0.75	0.75	1	1	0.25	0.5	0.75
6	0.5	0.75	1	0.5	0.75	1	0	0	0.75	0.5	0.75	1	0.75	1	1	0.5	0.75	1
	INTERNAL TURBULENCE									CONSUMER SPENDING CHARACTERISTICS (DEMOGRAPHY/CULTURE)								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.5	0.75	1	0.25	0.5	1	0.5	0.75	1	0.25	0.5	0.75	0.25	0.5	0.75	0.5	0.75	1
2	0.25	0.5	0.75	0.5	0.75	1	0.25	0.5	0.75	0.25	0.5	0.75	0.25	0.5	0.75	0.25	0.5	0.75
3	0.25	0.5	0.75	0	0.25	1	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75
4	0.25	0.5	0.75	0.5	0.75	1	0	0.25	0.75	0.25	0.5	0.75	0	0.25	0.75	0.75	1	1
5	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.25	0.5	0.75	0	0.25	0.75	0	0	0.25
6	0.5	0.75	1	0.75	1	1	0.25	0.5	0.75	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75
	LAND PRICE									CONSTRUCTION COST IN LOCATION OF CHOICE								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.75	1	1	0.75	1	1	0.25	0.5	0.75	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75
2	0.5	0.75	1	0.5	0.75	1	0	0	0.25	0.25	0.5	0.75	0	0.25	0.75	0	0.25	0.75
3	0.5	0.75	1	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75	0.25	0.5	0.75	0.5	0.75	1
4	0.5	0.75	1	0.25	0.5	1	0.5	0.75	1	0.75	1	1	0.25	0.5	0.75	0.5	0.75	1
5	0.75	1	1	0.5	0.75	1	0.25	0.5	0.75	0.75	1	1	0.5	0.75	1	0	0.25	0.75
6	0.75	1	1	0.75	1	1	0.25	0.5	0.75	0.75	1	1	0.75	1	1	0	0.25	0.75
	PER CAPITA INCOME IN LOCATION OF CHOICE									GROSS DOMESTIC PRODUCT (GDP)								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.5	0.75	1	0.5	0.75	1	0.75	1	1	0.5	0.75	1	0.25	0.5	0.75	0	0.25	0.75
2	0.25	0.5	0.75	0	0.25	1	0	0	0.25	0	0.25	0.75	0	0	0.25	0	0	0.25
3	0.5	0.75	1	0.5	0.75	1	0.75	1	1	0.5	0.75	1	0.5	0.75	1	0.75	1	1
4	0.75	1	1	0.5	0.75	1	0.25	0.5	0.75	0.5	0.75	1	0.25	0.5	0.75	0	0.25	0.75
5	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75	0.25	0.5	0.75	0	0.25	0.75	0.25	0.5	0.75
6	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75	0.75	1	1	0.75	1	1	0	0.25	0.75
	AVERAGE SALARIES PAID IN LOCATION OF CHOICE									DISASTER RISKS								
	IMPORTANCE			SEVERITY			DETECTION			IMPORTANCE			SEVERITY			DETECTION		
1	0.5	0.75	1	0.25	0.5	1	0	0.25	0.75	0.5	0.75	1	0.5	0.75	1	0.75	1	1
2	0	0.25	0.75	0	0	0	0.25	0.5	0.75	0.25	0.5	0.75	0.5	0.75	1	0.5	0.75	1
3	0.5	0.75	1	0.5	0.75	1	0.75	1	1	0.25	0.5	0.75	0.25	0.5	0.75	0.5	0.75	1
4	0.5	0.75	1	0.25	0.5	1	0	0.25	0.75	0.5	0.75	1	0.25	0.5	0.75	0.25	0.5	0.75
5	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75	0.5	0.75	1	0.75	1	1	0.5	0.75	1
6	0.5	0.75	1	0.5	0.75	1	0	0.25	0.75	0.25	0.5	0.75	0.75	1	1	0.75	1	1
	TRANSPORTATION COSTS																	
	IMPORTANCE			SEVERITY			DETECTION											
1	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75									
2	0.75	1	1	0.5	0.75	1	0	0	0.25									
3	0.75	1	1	0.75	1	1	0.5	0.75	1									
4	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75									
5	0.5	0.75	1	0.5	0.75	1	0.25	0.5	0.75									
6	0.5	0.75	1	0.75	1	1	0.5	0.75	1									

Appendix 4

Data of 25 Criteria (Sectors) /40 Respondents

S/R	1	2	3	4	5	6	7	8	9	10	11	12	13
A1	VH	VH	H	VH	VH	VH	VH	VH	VH	VH	H	H	M
A2	H	H	VH	VH	H	VH	VH	VH	VH	M	H	H	H
A3	H	H	H	H	H	VH	H	VH	VH	VH	VH	H	H
A4	M	M	M	H	M	M	H	H	VH	VH	VH	H	VH
A5	H	H	H	H	H	VH	H	H	H	H	H	H	H
A6	H	VH	M	M	L	H	M	M	H	H	M	M	H
A7	VH	H	M	H	M	VH	M	M	H	H	H	M	H
A8	L	M	H	VH	H	VH	VH	VH	H	VH	VH	M	M
A9	VH	VH	H	VH	VH	VH	VH	VH	VH	H	VH	M	VH
A10	VH	VH	M	M	H	H	M	H	M	M	VH	H	M
A11	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	H	VH
A12	VH	VH	H	H	H	VH	VH	H	H	VH	H	H	H
A13	VH	H	M	H	L	M	H	H	H	H	H	M	M
A14	H	H	VH	VH	VH	VH	VH	H	VH	H	H	M	H
A15	H	H	H	VH	H	H	VH	VH	H	H	VH	M	M
A16	M	H	M	H	L	H	H	H	H	H	H	M	H
A17	H	H	H	VH	H	H	H	H	H	H	H	M	H
A18	VH	VH	VH	H	H	VH	VH	VH	VH	H	VH	VH	H
A19	H	H	H	VH	H	M	H	VH	VH	VH	H	L	VH
A20	VH	VH	M	M	VH	VH	H	VH	M	VH	VH	M	H
P1	H	H	H	VH	H	H	H	VH	VH	VH	H	H	H
P2	VH	VH	H	H	H	H	H	H	H	VH	H	M	VH
P3	M	M	M	H	M	M	VH	M	H	M	H	M	L
P4	VH	VH	H	M	VH	H	H	H	M	M	H	M	H
P5	H	H	H	VH	VH	VH	VH	VH	VH	VH	VH	H	VH
P6	VH	VH	H	H	VH	VH	H	VH	VH	VH	VH	VH	VH
P7	H	H	H	H	H	VH	M	H	H	VH	VH	H	VH
P8	H	H	H	VH	VH	VH	H	H	H	H	H	M	M
P9	H	H	M	H	M	M	L	M	M	H	VH	H	M
P10	M	M	M	VH	H	M	VH	VH	VH	VH	VH	M	M
P11	VH	VH	H	H	VH	H	VH	VH	VH	VH	VH	VH	H
P12	H	VH	H	VH	VH	H	VH	VH	H	VH	VH	M	H
P13	H	VH	H	VH	VH	H	VH	VH	VH	VH	H	VH	H

P14	H	H	VH	H	H	H	H	H	H	VH	VH	H	H
P15	M	M	H	VH	VH	VH	VH	VH	VH	VH	VH	H	VH
P16	VH	VH	M	VH	VH	VH	H	VH	VH	VH	VH	M	H
P17	VH	VH	H	H	VH	VH	H	H	H	H	H	H	H
P18	VH	VH	L	H	VH	M	H	VH	VH	VH	H	H	H
P19	H	M	M	M	H	VH	H	M	VH	H	VH	M	H
P20	H	H	M	H	H	VH	H	H	VH	VH	M	L	VH

S/R	14	15	16	17	18	19	20	21	22	23	24	25
A1	VH	H	VH	H	H	H	VH	H	VH	VH	VH	VH
A2	H	H	VH	VH	VH	VH	H	VH	H	M	H	VH
A3	VH	VH	VH	H	VH	VH	VH	VH	VH	VH	H	H
A4	H	M	VH	M	H	VH	H	VH	H	VH	H	VH
A5	H	M	H	H	H	VH	VH	H	H	H	VH	VH
A6	L	M	H	M	H	H	H	M	L	M	H	M
A7	H	H	VH	H	VH	VH	VH	H	VH	H	H	H
A8	M	M	H	H	H	H	VH	VH	H	M	H	H
A9	H	VH	VH	H	VH	VH	VH	H	VH	M	VH	VH
A10	VH	M	VH	H	H	H	H	L	H	M	H	L
A11	H	H	VH	H	VH	VH	VH	VH	VH	H	VH	VH
A12	H	M	VH	H	H	H	H	H	H	H	H	H
A13	H	H	M	M	VH	H	M	M	H	M	M	VH
A14	H	VH	VH	VH	VH	VH	VH	VH	M	M	H	H
A15	H	VH	VH	VH	VH	VH	VH	M	M	M	H	H
A16	H	L	VH	VH	M	H	M	M	M	L	VH	VH
A17	M	M	H	H	H	VH	H	H	H	M	VH	VH
A18	H	M	VH	H	VH	VH	H	VH	H	H	H	VH
A19	M	M	VH	H	H	VH	VH	VH	H	VH	M	VH
A20	H	H	VH	VH	VH	VH	VH	M	M	M	VH	VH
P1	H	H	VH	H	H	VH	H	VH	M	VH	H	VH
P2	L	M	VH	H	H	H	H	L	H	H	VH	VH
P3	M	M	H	M	M	H	M	M	M	M	H	H
P4	M	M	VH	H	H	M	VH	L	M	H	H	H
P5	VH	H	VH	H	H	VH	VH	H	H	H	VH	VH
P6	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH
P7	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH
P8	H	H	VH	H	VH	VH	VH	H	H	H	VH	VH
P9	H	L	H	M	H	VH	H	M	VH	H	VH	H
P10	H	H	VH	H	VH	VH	VH	H	H	H	M	VH

P11	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	H
P12	H	M	VH	H	VH	H	VH	M	H	H	H	H
P13	VH	H	VH	VH	VH	VH	VH	VH	VH	VH	H	VH
P14	H	H	VH	VH	VH	VH	VH	VH	VH	M	VH	VH
P15	VH	H	VH	VH	VH	VH	VH	M	VH	M	VH	VH
P16	H	H	VH	VH	VH	H	H	H	VH	VH	VH	VH
P17	M	M	VH	M	H	H	H	M	H	M	VH	VH
P18	H	H	VH	VH	VH	VH	VH	H	VH	VH	VH	H
P19	M	H	H	H	H	VH	H	H	H	M	H	VH
P20	VH	VH	L	VH	VH	VH	M	H	VH	VH	VH	VH

Appendix 5

Data of 25 Criteria (Sectors) /150 Respondents

S/R	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	H	VH	M	M	H	M	M	M	H	H	M	M	M	VL	L	H	L	L	H	M	VL	M	M	VL	M
2	H	H	H	VH	H	H	H	VH	VH	VH	H	H	H	H	H	VH	H	H	VH	H	VH	M	VH	H	VH
3	H	VH	VH	H	H	H	VH	VH	VH	VH	H	H	VH	VH	M	VH	VH	VH	VH	VH	VH	VH	H	VH	VH
4	VH	VH	H	H	H	H	H	H	H	VH	H	M	VH	L	M	VH	H	H	H	H	L	H	H	VH	VH
5	VH	VH	H	VH	VH	VH	VH	VH	VH	VH	H	H	M	VH	H	VH	H	H	H	VH	H	VH	VH	VH	VH
6	H	H	VH	VH	H	VH	VH	VH	VH	M	H	H	H	H	H	VH	VH	VH	VH	H	VH	H	M	H	VH
7	H	VH	M	H	VH	H	M	H	VH	VH	VH	M	H	VH	H	VH	M	M	H	H	M	M	H	VH	VH
8	H	H	H	H	H	VH	H	VH	VH	VH	VH	H	H	VH	VH	VH	H	VH	VH	VH	VH	VH	VH	H	H
9	H	H	M	H	M	H	H	H	VH	VH	H	H	M	VH	M	VH	H	H	H	VH	M	H	M	H	M
10	VH	VH	VH	H	M	M	VH	VH	VH	VH	VH	H	H	M	H	VH	H	H	H	H	H	VH	H	H	H
11	VH	VH	M	H	VH	VH	H	H	H	H	VH	VH	H	H	M	VH	VH	VH	H	VH	M	VH	H	H	H
12	M	M	M	M	H	VH	H	H	H	H	H	M	L	L	H	H	H	L	M	H	M	M	H	H	M
13	M	H	M	H	H	M	M	H	H	H	H	H	M	M	VL	H	H	M	M	M	M	M	L	VH	VH
14	M	M	M	H	M	M	VH	M	H	M	H	M	L	M	M	H	M	M	H	M	M	M	M	H	H
15	VH	VH	H	M	VH	H	H	H	M	M	H	M	H	M	M	VH	H	H	M	VH	L	M	H	H	H
16	M	M	M	H	M	M	H	H	VH	VH	VH	H	VH	H	M	VH	M	H	VH	H	VH	H	VH	H	VH
17	VH	VH	H	H	H	VH	H	VH	VH	VH	VH	H	VH	H	M	VH	H	H	VH	VH	H	H	H	VH	VH
18	H	H	H	VH	VH	VH	VH	VH	VH	VH	VH	H	VH	VH	H	VH	H	H	VH	VH	H	H	H	VH	VH
19	M	M	M	H	M	L	H	VH	VH	VH	M	H	H	L	L	H	H	H	VH	M	M	H	H	VH	VH
20	VH	VH	H	H	VH	VH	H	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH
21	H	H	H	H	H	VH	H	H	H	H	H	H	H	H	M	H	H	H	VH	VH	H	H	H	VH	VH
22	H	VH	M	M	L	H	M	M	H	H	M	M	H	L	M	H	M	H	H	H	M	L	M	H	M
23	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	M	M	M	H	VH	VH	VH	VH	VH	VH	VH	M	VH	H	VH
24	VH	H	M	H	M	VH	M	M	H	H	H	M	H	H	H	VH	H	VH	VH	VH	H	VH	H	H	H
25	H	H	H	H	H	VH	M	H	H	VH	VH	H	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH
26	H	H	H	VH	VH	VH	H	H	H	H	H	M	M	H	H	VH	H	VH	VH	VH	H	H	H	VH	VH
27	VH	VH	H	VH	H	M	H	H	VH	H	H	H	M	M	H	VH	M	M	H	H	H	M	H	M	H
28	VH	VH	VH	VH	H	VH	H	VH	VH	VH	H	H	M	H	VH	VH	VH	H	VH	VH	VH	VH	H	H	H
29	H	VH	H	VH	VH	H	M	H	H	VH	H	M	M	H	H	VH	H	H	VH	VH	L	H	M	M	H
30	VH	VH	H	VH	H	H	H	H	H	H	VH	H	H	M	M	VH	H	VH	H	VH	VH	H	H	VH	H
31	H	VH	H	H	H	VH	VH	VH	H	H	H	M	H	H	M	VH	VH	H	H	H	M	M	M	M	M
32	H	H	M	H	M	M	L	M	M	H	VH	H	M	H	L	H	M	H	VH	H	M	VH	H	VH	H
33	H	VH	M	H	H	VH	VH	VH	VH	H	VH	VH	H	VH	H	VH	VH	VH	VH	H	H	H	H	VH	VH
34	VH	VH	M	M	H	VH	VH	H	H	H	H	M	M	H	M	H	VH	VH	VH	H	H	H	M	H	H
35	L	L	H	VH	H	H	M	H	H	H	VH	M	H	M	M	H	M	M	VH	H	H	M	M	H	H
36	H	H	H	H	VH	M	VH	H	M	H	M	M	M	H	H	H	H	M	H	VH	H	M	H	M	H
37	M	M	H	H	H	H	M	M	M	H	H	M	H	M	H	H	H	H	H	H	H	H	M	H	H
38	VH	VH	M	VH	VH	VH	H	H	VH	VH	VH	M	VH	VH	H	VH	VH	VH	VH	VH	M	M	M	VH	VH
39	H	H	M	H	H	H	H	H	H	VH	H	M	H	M	M	VH	H	H	H	VH	H	M	VL	M	H
40	H	H	VH	H	M	M	M	M	M	H	H	M	M	M	M	H	H	H	VH	VH	VH	H	M	VH	M
41	VH	VH	H	H	H	H	VH	VH	VH	M	VH	H	H	M	M	VH	VH	VH	VH	VH	H	H	H	VH	H

42	M	M	VH	VH	H	VH	VH	VH	VH	H	H	H	M	H	H	H	VH	VH	H	H	H	H	M	M	M
43	H	VH	H	VH	VH	M	H	H	H	VH	VH	VL	VH	L	H	VH	M	VH	VH	VH	M	M	L	M	VH
44	VH	VH	M	H	VH	VH	M	H	H	VH	VH	H	VH	H	VH	VH	VH	VH	VH	VH	VH	VH	H	VH	VH
45	L	VH	H	H	VL	M	VH	M	VH	VH	VH	M	H	H	M	H	H	L	H	M	M	M	M	VH	H
46	H	VH	M	VH	VH	VH	H	VH	VH	VH	VH	H	VH	H	H	VH	VH	M	H	VH	VH	H	M	H	VH
47	H	H	M	VH	VH	H	VH	H	H	VH	H	H	M	M	M	VH	H	VH	VH	VH	H	M	M	H	VH
48	VH	H	H	H	H	VH	VH	H	H	H	VH	H	H	H	H	H	M	VH	VH	H	H	H	H	H	H
49	VH	VH	H	VH	VH	VH	H	VH	VH	VH	VH	VH	VH	H	M	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH
50	H	H	M	H	M	VH	M	M	H	VH	VH	L	M	H	VL	VH	VH	VH	H	L	M	M	M	VH	H
51	M	M	H	H	M	H	H	M	H	M	M	M	H	M	M	H	H	H	VH	VH	H	M	M	M	M
52	VH	H	H	H	H	VH	M	H	H	H	VH	M	VH	VH	M	H	H	H	H	H	H	H	H	H	M
53	VH	VH	H	VH	VH	H	VH	VH	VH	VH	H	H	H	H	VH	VH	VH	VH	VH	VH	VH	VH	H	H	H
54	L	M	H	VH	H	VH	VH	VH	H	VH	VH	M	M	M	M	H	H	H	H	VH	VH	H	M	H	H
55	M	M	M	H	H	H	H	H	H	VH	VH	M	M	M	H	VH	H	H	VH	M	H	M	H	H	H
56	VH	VH	H	VH	H	H	H	H	H	VH	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
57	H	H	H	H	M	H	H	H	H	H	M	VL	L	H	VL	H	VH	M	H	H	H	M	H	VH	VH
58	VH	H	H	H	H	H	H	H	H	H	H	H	H	H	M	VH	H	H	H	H	M	H	H	H	VH
59	H	H	M	VH	VH	H	H	VH	VH	VH	H	H	M	M	M	VH	H	H	VH	VH	H	H	M	H	H
60	VH	VH	H	H	M	VH	VH	H	H	VH	VH	M	H	M	H	H	M	M	H	H	VH	H	L	M	M
61	M	H	H	VH	VH	H	VH	H	H	VH	H	M	M	H	M	VH	VH	VH	VH	H	VH	VH	M	VH	H
62	M	M	M	VH	H	M	VH	VH	VH	VH	VH	M	M	H	H	VH	H	VH	VH	VH	H	H	H	M	VH
63	VH	H	H	VH	H	VH	VH	H	VH	VH	H	H	H	H	H	H	H	VH	VH	VH	H	H	H	VH	VH
64	VH	VH	M	VH	VH	H	VH	VH	H	VH	VH	L	M	M	L	VH	VH	H	VH	H	VH	H	VH	VH	M
65	VH	VH	H	H	VH	H	VH	VH	VH	VH	VH	VH	H	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	H
66	H	VH	M	H	M	H	H	H	H	VH	H	VL	VL	M	VL	VH	VH	H	VH	H	H	H	H	VH	VH
67	H	VH	H	H	M	H	H	H	H	VH	H	H	M	M	H	H	H	H	VH	H	H	H	H	H	H
68	VH	VH	H	H	H	H	VH	H	H	H	VH	L	H	H	M	H	H	H	VH	VH	VH	H	H	H	M
69	H	VH	H	VH	VH	H	VH	VH	H	VH	VH	M	H	H	M	VH	H	VH	H	VH	M	H	H	H	H
70	H	VH	M	VH	M	VH	VH	M	L	VH	VH	H	M	H	M	VH	L	M	L	VH	VH	H	M	M	L
71	VH	VH	H	VH	H	VH	VH	VH	VH	VH	VH	M	VH	M	M	VH	VH	VH	VH	VH	VH	H	H	VH	VH
72	VH	VH	M	H	H	H	H	H	H	H	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
73	H	H	M	VH	H	H	VH	H	VH	H	H	M	H	M	M	H	H	H	H	VH	H	H	M	VH	VH
74	H	H	H	VH	VH	VH	VH	H	H	VH	VH	M	VH	H	M	H	VH	H	VH	H	VH	VH	M	VH	VH
75	VH	H	H	H	M	M	M	H	H	H	H	L	M	M	M	M	H	H	H	H	H	M	M	M	H
76	VH	VH	H	VH	H	VH	VH	H	VH	H	H	VH	H	M	L	VH	H	VH	H	VH	VH	H	H	VH	H
77	VH	H	M	VH	VH	VH	H	H	M	VH	VH	VH	VH	H	VH	VH	VH	VH	H	VH	VH	VH	VH	VH	VH
78	M	M	H	H	M	H	H	H	H	M	H	H	H	M	H	H	H	H	VH	H	H	M	H	H	H
79	H	VH	H	VH	VH	H	VH	VH	VH	VH	H	VH	H	VH	H	VH	VH	VH	VH	VH	VH	VH	VH	H	VH
80	VH	VH	H	H	H	VH	H	VH	VH	VH	VH	M	VH	H	H	VH	VH	VH	H	VH	H	VH	M	H	VH
81	H	H	H	H	H	VH	VH	VH	VH	VH	VH	H	VH	H	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH
82	H	H	H	H	H	H	H	H	H	H	H	M	M	M	H	H	H	H	H	H	H	H	H	H	H
83	VH	VH	H	VH	VH	VH	VH	VH	VH	H	VH	M	VH	H	VH	VH	H	VH	VH	VH	H	VH	M	VH	VH
84	H	H	H	M	M	VH	VH	VH	VH	VH	VH	M	H	VH	VL	VH	VH	M	H	VH	M	L	M	VH	VH
85	H	H	VH	H	H	H	H	H	H	VH	VH	H	H	H	H	VH	VH	VH	VH	VH	VH	VH	M	VH	VH
86	M	M	M	H	H	H	H	H	VH	VH	H	H	VH	H	H	VH	VH	VH	VH	VH	VH	H	H	H	VH
87	H	VH	H	M	M	H	M	M	M	M	H	L	H	H	H	VH	VH	VH	H	H	H	H	M	H	M

88	VH	VH	VH	H	H	VH	M	H	H	H	VH	H	H	H	M	VH	VH	H	H	VH	M	H	H	H	M
89	VH	VH	H	H	H	VH	H	VH	VH	VH	H	VH	VH	M	H	VH	VH	VH	H	VH	VH	VH	H	VH	H
90	VH	H	H	H	H	H	VH	H	H	H	VH	M	H	H	H	VH	H	H	H	H	VH	H	M	H	H
91	VH	VH	VH	H	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH
92	VH	VH	H	VH	VH	VH	H	VH	VH	VH	VH	M	VH	H	H	VH	VH	VH	VH	VH	VH	VH	M	VH	VH
93	VH	VH	M	VH	H	VH	VH	VH	VH	VH	VH	M	VH	M	VH	VH	VH	H	H	VH	VH	VH	VH	VH	VH
94	VH	VH	M	M	H	H	M	H	M	M	VH	H	M	VH	M	VH	H	H	H	H	L	H	M	H	L
95	M	H	H	VH	H	VH	VH	H	VH	VH	VH	H	H	H	H	VH	H	VH	VH	VH	H	H	M	H	H
96	H	H	H	VH	H	H	VH	H	H	VH	VH	H	VH	H	H	VH	H	H	VH	H	VH	H	H	VH	H
97	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	H	VH	H	H	VH	H	VH	VH	VH	VH	VH	H	VH	VH
98	VH	VH	H	H	H	VH	VH	H	H	VH	H	H	H	H	M	VH	H	H	H	H	H	H	H	H	H
99	H	H	H	H	H	VH	H	H	H	H	M	VH	VH	H	M	H	H	VH	VH	VH	VH	H	M	VH	H
100	H	VH	H	VH	VH	H	H	VH	VH	H	VH	M	H	M	M	H	M	H	VH	H	VH	H	H	VH	VH
101	H	H	M	M	M	H	VH	H	VH	VH	VH	M	M	M	M	H	M	H	VH	H	M	VH	M	VH	H
102	H	H	H	VH	H	H	H	H	H	H	VH	M	H	M	M	VH	H	H	H	H	H	M	H	M	VH
103	VH	H	M	H	L	M	H	H	H	H	H	M	M	H	H	M	M	VH	H	M	M	H	M	M	**VH**
104	H	H	VH	VH	VH	VH	VH	H	VH	H	H	M	H	H	VH	VH	VH	VH	VH	VH	VH	M	M	H	H
105	H	H	VH	H	VH	VH	H	H	VH	VH	VH	M	H	M	H	VH	H	VH	VH	VH	VH	H	M	H	VH
106	H	H	H	VH	H	H	VH	VH	H	H	VH	M	M	H	VH	VH	VH	VH	VH	VH	M	M	M	H	H
107	H	H	M	M	VH	VH	H	VH	VH	H	VH	VL	H	VH	M	VH	VH	VH	VH	VH	H	H	H	VH	M
108	H	H	M	M	M	H	H	H	H	H	H	M	H	H	M	VH	H	H	M	M	M	M	M	VH	H
109	M	M	H	VH	VH	VH	VH	VH	VH	VH	VH	H	VH	VH	H	VH	VH	VH	VH	VH	M	VH	M	VH	VH
110	VL	VL	VL	M	L	L	H	H	M	VH	M	VL	VH	H	H	L	M	M	VH	L	VL	VL	VH	VL	VH
111	H	H	H	H	H	VH	H	H	H	H	H	H	H	H	H	H	H	H	H	VH	M	H	H	H	H
112	VH	VH	M	VH	VH	VH	H	VH	VH	VH	**VH**	M	**H**	H	H	VH	VH	VH	H	H	H	VH	VH	VH	VH
113	VH	VH	H	H	H	H	VH	VH	VH	VH	H	M	H	H	M	VH	H	VH	VH	VH	H	H	VH	VH	H
114	M	H	M	H	L	H	H	H	H	H	H	M	H	H	L	VH	VH	M	H	M	M	M	L	VH	VH
115	VH	VH	H	H	H	H	H	M	H	M	H	H	H	H	M	H	H	H	H	H	H	H	H	H	H
116	H	H	H	M	H	VH	H	VH	VH	VH	H	H	VH	H	M	VH	M	H	VH	VH	M	VH	H	VH	VH
117	VH	VH	M	H	VH	H	H	H	VH	VH	VH	VH	VH	H	M	VH	H	VH	VH	VH	H	VH	H	H	H
118	VH	VH	H	H	M	VH	VH	VH	VH	VH	VH	VH	VH	M	M	H	VH	VH	VH	VH	VH	VH	VH	VH	VH
119	H	H	L	M	H	VH	L	H	VH	H	VH	M	H	L	L	M	VL	L	VH	H	VL	H	M	VH	H
120	VH	VH	H	H	VH	VH	H	H	H	H	H	H	H	M	M	VH	M	H	H	H	M	H	M	VH	VH
121	H	H	M	H	M	M	M	H	M	H	M	L	VH	L	L	M	H	H	VH	H	L	M	H	VH	H
122	VH	VH	H	H	H	VH	H	H	H	H	VH	H	VH	H	VH	VH	H	H	VH	VH	H	VH	H	VH	H
123	H	H	H	H	H	H	H	H	VH	H	VH	H	H	H	VH	VH	H	H	VH	H	H	H	VH	H	VH
124	H	VH	M	VH	VH	M	VH	H	H	M	H	M	H	M	H	VH	H	H	H	H	M	M	H	L	H
125	H	H	M	VH	H	H	VH	VH	VH	VH	VH	M	H	H	H	VH	H	H	VH	VH	H	H	VH	H	H
126	H	H	H	VH	H	H	H	H	H	H	H	M	H	M	M	H	H	H	VH	H	H	H	M	VH	VH
127	H	VH	M	VH	VH	VH	VH	VH	H	VH	VH	L	VH	L	L	VH	H	H	H	VH	M	M	L	VH	VH
128	H	H	H	L	H	L	H	H	H	H	H	M	H	H	VH	H	VH	H	H	H	M	H	H	H	H
129	H	H	M	L	VH	H	H	VH	H	VH	H	L	M	M	M	H	M	M	VH	H	H	M	M	VL	H
130	VH	VH	VH	H	H	VH	VH	VH	VH	H	VH	VH	H	H	M	VH	H	VH	VH	H	VH	H	H	H	VH
131	H	VH	H	H	H	H	H	H	M	H	L	H	M	H	H	VH	VH	H	VH	H	H	VH	H	M	VL
132	H	H	M	H	H	M	H	H	H	H	M	M	H	H	H	VH	H	H	VH	H	H	H	H	M	H
133	VH	VH	L	H	VH	M	H	VH	VH	VH	H	H	H	H	H	VH	VH	VH	VH	VH	H	VH	VH	VH	H

134	H	VH	M	H	VH	VH	H	VH	M	VH	VH	VH	VH	M	H	VH	VH	VH	VH	VH	H	VH	VH	VH	VH
135	**H**	M	M	M	H	VH	H	M	VH	H	VH	M	H	M	H	H	H	H	VH	H	H	H	M	H	VH
136	H	H	H	VH	H	M	H	VH	VH	VH	H	L	VH	M	M	VH	H	H	VH	VH	VH	H	VH	M	VH
137	M	H	M	VH	H	VH	VH	H	VH	VH	VH	M	H	M	M	VH	H	VH	VH	VH	H	H	H	VH	VH
138	H	H	M	H	H	L	L	H	H	VH	VH	M	VH	VL	M	VH	VH	H	VH	H	VH	VH	VH	H	VH
139	H	H	H	H	M	M	VH	H	VH	H	VH	M	VH	M	H	VH	M	H	VH	VH	VH	M	H	VH	VH
140	M	M	L	H	M	H	H	H	M	H	M	M	M	H	H	H	M	H	H	H	M	M	L	M	VH
141	M	M	VH	VH	H	M	H	H	VH	H	VH	M	H	M	M	H	L	L	VH	H	H	M	L	L	M
142	H	VH	VH	H	H	VH	VH	VH	H	M	VH	M	H	VH	H	H	H	H	H	H	M	VH	VH	VH	M
143	M	M	H	VH	M	H	H	H	VH	VH	H	M	H	H	VH	VH	H	VH	VH	VH	H	VH	VH	VH	H
144	M	H	H	VH	M	M	VH	H	H	VH	VH	H	H	H	H	VH	VH	H	VH	VH	H	M	VH	VH	H
145	H	VH	M	H	VH	M	VH	H	VH	VH	VH	H	VH	M	H	VH	VH	VH	VH	VH	H	VH	VH	VH	VH
146	VH	VH	L	M	H	H	M	H	H	H	VH	H	H	H	M	H	H	H	M	M	M	H	H	H	H
147	H	H	M	H	H	VH	H	H	**VH**	VH	M	L	VH	VH	VH	L	VH	VH	VH	M	**H**	VH	VH	VH	VH
148	H	H	M	H	H	M	H	VH	VH	VH	H	H	H	M	H	VH	VH	H	H	H	M	H	L	M	H
149	H	H	H	H	H	M	H	M	M	M	M	M	H	M	M	H	M	M	M	M	H	H	M	H	M
150	VH	VH	M	M	VH	VH	H	VH	M	VH	VH	M	H	H	H	VH	VH	VH	VH	VH	M	M	M	VH	VH

Appendix 6

Criteria Importance Data

	CRITERIA IMPORTANCE								
C/R	AOL	SS	DFLC	LONS	ECI	DA	IOL	ATPS	DFRA
1	High	High	High	Medium	High	Medium	Medium	High	Low
2	Low	Very Low	Very Low	Low	Low	Very Low	Low	Very Low	Low
3	Very High	High	Medium	High	Very High	Low	Low	Very High	Low
4	High	Medium	Medium	Low	High	High	High	Medium	Low
5	High	High	High	High	Very Low	Very Low	Very Low	High	Low
6	Very High	Medium	Medium	Medium	Low	High	High	High	Low
7	High	High	Medium	Medium	High	Low	Medium	Medium	Medium
8	Very High	Medium	Low	Low	Very High	Medium	Low	Medium	Medium
9	Very High	Medium	High	High	High	Medium	Medium	Medium	Medium
10	High	Medium	Medium	Medium	High	Low	Medium	High	High
11	Medium	Low	Low	Low	Medium	Very Low	Medium	Low	Very Low
12	High	Very High	High	Very High	Low	High	Low	Very High	Low
13	Medium	High	Low	Medium	Very Low	Very Low	Very Low	Very Low	Medium
14	Very High	High	Very High	Very High	High	Medium	High	Very High	Medium
15	Very High	Medium	Medium	Medium	Low	Medium	Low	Medium	Low
16	High	High	High	Very High	Medium	Medium	Medium	Low	Low
17	Very High	Medium	High	High	Very High	Low	Very High	Medium	Very Low

Appendix 7

Alternative Importance Data for AOL & SS

C	AOL				SS			
A/R	VV	PT	CG	PKB	VV	PT	CG	PKB
1	Good	Fair	Good	Very good	Fair	Fair	Good	Very good
2	Fair	Poor	Fair	Good	Poor	Poor	Poor	Fair
3	Very good	Good	Good	Very good	Very good	Good	Good	Very good
4	Good	Fair	Good	Fair	Fair	Fair	Good	Good
5	Poor	Very Poor	Fair	Good	Poor	Fair	Fair	Good
6	Fair	Good	Good	Good	Fair	Fair	Fair	Fair
7	Good	Fair	Fair	Good	Fair	Fair	Fair	Fair
8	Good	Fair	Good	Very good	Fair	Fair	Fair	Fair
9	Fair	Fair	Fair	Fair	Poor	Poor	Fair	Fair
10	Good	Good	Good	Good	Good	Fair	Good	Good
11	Fair	Poor	Poor	Fair	Fair	Fair	Fair	Fair
12	Poor	Fair	Good	Good	Fair	Fair	Good	Good
13	Very good	Good	Good	Very good	Fair	Very Poor	Good	Poor
14	very poor	Fair	Fair	Very good	Fair	Fair	Fair	Very good
15	Good	Good	Very good	Very good	Fair	Good	Fair	Good
16	Good	Good	Good	Good	Good	Fair	Good	Good
17	Very good	Fair	Fair	Very good	Good	Fair	Good	Very good

Appendix 8

Alternative Importance Data for DFLC & LONS

C	DFLC				LONS			
A/R	VV	PT	CG	PKB	VV	PT	CG	PKB
1	Moderate	moderate	far	Close	moderate	moderate	moderate	Close
2	Far	Very far	far	moderate	Very far	Very far	Very far	Moderate
3	Moderate	moderate	moderate	very close	moderate	moderate	moderate	very close
4	Moderate	moderate	moderate	Close	moderate	moderate	moderate	Close
5	Far	Far	far	Close	Very far	far	far	Close
6	Moderate	moderate	moderate	moderate	moderate	moderate	moderate	Moderate
7	Far	Close	moderate	moderate	moderate	moderate	moderate	Moderate
8	Far	Far	far	moderate	moderate	moderate	moderate	Moderate
9	Moderate	moderate	moderate	moderate	far	far	far	Moderate
10	Far	moderate	far	moderate	far	far	far	Far
11	Moderate	moderate	far	moderate	moderate	moderate	moderate	Moderate
12	Moderate	moderate	moderate	close	moderate	moderate	moderate	Close
13	Moderate	Far	far	Close	far	moderate	moderate	Very far
14	Very far	moderate	far	Far	Very far	Very far	Very far	Very far
15	Close	moderate	far	Close	moderate	moderate	far	Close
16	Far	Very far	moderate	Close	moderate	far	moderate	Far
17	Close	Far	moderate	very close	close	moderate	moderate	very close

Appendix 9

Alternative Importance Data for ECI, DA & IOL

C	ECI				DA				IOL			
A/R	VV	PT	CG	PKB	VV	PT	CG	PKB	VV	PT	CG	PKB
1	moderate	Low	Moderate	Low	low	Fair	Fair	Fair	low	moderate	moderate	low
2	moderate	Low	Moderate	Very low	Very low	Fair	Very low	Very low	low	Low	Low	low
3	Very high	Very high	Very high	Very high	Very low	high	Very low	Fair	Very low	moderate	moderate	high
4	moderate	Low	Moderate	Low	Fair	low	Fair	Fair	moderate	Low	moderate	low
5	moderate	Moderate	Low	Very low	Very low	low	Very low	Very low	high	High	low	Very low
6	low	Low	Low	Low	Fair	low	low	low	moderate	moderate	moderate	Moderate
7	moderate	Moderate	Moderate	moderate	Fair	Fair	Fair	Fair	moderate	moderate	moderate	Moderate
8	high	Moderate	High	Low	Fair	Fair	Fair	Fair	low	Low	Low	Low
9	moderate	Moderate	Moderate	moderate	low	Fair	low	Fair	low	Low	moderate	Low
10	moderate	Low	Moderate	Low	low	Very low	low	Fair	moderate	Low	Low	Moderate
11	high	Moderate	High	moderate	Fair	high	Fair	high	low	moderate	Low	High
12	low	Low	Low	Low	high	high	Fair	Fair	low	Low	Low	Low
13	Very low	Very low	Very low	Very low	Very low	Very low	Very low	Fair	low	Low	moderate	Moderate
14	Very high	Low	High	Very low	low	Fair	low	Fair	Very low	High	low	High
15	low	Moderate	Low	Low	Fair	low	Fair	low	low	moderate	moderate	Low
16	low	Low	Moderate	moderate	low	Very low	Very high	high	Very low	Very low	moderate	Moderate
17	moderate	Moderate	Moderate	Low	low	Fair	low	low	Very high	Very high	Very high	Low

Appendix 10

Alternative Importance Data for ATPS & DFRA

C	ATPS				DFRA			
A/R	VV	PT	CG	PKB	VV	PT	CG	PKB
1	Fair	Fair	Fair	Good	far	Moderate	far	Close
2	Poor	Fair	Poor	Good	very far	Moderate	far	Close
3	Good	Good	Good	Very good	very far	Moderate	far	Very close
4	Fair	Fair	Fair	Fair	moderate	Moderate	far	Moderate
5	Fair	Good	Fair	Very good	moderate	Moderate	far	very far
6	Poor	Poor	Poor	Fair	very far	very far	far	moderate
7	Fair	Fair	Fair	Fair	far	far	far	Far
8	Fair	Fair	Fair	Fair	moderate	moderate	far	moderate
9	Poor	Fair	Fair	Good	far	moderate	close	close
10	Good	Good	Fair	Good	far	far	far	moderate
11	Fair	Fair	Fair	Good	far	far	far	moderate
12	Fair	Fair	Good	Good	far	far	moderate	moderate
13	Very Poor	Very Poor	Poor	Poor	moderate	far	far	moderate
14	Very Poor	Very good	Fair	Very good	very far	moderate	moderate	close
15	Good	Fair	Good	Good	close	moderate	moderate	close
16	Very Poor	Very Poor	Very Poor	Fair	very far	very far	very far	moderate
17	Fair	Good	Fair	Very good	moderate	moderate	moderate	Far

REFERENCES

[1] X. Wickett, J. Nilsson-Wright, and T. Summers, "The Asia-Pacific Power Balance," *US Proj. Asia Program.*, no. September, p. 78, 2015.

[2] M. T. Melo, S. Nickel, and F. Saldanha-da-Gama, "Facility location and supply chain management - A review," *Eur. J. Oper. Res.*, vol. 196, no. 2, pp. 401–412, 2009, doi: 10.1016/j.ejor.2008.05.007.

[3] S. A. Melnyk, R. Narasimhan, and H. A. DeCampos, "Supply chain design: Issues, challenges, frameworks and solutions," *Int. J. Prod. Res.*, vol. 52, no. 7, pp. 1887–1896, 2014, doi: 10.1080/00207543.2013.787175.

[4] C. Revelle and R. Church, "A Spatial Model for the Location Construct of Teitz," *Reg. Sci. Assoc.*, vol. 39, pp. 129–135.

[5] C. G. Chentnik, "Fixed Facility Location Techniques," *Int. J. Phys. Distrib.*, vol. 4, no. 1, pp. 16–25, 1973, [Online]. Available: http://dx.doi.org/10.1108/eb014.

[6] S. A. Terouhid, R. Ries, and M. Mirhadi Fard, "Towards Sustainable Facility Location – A Literature Review," *J. Sustain. Dev.*, vol. 5, no. 7, 2012, doi: 10.5539/jsd.v5n7p18.

[7] R. Bhatnagar and A. S. Sohal, "Supply chain competitiveness: measuring the impact of location factors, uncertainty and manufacturing practices," *Technovation*, vol. 25, no. 5, pp. 443–456, 2005, doi: 10.1016/j.technovation.2003.09.012.

[8] I. U. Munasinghe, T. D. Rupasinghe, and R. Wickramarachchi, "A Simulation-Based Modeling Approach to Assess the Multi-Echelon Supply Chain Network Design," in *IEEE International Conference on Industrial Engineering and Engineering Management*, 2017, pp. 1372–1376.

[9] D. Ozgen and B. Gulsun, "Combining possibilistic linear programming and fuzzy AHP for solving the multi-objective capacitated multi-facility location problem," *Inf. Sci. (Ny).*, vol. 268, pp. 185–201, 2014, doi: 10.1016/j.ins.2014.01.024.

[10] S. Bishnu, "No Title," *Singur – A Case Study*, 2008. https://www.countercurrents.org/bishnu190908.htm (accessed Dec. 19, 2015).

[11] A. H. Kalantari, "Facility Location Selection for Global Manufacturing," *Univ. Wisconsin-Milwaukee*, vol. 81, no. 19, p. 87, 2013, [Online]. Available: http://dc.uwm.edu/etd.

[12] K. S. Bhutta, "International facility location decisions: a review of the modelling literature," *Int. J. Integr. Supply Manag.*, vol. 1, no. 1, pp. 33–50, 2004, doi: 10.1504/IJISM.2004.004596.

[13] S. Burciu, M. Popa, E. Rosca, F. Rusca, and D. Costescu, "Location of Production

Facilities in the Framework of Sustainable Development," *Procedia Technol.*, vol. 22, pp. 274–281, 2016, doi: 10.1016/j.protcy.2016.01.080.

[14] S. Chopra and P. Meindl, *Supply Chain Management Strategy, Planning, and Operation 5th Edition*, 5th Editio. Prentice Hall, 2013.

[15] S. Biswas, "Supply Chain Performance Measures," 2000. http://lcm.csa.iisc.ernet.in/scm/coimbatore/node11.html (accessed Dec. 20, 2016).

[16] L. A. Zadeh, "Fuzzy Sets," *Inf. Control*, vol. 8, pp. 338–353, 1965.

[17] C. W. Chang, C. R. Wu, and H. C. Chen, "Using expert technology to select unstable slicing machine to control wafer slicing quality via fuzzy AHP," *Expert Syst. Appl.*, vol. 34, no. 3, pp. 2210–2220, 2008, doi: 10.1016/j.eswa.2007.02.042.

[18] T. C. Chu, "Selecting plant location via a fuzzy TOPSIS approach," *Int. J. Adv. Manuf. Technol.*, vol. 20, no. 11, pp. 859–864, 2002, doi: 10.1007/s001700200227.

[19] R. Moghimi and A. Anvari, "An integrated fuzzy MCDM approach and analysis to evaluate the financial performance of Iranian cement companies," *Int. J. Adv. Manuf. Technol.*, vol. 71, no. 1–4, pp. 685–698, 2014, doi: 10.1007/s00170-013-5370-6.

[20] E. Bellman and L. A. Zadeh, "A fuzzy environment," *Manage. Sci.*, vol. 17, no. 4, pp. B141–B164, 1970.

[21] H. C. Tsai and S. W. Hsiao, "Evaluation of alternatives for product customization using fuzzy logic," *Inf. Sci. (Ny).*, vol. 158, no. 1–4, pp. 233–262, 2004, doi: 10.1016/j.ins.2003.08.001.

[22] S. Gao, Z. Zhang, and C. Cao, "Multiplication operation on fuzzy numbers," *J. Softw.*, vol. 4, no. 4, pp. 331–338, 2009, doi: 10.4304/jsw.4.4.331-338.

[23] T. T. Nguyen and S. Olapiriyakul, "Optimizing Facility Location Decisions Considering Health Impact on Local Population," *Procedia CIRP*, vol. 40, pp. 289–294, 2016, doi: 10.1016/j.procir.2016.01.124.

[24] J. Vargas Florez, M. Lauras, U. Okongwu, and L. Dupont, "A decision support system for robust humanitarian facility location," *Eng. Appl. Artif. Intell.*, vol. 46, pp. 326–335, 2015, doi: 10.1016/j.engappai.2015.06.020.

[25] S. Bespamyatnikh, K. Kedem, M. Segal, and A. Tamir, "Optimal facility location u n d e r various distance f u n c t i o n s," vol. 10, no. 5, pp. 523–534, 2000.

[26] S. H. Owen and M. S. Daskin, "Strategic facility location: A review," *Eur. J. Oper. Res.*, vol. 111, no. 3, pp. 423–447, 1998, doi: 10.1016/S0377-2217(98)00186-6.

[27] M. S. Daskin, L. V Snyder, and R. T. Berger, "Facility Location in Supply Chain Design," 2003.

[28] R. Z. Farahani, N. Asgari, N. Heidari, M. Hosseininia, and M. Goh, "Covering

problems in facility location: A review," *Comput. Ind. Eng.*, vol. 62, no. 1, pp. 368–407, 2012, doi: 10.1016/j.cie.2011.08.020.

[29] L. Chen, J. Olhager, and O. Tang, "Manufacturing facility location and sustainability: A literature review and research agenda," *Int. J. Prod. Econ.*, vol. 149, pp. 154–163, 2014, doi: 10.1016/j.ijpe.2013.05.013.

[30] J. Sarkis and R. P. Sundarraj, "Hub location at Digital Equipment Corporation: A comprehensive analysis of qualitative and quantitative factors," *Eur. J. Oper. Res.*, vol. 137, no. 2, pp. 336–347, 2002, doi: 10.1016/S0377-2217(01)00138-2.

[31] D. Ravet, "An exploration of facility location metrics in international supply chain," *Trends Int. Bus.*, pp. 1–18, 2012, [Online]. Available: http://halshs.archives-ouvertes.fr/hal-00747397/.

[32] UNIDO, "The role of technology and innovation in inclusive and sustainable industrial development," 2015. doi: 10.18356/1b194e1c-en.

[33] F. Azmat, "Sustainable Development in Developing Countries: The Role of Social Entrepreneurs," *Int. J. Public Adm.*, vol. 36, no. 5, pp. 293–304, 2013, doi: 10.1080/01900692.2012.756891.

[34] I. Yüksel, "Developing a Multi-Criteria Decision Making Model for PESTEL Analysis," *Int. J. Bus. Manag.*, vol. 7, no. 24, pp. 52–66, 2012, doi: 10.5539/ijbm.v7n24p52.

[35] A. Kolios and G. Read, "A Political, economic, social, technology, legal and environmental (PESTLE) approach for risk identification of the tidal industry in the United Kingdom," *Energies*, vol. 6, no. 10, pp. 5023–5045, 2013, doi: 10.3390/en6105023.

[36] N. Rastogi and M. K. Trivedi, "Pestle Technique-a Tool To Identify External Risks in Construction Projects," *Int. Res. J. Eng. Technol.*, vol. 3, no. 1, pp. 384–388, 2016.

[37] K. Pourmohammadi, P. Bastani, P. Shojaei, N. Hatam, and A. Salehi, "A comprehensive environmental scanning and strategic analysis of Iranian Public Hospitals: A prospective approach," *BMC Res. Notes*, vol. 13, no. 1, pp. 1–7, 2020, doi: 10.1186/s13104-020-05002-8.

[38] C. Zalengera, R. E. Blanchard, P. C. Eames, A. M. Juma, M. L. Chitawo, and K. T. Gondwe, "Overview of the Malawi energy situation and A PESTLE analysis for sustainable development of renewable energy," *Renew. Sustain. Energy Rev.*, vol. 38, pp. 335–347, 2014, doi: 10.1016/j.rser.2014.05.050.

[39] Z. Srdjevic, R. Bajcetic, and B. Srdjevic, "Identifying the Criteria Set for Multicriteria Decision Making Based on SWOT/PESTLE Analysis: A Case Study of Reconstructing

A Water Intake Structure," *Water Resour. Manag.*, vol. 26, no. 12, pp. 3379–3393, 2012, doi: 10.1007/s11269-012-0077-2.

[40] R. Sridhar *et al.*, "A Political, Economic, Social, Technological, Legal and Environmental (PESTLE) approach for assessment of coastal zone management practice in India," *Int. Rev. Public Adm.*, vol. 21, no. 3, pp. 216–232, 2016, doi: 10.1080/12294659.2016.1237091.

[41] H. Fosher, "Understanding the Marketing and Management of Trails Using Pestel Analysis," vol. 1183, p. 1-37, 2018, [Online]. Available: https://scholars.unh.edu/cgi/viewcontent.cgi?article=2182&context=thesis

[42] E. KARA, "A Contemporary Approach For Strategic Management in Tourism Sector: PESTEL Analysis on The City Muğla, Turkey," *J. Bus. Res. - Turk*, vol. 10, no. 2, pp. 598–608, 2018, doi: 10.20491/isarder.2018.446.

[43] L. M. Hager, "Bureaucratic Corruption in India Legal Control of Maladministration," *Comp. Polit. Stud.*, vol. 6, no. 2, pp. 197–219, 1973.

[44] S. Kumar and L. Thacker-Kumar, "Investing in India: Strategies for tackling bureaucratic hurdles," *Bus. Horiz.*, vol. 39, no. 1, pp. 10–16, 1996, doi: 10.1016/S0007-6813(96)90077-4.

[45] F. Pattanaik and N. C. Nayak, "Economic freedom and economic growth in India: What is the empirical relationship?," *Econ. Chang. Restruct.*, vol. 47, no. 4, pp. 275–298, 2014, doi: 10.1007/s10644-014-9150-6.

[46] R. Nirmala, "Politics in India: At a Glance: A Study of Indian Political System and Elections," vol. 7, no. 12, pp. 1–17, 2018, [Online]. Available: www.ijhssi.org.

[47] J. Borkakoti, "Democratic deficits in Indian political system," *Sp. Cult. India*, vol. 3, no. 3, pp. 1–4, 2016, doi: 10.20896/saci.v3i3.179.

[48] Y. Feng, "Democracy, political stability and economic growth," *Br. J. Polit. Sci.*, vol. 27, no. 3, pp. 391–418, 1997, doi: 10.1017/S0007123497000197.

[49] Rrr. K. Altun, "The Effect of Political Stability and Governance on Economic Development," *SSRN Electron. J.*, no. 4021525, 2018, doi: 10.2139/ssrn.2948652.

[50] A. Mehta, "Internal (In) Security in India Challenges and Responses," no. May, 2017.

[51] N. Manoharan, "India's Internal Security Situation: Threats and Responses," *India Q.*, vol. 69, no. 4, pp. 367–381, 2013, doi: 10.1177/0974928413503748.

[52] E. Doldor, "From Politically Naïve to Politically Mature: Conceptualizing Leaders' Political Maturation Journey," *Br. J. Manag.*, vol. 28, no. 4, pp. 666–686, 2017, doi: 10.1111/1467-8551.12219.

[53] M. Asrar-ul-Haq and S. Anwar, "The many faces of leadership: Proposing research

agenda through a review of literature," *Futur. Bus. J.*, vol. 4, no. 2, pp. 179–188, 2018, doi: 10.1016/j.fbj.2018.06.002.

[54] D. Scott, "India's 'Extended Neighborhood' Concept: Power Projection for a Rising Power," *India Rev.*, vol. 8, no. 2, pp. 107–143, 2009, doi: 10.1080/14736480902901038.

[55] S. S. Pattanaik, "India's neighbourhood policy: Perceptions from Bangladesh," *Strateg. Anal.*, vol. 35, no. 1, pp. 71–87, 2011, doi: 10.1080/09700161.2011.530985.

[56] M. Singh *et al.*, "A Study for Comparing Salaries/ Emoluments in the Government Sector vis-à-vis Central Public Sector Undertakings/ Private Sector in India Study Commissioned by the Seventh Central Pay Commission constituted by the Government of India Indian Institute of M," no. August 2016, 2015.

[57] J. P. Bist, "Financial development and economic growth: Evidence from a panel of 16 African and non-African low-income countries," *Cogent Econ. Financ.*, vol. 6, no. 1, 2018, doi: 10.1080/23322039.2018.1449780.

[58] R. Mukherji, "The State, Economic Growth, and Development in India," *India Rev.*, vol. 8, no. 1, pp. 81–106, 2009, doi: 10.1080/14736480802665238.

[59] L. Das and R. Raut, "Impact of Changes in Service Sector in India in Shaping the Future of Business & Society," *Procedia Econ. Financ.*, vol. 11, no. 14, pp. 795–803, 2014, doi: 10.1016/s2212-5671(14)00243-3.

[60] S. V. Conceição, L. H. P. Pedrosa, A. S. C. Neto, M. Vinagre, and E. Wolff, "The facility location problem in the steel industry: A case study in Latin America," *Prod. Plan. Control*, vol. 23, no. 1, pp. 26–46, 2012, doi: 10.1080/09537287.2010.539991.

[61] M. Eterovic and S. Özgül, "Study of a Country Level Facility LocationSelection for a Small Company," 2012, [Online]. Available: http://www.diva-portal.org/smash/record.jsf?pid=diva2%3A628743&dswid=4887.

[62] B. L. MacCarthy and W. Atthirawong, "Factors affecting location decisions in international operations - A Delphi study," *Int. J. Oper. Prod. Manag.*, vol. 23, no. 7–8, pp. 794–818, 2003, doi: 10.1108/01443570310481568.

[63] M. G. Ashtiani, "Competitive location: A state-of-art review," *Int. J. Ind. Eng. Comput.*, vol. 7, no. 1, pp. 1–18, 2016, doi: 10.5267/j.ijiec.2015.8.002.

[64] B. L. MacCarthy and W. Atthirawong, *Factors affecting location decisions in international operations - A Delphi study*, vol. 23, no. 7–8. 2003.

[65] J. G. Kowalski and C. C. Paraskevopoulos, "The impact of location on urban industrial land prices," *J. Urban Econ.*, vol. 27, no. 1, pp. 16–24, 1990, doi: 10.1016/0094-1190(90)90021-E.

[66] R. Qiu, W. Xu, and J. Zhang, "The transformation of urban industrial land use: A quantitative method," *J. Urban Manag.*, vol. 4, no. 1, pp. 40–52, 2015, doi: 10.1016/j.jum.2015.07.001.

[67] F. Y. Partovi, "An analytic model for locating facilities strategically," *Omega*, vol. 34, no. 1, pp. 41–55, 2006, doi: 10.1016/j.omega.2004.07.018.

[68] S. K. Reddy and S. L. Holak, "The effects of market structure characteristics on competitive reaction intensity: A longitudinal analysis," *Mark. Lett.*, vol. 2, no. 3, pp. 293–308, 1991, doi: 10.1007/BF02404079.

[69] S. Sarkar, "The parallel economy in India: causes, impacts and governement initiatives," *Econ. J. Dev. Issues*, vol. 11, no. 1, pp. 124–134, 2012, doi: 10.3126/ejdi.v11i0.6111.

[70] R. Gujrati, "Causes and Remedies of Parallel Economy in India," no. May, 2019, [Online]. Available: https://www.researchgate.net/publication/333131511.

[71] P. Menon, "The rise of the shadow economy: An Indian perspective," *J. Public Aff.*, vol. 19, no. 1, pp. 1–7, 2019, doi: 10.1002/pa.1880.

[72] A. G. Mulky, "Distribution challenges and workable solutions," *IIMB Manag. Rev.*, vol. 25, no. 3, pp. 179–195, 2013, doi: 10.1016/j.iimb.2013.06.011.

[73] F. Ciari, M. Löchl, and K. W. Axhausen, "Location Decisions of Retailers : An Agent-Based Approach," *15th Int. Conf. Recent Adv. Retail. Serv. Sci.*, no. July, pp. 1–34, 2008.

[74] K. Abhishek and S. Lav, "Biotechnology industry in India: Opportunities or challenges," *African J. Bus. Manag.*, vol. 6, no. 44, pp. 10834–10839, 2012, doi: 10.5897/ajbm10.1236.

[75] N. M. Agrawal, R. Pandit, and D. Menon, "Strategy to usher in the next phase of growth in the Indian IT industry," *IIMB Manag. Rev.*, vol. 24, no. 3, pp. 164–179, 2012, doi: 10.1016/j.iimb.2012.06.001.

[76] M. Sagar and D. Singh, "Supplier Selection Criteria: Study of Automobile Sector in India," *Int. J. Eng. Res. Dev.*, vol. 4, no. 4, pp. 34–39, 2012, [Online]. Available: http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Supplier+Selection+Criteria+:+Study+of+Automobile+Sector+in+India#0.

[77] D. Wheeler and A. Mody, "International investment location decisions. The case of U.S. firms," *J. Int. Econ.*, vol. 33, no. 1–2, pp. 57–76, 1992, doi: 10.1016/0022-1996(92)90050-T.

[78] A. Izadi, M. Nabipour, and O. Titidezh, "Cost Models and Cost Factors of Road Freight Transportation: A Literature Review and Model Structure," *Fuzzy Inf. Eng.*,

vol. 00, no. 0, pp. 1–21, 2020, doi: 10.1080/16168658.2019.1688956.

[79] R. M. Potluri and S. P. Tejaswi, "Challenges of transport sector in India: A dyadic perspective," *J. Asian Financ. Econ. Bus.*, vol. 5, no. 3, pp. 95–102, 2018, doi: 10.13106/jafeb.2018.vol5.no3.95.

[80] M. Fulton and L. C. Hoch, "Transportation Factors Affecting Locational Decisions," *Econ. Geogr.*, vol. 35, no. 1, p. 51, 1959, doi: 10.2307/142078.

[81] R. K. Singh, N. Chaudhary, and N. Saxena, "Selection of warehouse location for a global supply chain: A case study," *IIMB Manag. Rev.*, vol. 30, no. 4, pp. 343–356, 2018, doi: 10.1016/j.iimb.2018.08.009.

[82] M. Kchaou Boujelben and Y. Boulaksil, "Modeling international facility location under uncertainty: A review, analysis, and insights," *IISE Trans.*, vol. 50, no. 6, pp. 535–551, 2018, doi: 10.1080/24725854.2017.1408165.

[83] J. Ko, "Solving a distribution facility location problem using an analytic hierarchy process approach," *Int. Symp. Anal. Hierarchy Process 2005*, p. 6, 2005, [Online]. Available: http://www.isahp.org/2005Proceedings/Papers/KoJ_Distribution_Facility.pdf.

[84] A. Dixit, C. Clouse, and N. Turken, "Strategic Business Location Decisions: Importance of Economic Factors and Place Image," *Rutgers Bus. Rev.*, vol. 4, no. 1, pp. 73–91, 2019.

[85] D. Shankar, "Developing Countries' Foreign Direct Investment and Portfolio," *OECD Glob. Forum Int. Dev.*, pp. 1–48, 2008, [Online]. Available: https://lra.le.ac.uk/bitstream/2381/38031/1/2016KhayatSHAPhD.pdf.

[86] M. Ketokivi, V. Turkulainen, T. Seppälä, P. Rouvinen, and J. Ali-Yrkkö, "Why locate manufacturing in a high-cost country? A case study of 35 production location decisions," *J. Oper. Manag.*, vol. 49–51, pp. 20–30, 2017, doi: 10.1016/j.jom.2016.12.005.

[87] D. Jain, K. Nair, and V. Jain, "Factors Affecting GDP (Manufacturing, Services, Industry): An Indian Perspective," *Annu. Res. J. SCMS Pune*, vol. 3, no. April 2015, pp. 38–56, 2015.

[88] Y. Neog, "Structural Shift in Components of Indian GDP : An Empirical Structural Shift in Components of Indian GDP : An Empirical Analysis," no. December 2017, 2018.

[89] D. Fornahl, A. Schaffer, and J. Siegele, "Regional per Capita-Income — The Importance of Region-Specific Production Factors," *Swiss J. Econ. Stat.*, vol. 145, no. 2, pp. 155–185, 2009, doi: 10.1007/bf03399279.

[90] S. A. Rizwan, B. Nongkynrih, and S. K. Gupta, "Air pollution in Delhi: Its Magnitude and Effects on Health," *Indian J. Community Med.*, vol. 38, no. 1, pp. 4–8, 2013, doi: 10.4103/0970-0218.106617.

[91] M. Pascal *et al.*, "A review of the epidemiological methods used to investigate the health impacts of air pollution around major industrial areas," *J. Environ. Public Health*, vol. 2013, 2013, doi: 10.1155/2013/737926.

[92] R. Starley, "Blind faith in bad leaders," *The salt Lake Tribune*, 2006. https://archive.sltrib.com/story.php?ref=/opinion/ci_3626051 (accessed Jan. 15, 2017).

[93] S. Modh and M. Studies, "Comparing leadership styles of Mr Narendra Modi and Dr Manmohan Singh," no. October, 2015, doi: 10.13140/RG.2.1.2430.0242.

[94] J. X. Fan and M. Abdel-Ghany, "Patterns of spending behavior and the relative position in the income distribution: Some empirical evidence," *J. Fam. Econ. Issues*, vol. 25, no. 2, pp. 163–178, 2004, doi: 10.1023/B:JEEI.0000023636.75717.61.

[95] J. A. Parker, N. S. Souleles, D. S. Johnson, and R. McClelland, "Consumer spending and the economic stimulus payments of 2008," *Am. Econ. Rev.*, vol. 103, no. 6, pp. 2530–2553, 2013, doi: 10.1257/aer.103.6.2530.

[96] Y. A. Sheikh, "Higher Education in India, Challenges and Opportunities," *J. Educ. Pract.*, vol. 8, no. 1, pp. 39–42, 2017.

[97] P. J. Boruah, "A Study On Availability Of Educational Facilities For The Teachers And Students In Primary Schools With Special Reference To Nazira Sub-Division Of Sibsagar District Of Assam," vol. 5, no. 4, pp. 960–963, 2017.

[98] A. Blom and H. Saeki, "Employability and Skill Set of Newly Graduated Engineers in India," *IUP J. Soft Ski.*, no. 4, pp. 7–50, 2011.

[99] M. Khare, "Employment, Employability and Higher Education in India," *High. Educ. Futur.*, vol. 1, no. 1, pp. 39–62, 2014, doi: 10.1177/2347631113518396.

[100] M. K. J. Abdullah Sani, M. Zailan Endin, M. Noorman Masre, N. Z. Sahid, J. Baba, and Y. Kamis, "Integrity and Job Performance: The Experiences of Public Library Leaders," *J. Southeast Asian Res.*, no. June 2017, pp. 1–15, 2016, doi: 10.5171/2016.452256.

[101] D. V. L. Sati, "Make in India: Role of Professional Ethics," *Int. J. Sci. Res.*, vol. 5, no. 12, pp. 987–989, 2016, [Online]. Available: https://www.ijsr.net/archive/v5i12/ART20162394.pdf.

[102] N. D. Aghera, "Sociology A Study of Workplace Hazards Faced by Workers in Textile Industry as a Part of Occupational Health and Safety," *Indian J. Res.*, vol. 2, no. 4, pp. 333–334, 2013.

[103] P. K. Sethi and D. Khandelwal, "Cadmium exposure: health hazards of silver cottage industry in developing countries.," *J. Med. Toxicol.*, vol. 2, no. 1, pp. 14–15, 2006, doi: 10.1007/BF03161007.

[104] D. P. Tripathy and C. K. Ala, "Identification of safety hazards in Indian underground coal mines," *J. Sustain. Min.*, vol. 17, no. 4, pp. 175–183, 2018, doi: 10.1016/j.jsm.2018.07.005.

[105] P. Staniland, "Internal security strategy in India," *India Rev.*, vol. 17, no. 1, pp. 142–158, 2018, doi: 10.1080/14736489.2018.1415287.

[106] G. Pillai, "ISAS Insights India: Towards a Knowledge Superpower? – A View from Outside," no. 28, pp. 1–16, 2008, [Online]. Available: https://www.files.ethz.ch/isn/55901/29.pdf.

[107] S. Bhattacharya, "Knowledge economy in India: Challenges and opportunities," *J. Inf. Knowl. Manag.*, vol. 9, no. 3, pp. 203–225, 2010, doi: 10.1142/S0219649210002620.

[108] S. S. Verick, "The Puzzles and Contradictions of the Indian Labour Market : What Will the Future of Work Look Like ?," *IMF WOrld Economic Outlook*, 2018.

[109] S. K. Bhar, N. Azlah, A. Bakar, and C. Y. Eng, "Language barriers: feedback from the IT industry," *J. Tech. Educ. Train.*, vol. 4, no. 2, pp. 9–20, 2012.

[110] Jones Kerry, "The Most Desirable Employee Benefits," *Harv. Bus. Rev.*, pp. 2–7, 2017, [Online]. Available: https://hbr.org/2017/02/the-most-desirable-employee-benefits.

[111] O.-I. Dobre, "Employee motivation and organisational performance," *Rev. Appl. Socio Econ. Res.*, vol. 5, no. 1, p. 53, 2013, doi: 10.1007/s11668-018-0520-7.

[112] A. Ali, L. Z. Bin, H. J. Piang, and Z. Ali, "The Impact of Motivation on the Employee Performance and Job Satisfaction in IT Park (Software House) Sector of Peshawar, Pakistan," *Int. J. Acad. Res. Bus. Soc. Sci.*, vol. 6, no. 9, pp. 297–310, 2016, doi: 10.6007/ijarbss/v6-i9/2311.

[113] O. Robescu and A.-G. Iancu, "The Effects of Motivation on Employees Performance in Organizations," *Valahian J. Econ. Stud.*, vol. 7, no. 2, pp. 49–56, 2016, doi: 10.1515/vjes-2016-0006.

[114] R. H. Dehejia and V. H. Dehejia, "Religion and Economic Activity in India: An Historical Perspective," *Am. J. Econ. Sociol.*, vol. 52, no. 2, pp. 145–153, 1993, doi: 10.1111/j.1536-7150.1993.tb02524.x.

[115] B. P. Mathur, "Rethinking Development: India's Cultural Ethos as Foundation," *Indian J. Public Adm.*, vol. 65, no. 1, pp. 29–44, 2019, doi: 10.1177/0019556118822023.

[116] K. R. Shyam Sundar, "Trade unions in India: From politics of fragmentation to politics of expansion and integration?," *Trade Unions Asia An Econ. Sociol. Anal.*, no.

February, pp. 157–176, 2008, doi: 10.4324/9780203926499.

[117] M. Dhal, "India Trade Union Strategy and Responses to Changes in Employment Structure and Forms in India," *Japan Labor Issues*, vol. 2, no. 8, pp. 101–108, 2018.

[118] S. Saran and A. D. Shirodkar, "Vastu Shastra And Feng Shui The Ancient Sciences And Their Fusion In Context Of Indian Architecture," *Int. J. Sci. Technol. Res.*, vol. 6, no. 11, pp. 136–144, 2017.

[119] N. Antara, "Utility of the Ancient Indian Science of Vaastu in Modern Architecture," *J. Civ. Eng. Environ. Sci.*, vol. 3, pp. 008–012, 2017, doi: 10.17352/2455-488x.000014.

[120] P. A. Owusu and S. Asumadu-Sarkodie, "A review of renewable energy sources, sustainability issues and climate change mitigation," *Cogent Eng.*, vol. 3, no. 1, 2016, doi: 10.1080/23311916.2016.1167990.

[121] S. Turhan, B. C. Ozbag, and B. Cetin, "Factors affecting location decisions of food processing plants," *Journal of Applied Sciences*, vol. 7, no. 13. pp. 1734–1740, 2007, doi: 10.3923/jas.2007.1734.1740.

[122] D. A. Richardson, S. De Leeuw, and W. Dullaert, "Factors Affecting Global Inventory Prepositioning Locations in Humanitarian Operations - A Delphi Study," *J. Bus. Logist.*, vol. 37, no. 1, pp. 59–74, 2016, doi: 10.1111/jbl.12112.

[123] H. Sahin and B. Topal, "The Effect of the use of Information Technologies in Businesses on Cost and Financial Performance," *Int. J. Eng. Innov. Res.*, vol. 5, no. December, pp. 394–402, 2016.

[124] J. Bessen, "Technology adoption costs and productivity growth: The transition to information technology," *Rev. Econ. Dyn.*, vol. 5, no. 2, pp. 443–469, 2002, doi: 10.1006/redy.2001.0152.

[125] S. Mitra and A. K. Chaya, "Analyzing Cost-Effectiveness of Organizations: The Impact of Information Technology Spending," *J. Manag. Inf. Syst.*, vol. 13, no. 2, pp. 29–57, 1996, doi: 10.1080/07421222.1996.11518122.

[126] V. Thumawongchai and L. Huang, "Models and factors used for production location decisions: a review and categorizing framework," p. 86, 2011.

[127] Y. Kathawala and H. Gholamnezhad, "New approach to facility locations decisions," *Int. J. Syst. Sci.*, vol. 18, no. 2, pp. 389–402, 1987, doi: 10.1080/00207728708963974.

[128] R. K. Kumar, "Technology and healthcare costs," *Ann. Pediatr. Cardiol.*, vol. 4, no. 1, pp. 84–86, 2011, doi: 10.4103/0974-2069.79634.

[129] J. Fagerberg, "Technological and International Differences in Growth Rates," *J. Econ. Lit.*, vol. 32, no. 3, pp. 1147–1175, 1994.

[130] S. M. T. Rahman and A. Kabir, "Factors influencing location choice and cluster pattern

of manufacturing small and medium enterprises in cities: evidence from Khulna City of Bangladesh," *J. Glob. Entrep. Res.*, vol. 9, no. 1, 2019, doi: 10.1186/s40497-019-0187-x.

[131] H. Vlachou and O. Iakovidou, "The journey of business location factors through years: a literature review.," *Proc. Annu. South-East Eur. Dr. Student Conf.*, pp. 188–221, 2013, [Online]. Available: http://0-search.ebscohost.com.innopac.wits.ac.za/login.aspx?direct=true&db=asn&AN=92952702&site=ehost-live&scope=site.

[132] M. A. Badri, "A multicriteria approach to global facility location-allocation problem," *Int. J. Inf. Manag. Sci.*, vol. 7, no. 3, pp. 1–19, 1996.

[133] J. Luo, D. Roos, and J. Moavenzadeh, "The Impact of Government Policies on Industrial Evolution: The Case of China's Automotive Industry," *SSRN Electron. J.*, no. August 2006, 2011, doi: 10.2139/ssrn.1431350.

[134] K. E. Mohamed Elderjy, D. Hamid, and H. N. Utami, "The Analysis of Plant Location Effectiveness the Study of Sarir Gas Turbine 855 Mw Project Site at General Electric Company of Libya," *IOSR J. Bus. Manag.*, vol. 16, no. 10, pp. 49–55, 2014, doi: 10.9790/487x-161014955.

[135] M. Abe and L. Ye, "Building Resilient Supply Chains against Natural Disasters: The Cases of Japan and Thailand," *Glob. Bus. Rev.*, vol. 14, no. 4, pp. 567–586, 2013, doi: 10.1177/0972150913501606.

[136] F. Chari and B. S. Ngcamu, "An assessment of the impact of disaster risks on dairy supply chain performance in Zimbabwe," *Cogent Eng.*, vol. 4, no. 1, pp. 1–14, 2017, doi: 10.1080/23311916.2017.1409389.

[137] S. Ahuti, "Industrial Growth and Environmental Degredation," *Environ. Sci.*, vol. 1, no. 5, pp. 5–7, 2015.

[138] C. E. Gundogdu, "Selection of facility location under environmental damage priority and using ELECTRE method," *J. Environ. Biol.*, vol. 32, no. 2, pp. 221–226, 2011.

[139] R. Patnaik, "Impact of Industrialization on Environment and Sustainable Solutions - Reflections from a South Indian Region," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 120, no. 1, pp. 0–8, 2018, doi: 10.1088/1755-1315/120/1/012016.

[140] D. P. Dupont and S. Renzetti, "The role of water in manufacturing," *Environ. Resour. Econ.*, vol. 18, no. 4, pp. 411–432, 2001, doi: 10.1023/A:1011117319932.

[141] M. Kummu *et al.*, "The world's road to water scarcity: Shortage and stress in the 20th century and pathways towards sustainability," *Sci. Rep.*, vol. 6, no. May, pp. 1–16, 2016, doi: 10.1038/srep38495.

[142] B. C. Balusa and A. K. Gorai, "Sensitivity analysis of fuzzy-analytic hierarchical process (FAHP) decision-making model in selection of underground metal mining method," *J. Sustain. Min.*, vol. 18, no. 1, pp. 8–17, 2019, doi: 10.1016/j.jsm.2018.10.003.

[143] E. B. Beşikçi, T. Kececi, O. Arslan, and O. Turan, "An application of fuzzy-AHP to ship operational energy efficiency measures," *Ocean Eng.*, vol. 121, pp. 392–402, 2016, doi: 10.1016/j.oceaneng.2016.05.031.

[144] K. A. Bian, "Application of fuzzy AHP and ELECTRE to China dry port location selection," *Asian J. Shipp. Logist.*, vol. 27, no. 2, pp. 331–353, 2011, doi: 10.1016/S2092-5212(11)80015-5.

[145] F. T. Bozbura, A. Beskese, and C. Kahraman, "Prioritization of human capital measurement indicators using fuzzy AHP," *Expert Syst. Appl.*, vol. 32, no. 4, pp. 1100–1112, 2007, doi: 10.1016/j.eswa.2006.02.006.

[146] F. T. Bozbura and A. Beskese, "Prioritization of organizational capital measurement indicators using fuzzy AHP," *Int. J. Approx. Reason.*, vol. 44, no. 2, pp. 124–147, 2007, doi: 10.1016/j.ijar.2006.07.005.

[147] S. Butdee and P. Phuangsalee, "Uncertain risk assessment modelling for bus body manufacturing supply chain using AHP and fuzzy AHP," *Procedia Manuf.*, vol. 30, pp. 663–670, 2019, doi: 10.1016/j.promfg.2019.02.094.

[148] G. Büyüközkan and G. Çifçi, "A combined fuzzy AHP and fuzzy TOPSIS based strategic analysis of electronic service quality in healthcare industry," *Expert Syst. Appl.*, vol. 39, no. 3, pp. 2341–2354, 2012, doi: 10.1016/j.eswa.2011.08.061.

[149] G. Büyüközkan, G. Çifçi, and S. Güleryüz, "Strategic analysis of healthcare service quality using fuzzy AHP methodology," *Expert Syst. Appl.*, vol. 38, no. 8, pp. 9407–9424, 2011, doi: 10.1016/j.eswa.2011.01.103.

[150] A. Calabrese, R. Costa, and T. Menichini, "Using Fuzzy AHP to manage Intellectual Capital assets: An application to the ICT service industry," *Expert Syst. Appl.*, vol. 40, no. 9, pp. 3747–3755, 2013, doi: 10.1016/j.eswa.2012.12.081.

[151] A. Calabrese, R. Costa, N. Levialdi, and T. Menichini, "Integrating sustainability into strategic decision-making: A fuzzy AHP method for the selection of relevant sustainability issues," *Technol. Forecast. Soc. Change*, vol. 139, no. March, pp. 155–168, 2019, doi: 10.1016/j.techfore.2018.11.005.

[152] U. Cebeci, "Fuzzy AHP-based decision support system for selecting ERP systems in textile industry by using balanced scorecard," *Expert Syst. Appl.*, vol. 36, no. 5, pp. 8900–8909, 2009, doi: 10.1016/j.eswa.2008.11.046.

[153] I. Chamodrakas, D. Batis, and D. Martakos, "Supplier selection in electronic marketplaces using satisficing and fuzzy AHP," *Expert Syst. Appl.*, vol. 37, no. 1, pp. 490–498, 2010, doi: 10.1016/j.eswa.2009.05.043.

[154] C. H. Cheng, "Evaluating naval tactical missile systems by fuzzy AHP based on the grade value of membership function," *Eur. J. Oper. Res.*, vol. 96, no. 2, pp. 343–350, 1997, doi: 10.1016/S0377-2217(96)00026-4.

[155] J. Cho and J. Lee, "Development of a new technology product evaluation model for assessing commercialization opportunities using Delphi method and fuzzy AHP approach," *Expert Syst. Appl.*, vol. 40, no. 13, pp. 5314–5330, 2013, doi: 10.1016/j.eswa.2013.03.038.

[156] M. Dağdeviren and I. Yüksel, "Developing a fuzzy analytic hierarchy process (AHP) model for behavior-based safety management," *Inf. Sci. (Ny).*, vol. 178, no. 6, pp. 1717–1733, 2008, doi: 10.1016/j.ins.2007.10.016.

[157] S. Dožić, T. Lutovac, and M. Kalić, "Fuzzy AHP approach to passenger aircraft type selection," *J. Air Transp. Manag.*, vol. 68, pp. 165–175, 2018, doi: 10.1016/j.jairtraman.2017.08.003.

[158] O. Durán, "Computer-aided maintenance management systems selection based on a fuzzy AHP approach," *Adv. Eng. Softw.*, vol. 42, no. 10, pp. 821–829, 2011, doi: 10.1016/j.advengsoft.2011.05.023.

[159] H. P. Fu, P. Chao, T. H. Chang, and Y. S. Chang, "The impact of market freedom on the adoption of third-party electronic marketplaces: A fuzzy AHP analysis," *Ind. Mark. Manag.*, vol. 37, no. 6, pp. 698–712, 2008, doi: 10.1016/j.indmarman.2007.07.001.

[160] S. Gold and A. Awasthi, "Sustainable global supplier selection extended towards sustainability risks from (1+n)th tier suppliers using fuzzy AHP based approach," *IFAC-PapersOnLine*, vol. 28, no. 3, pp. 966–971, 2015, doi: 10.1016/j.ifacol.2015.06.208.

[161] Z. Güngör, G. Serhadlioğlu, and S. E. Kesen, "A fuzzy AHP approach to personnel selection problem," *Appl. Soft Comput. J.*, vol. 9, no. 2, pp. 641–646, 2009, doi: 10.1016/j.asoc.2008.09.003.

[162] S. Gupta, U. Soni, and G. Kumar, "Green supplier selection using multi-criterion decision making under fuzzy environment: A case study in automotive industry," *Comput. Ind. Eng.*, vol. 136, pp. 663–680, 2019, doi: 10.1016/j.cie.2019.07.038.

[163] E. Heo, J. Kim, and K. J. Boo, "Analysis of the assessment factors for renewable energy dissemination program evaluation using fuzzy AHP," *Renew. Sustain. Energy Rev.*, vol. 14, no. 8, pp. 2214–2220, 2010, doi: 10.1016/j.rser.2010.01.020.

[164] W. Ho, T. He, C. K. M. Lee, and A. Emrouznejad, "Strategic logistics outsourcing: An integrated QFD and fuzzy AHP approach," *Expert Syst. Appl.*, vol. 39, no. 12, pp. 10841–10850, 2012, doi: 10.1016/j.eswa.2012.03.009.

[165] E. Ilbahar, A. Karaşan, S. Cebi, and C. Kahraman, "A novel approach to risk assessment for occupational health and safety using Pythagorean fuzzy AHP & fuzzy inference system," *Saf. Sci.*, vol. 103, no. October 2017, pp. 124–136, 2018, doi: 10.1016/j.ssci.2017.10.025.

[166] M. T. Isaai, A. Kanani, M. Tootoonchi, and H. R. Afzali, "Intelligent timetable evaluation using fuzzy AHP," *Expert Syst. Appl.*, vol. 38, no. 4, pp. 3718–3723, 2011, doi: 10.1016/j.eswa.2010.09.030.

[167] A. Ishizaka and N. H. Nguyen, "Calibrated fuzzy AHP for current bank account selection," *Expert Syst. Appl.*, vol. 40, no. 9, pp. 3775–3783, 2013, doi: 10.1016/j.eswa.2012.12.089.

[168] P. Jaskowski, S. Biruk, and R. Bucon, "Assessing contractor selection criteria weights with fuzzy AHP method application in group decision environment," *Autom. Constr.*, vol. 19, no. 2, pp. 120–126, 2010, doi: 10.1016/j.autcon.2009.12.014.

[169] H. M. M. M. Jayawickrama, A. K. Kulatunga, and S. Mathavan, "Fuzzy AHP based Plant Sustainability Evaluation Method," *Procedia Manuf.*, vol. 8, no. October 2016, pp. 571–578, 2017, doi: 10.1016/j.promfg.2017.02.073.

[170] S. Kaganski, J. Majak, and K. Karjust, "Fuzzy AHP as a tool for prioritization of key performance indicators," *Procedia CIRP*, vol. 72, pp. 1227–1232, 2018, doi: 10.1016/j.procir.2018.03.097.

[171] K. Kamvysi, K. Gotzamani, A. Andronikidis, and A. C. Georgiou, "Capturing and prioritizing students' requirements for course design by embedding Fuzzy-AHP and linear programming in QFD," *Eur. J. Oper. Res.*, vol. 237, no. 3, pp. 1083–1094, 2014, doi: 10.1016/j.ejor.2014.02.042.

[172] H. Y. Kang and A. H. I. Lee, "Priority mix planning for semiconductor fabrication by fuzzy AHP ranking," *Expert Syst. Appl.*, vol. 32, no. 2, pp. 560–570, 2007, doi: 10.1016/j.eswa.2006.01.035.

[173] A. Keprate and R. M. C. Ratnayake, "Enhancing offshore process safety by selecting fatigue critical piping locations for inspection using Fuzzy-AHP based approach," *Process Saf. Environ. Prot.*, vol. 102, pp. 71–84, 2016, doi: 10.1016/j.psep.2016.02.013.

[174] A. A. Khan, M. Shameem, R. R. Kumar, S. Hussain, and X. Yan, "Fuzzy AHP based prioritization and taxonomy of software process improvement success factors in global

software development," *Appl. Soft Comput. J.*, vol. 83, p. 105648, 2019, doi: 10.1016/j.asoc.2019.105648.

[175] J. Kim, J. Lee, B. C. Kim, and J. Kim, "Raw material criticality assessment with weighted indicators: An application of fuzzy analytic hierarchy process," *Resour. Policy*, vol. 60, no. December 2018, pp. 225–233, 2019, doi: 10.1016/j.resourpol.2019.01.005.

[176] V. B. Kreng and C. Y. Wu, "Evaluation of knowledge portal development tools using a fuzzy AHP approach: The case of Taiwanese stone industry," *Eur. J. Oper. Res.*, vol. 176, no. 3, pp. 1795–1810, 2007, doi: 10.1016/j.ejor.2005.10.052.

[177] R. J. Kuo, S. C. Chi, and S. S. Kao, "Decision support system for locating convenience store through fuzzy AHP," *Comput. Ind. Eng.*, vol. 37, no. 1, pp. 323–326, 1999, doi: 10.1016/S0360-8352(99)00084-4.

[178] S. H. Lee, "Using fuzzy AHP to develop intellectual capital evaluation model for assessing their performance contribution in a university," *Expert Syst. Appl.*, vol. 37, no. 7, pp. 4941–4947, 2010, doi: 10.1016/j.eswa.2009.12.020.

[179] S. Lee, G. Mogi, S. Lee, and J. Kim, "Prioritizing the weights of hydrogen energy technologies in the sector of the hydrogen economy by using a fuzzy AHP approach," *Int. J. Hydrogen Energy*, vol. 36, no. 2, pp. 1897–1902, 2011, doi: 10.1016/j.ijhydene.2010.01.035.

[180] Y. Li, "AHP-Fuzzy Evaluation on Financing Bottleneck in Energy Performance Contracting in China," *Energy Procedia*, vol. 14, pp. 121–126, 2012, doi: 10.1016/j.egypro.2011.12.887.

[181] M. Ligus and P. Peternek, "Determination of most suitable low-emission energy technologies development in Poland using integrated fuzzy AHP-TOPSIS method," *Energy Procedia*, vol. 153, pp. 101–106, 2018, doi: 10.1016/j.egypro.2018.10.046.

[182] F. R. Lima Junior, L. Osiro, and L. C. R. Carpinetti, "A comparison between Fuzzy AHP and Fuzzy TOPSIS methods to supplier selection," *Appl. Soft Comput. J.*, vol. 21, pp. 194–209, 2014, doi: 10.1016/j.asoc.2014.03.014.

[183] H. F. Lin, "An application of fuzzy AHP for evaluating course website quality," *Comput. Educ.*, vol. 54, no. 4, pp. 877–888, 2010, doi: 10.1016/j.compedu.2009.09.017.

[184] Y. F. Lo and M. H. Wen, "A fuzzy-ahp-based technique for the decision of design feature selection in massively multiplayer online role-playing game development," *Expert Syst. Appl.*, vol. 37, no. 12, pp. 8685–8693, 2010, doi: 10.1016/j.eswa.2010.06.059.

[185] P. T. M. Ly, W. H. Lai, C. W. Hsu, and F. Y. Shih, "Fuzzy AHP analysis of Internet of Things (IoT) in enterprises," *Technol. Forecast. Soc. Change*, vol. 136, no. April, pp. 1–13, 2018, doi: 10.1016/j.techfore.2018.08.016.

[186] K. Mandic, B. Delibasic, S. Knezevic, and S. Benkovic, "Analysis of the financial parameters of Serbian banks through the application of the fuzzy AHP and TOPSIS methods," *Econ. Model.*, vol. 43, pp. 30–37, 2014, doi: 10.1016/j.econmod.2014.07.036.

[187] S. K. Mangla, P. Kumar, and M. K. Barua, "Resources , Conservation and Recycling Risk analysis in green supply chain using fuzzy AHP approach : A case study," *Resour. Conserv. Recycl.*, vol. 104, pp. 375–390, 2015.

[188] A. Moktadir, T. Rahman, C. J. C. Jabbour, S. Mithun Ali, and G. Kabir, "Prioritization of drivers of corporate social responsibility in the footwear industry in an emerging economy: A fuzzy AHP approach," *J. Clean. Prod.*, vol. 201, pp. 369–381, 2018, doi: 10.1016/j.jclepro.2018.07.326.

[189] B. Nepal, O. P. Yadav, and A. Murat, "A fuzzy-AHP approach to prioritization of CS attributes in target planning for automotive product development," *Expert Syst. Appl.*, vol. 37, no. 10, pp. 6775–6786, 2010, doi: 10.1016/j.eswa.2010.03.048.

[190] S. Önüt and S. Soner, "Transshipment site selection using the AHP and TOPSIS approaches under fuzzy environment," *Waste Manag.*, vol. 28, no. 9, pp. 1552–1559, 2008, doi: 10.1016/j.wasman.2007.05.019.

[191] M. Özyol and Y. E. Albayrak, "The fuzzy AHP process for choice of knowledge-based management styles," *IFAC Proc. Vol.*, vol. 9, no. PART 1, pp. 442–447, 2006, doi: 10.3182/20060522-3-fr-2904.00071.

[192] N. F. Pan, "Fuzzy AHP approach for selecting the suitable bridge construction method," *Autom. Constr.*, vol. 17, no. 8, pp. 958–965, 2008, doi: 10.1016/j.autcon.2008.03.005.

[193] S. K. Patil and R. Kant, "A fuzzy AHP-TOPSIS framework for ranking the solutions of Knowledge Management adoption in Supply Chain to overcome its barriers," *Expert Syst. Appl.*, vol. 41, no. 2, pp. 679–693, 2014, doi: 10.1016/j.eswa.2013.07.093.

[194] S. Pourebrahim, M. Hadipour, M. Bin Mokhtar, and S. Taghavi, "Application of VIKOR and fuzzy AHP for conservation priority assessment in coastal areas: Case of Khuzestan district, Iran," *Ocean Coast. Manag.*, vol. 98, pp. 20–26, 2014, doi: 10.1016/j.ocecoaman.2014.05.009.

[195] M. Rajak and K. Shaw, "Evaluation and selection of mobile health (mHealth) applications using AHP and fuzzy TOPSIS," *Technol. Soc.*, vol. 59, p. 101186, 2019,

doi: 10.1016/j.techsoc.2019.101186.

[196] J. Rezaei, P. B. M. Fahim, and L. Tavasszy, "Supplier selection in the airline retail industry using a funnel methodology: Conjunctive screening method and fuzzy AHP," *Expert Syst. Appl.*, vol. 41, no. 18, pp. 8165–8179, 2014, doi: 10.1016/j.eswa.2014.07.005.

[197] R. Rostamzadeh and S. Sofian, "Prioritizing effective 7Ms to improve production systems performance using fuzzy AHP and fuzzy TOPSIS (case study)," *Expert Syst. Appl.*, vol. 38, no. 5, pp. 5166–5177, 2011, doi: 10.1016/j.eswa.2010.10.045.

[198] Y. K. Sharma, A. K. Yadav, S. K. Mangla, and P. P. Patil, "Ranking the Success Factors to Improve Safety and Security in Sustainable Food Supply Chain Management Using Fuzzy AHP," *Mater. Today Proc.*, vol. 5, no. 5, pp. 12187–12196, 2018, doi: 10.1016/j.matpr.2018.02.196.

[199] M. Shaverdi, M. R. Heshmati, E. Eskandaripour, and A. A. A. Tabar, "Developing sustainable SCM evaluation model using fuzzy AHP in publishing industry," *Procedia Comput. Sci.*, vol. 17, pp. 340–349, 2013, doi: 10.1016/j.procs.2013.05.044.

[200] M. Shaverdi, M. R. Heshmati, and I. Ramezani, "Application of fuzzy AHP approach for financial performance evaluation of iranian petrochemical sector," *Procedia Comput. Sci.*, vol. 31, no. Itqm, pp. 995–1004, 2014, doi: 10.1016/j.procs.2014.05.352.

[201] K. Shaw, R. Shankar, S. S. Yadav, and L. S. Thakur, "Supplier selection using fuzzy AHP and fuzzy multi-objective linear programming for developing low carbon supply chain," *Expert Syst. Appl.*, vol. 39, no. 9, pp. 8182–8192, 2012, doi: 10.1016/j.eswa.2012.01.149.

[202] P. Sirisawat and T. Kiatcharoenpol, "Fuzzy AHP-TOPSIS approaches to prioritizing solutions for reverse logistics barriers," *Comput. Ind. Eng.*, vol. 117, no. September 2017, pp. 303–318, 2018, doi: 10.1016/j.cie.2018.01.015.

[203] Z. Song, H. Zhu, G. Jia, and C. He, "Comprehensive evaluation on self-ignition risks of coal stockpiles using fuzzy AHP approaches," *J. Loss Prev. Process Ind.*, vol. 32, no. 1, pp. 78–94, 2014, doi: 10.1016/j.jlp.2014.08.002.

[204] L. Suganthi, "Multi expert and multi criteria evaluation of sectoral investments for sustainable development: An integrated fuzzy AHP, VIKOR / DEA methodology," *Sustain. Cities Soc.*, vol. 43, pp. 144–156, 2018, doi: 10.1016/j.scs.2018.08.022.

[205] C. C. Sun, "A performance evaluation model by integrating fuzzy AHP and fuzzy TOPSIS methods," *Expert Syst. Appl.*, vol. 37, no. 12, pp. 7745–7754, 2010, doi: 10.1016/j.eswa.2010.04.066.

[206] R. R. Tan, K. B. Aviso, A. P. Huelgas, and M. A. B. Promentilla, "Fuzzy AHP

approach to selection problems in process engineering involving quantitative and qualitative aspects," *Process Saf. Environ. Prot.*, vol. 92, no. 5, pp. 467–475, 2014, doi: 10.1016/j.psep.2013.11.005.

[207] O. Taylan, A. O. Bafail, R. M. S. Abdulaal, and M. R. Kabli, "Construction projects selection and risk assessment by fuzzy AHP and fuzzy TOPSIS methodologies," *Appl. Soft Comput. J.*, vol. 17, pp. 105–116, 2014, doi: 10.1016/j.asoc.2014.01.003.

[208] S. K. Thengane, A. Hoadley, S. Bhattacharya, S. Mitra, and S. Bandyopadhyay, "Cost-benefit analysis of different hydrogen production technologies using AHP and Fuzzy AHP," *Int. J. Hydrogen Energy*, vol. 39, no. 28, pp. 15293–15306, 2014, doi: 10.1016/j.ijhydene.2014.07.107.

[209] M. L. Tseng, Y. H. Lin, and A. S. F. Chiu, "Fuzzy AHP-based study of cleaner production implementation in Taiwan PWB manufacturer," *J. Clean. Prod.*, vol. 17, no. 14, pp. 1249–1256, 2009, doi: 10.1016/j.jclepro.2009.03.022.

[210] P. J. M. Van LAARHOVEN and W. PEDRYCZ, "A Fuzzy Extension of Saaty's Priority Theory," *Fuzzy Sets Syst.*, vol. 11, pp. 229–241, 1983.

[211] S. Vinodh, M. Prasanna, and N. Hari Prakash, "Integrated Fuzzy AHP-TOPSIS for selecting the best plastic recycling method: A case study," *Appl. Math. Model.*, vol. 38, no. 19–20, pp. 4662–4672, 2014, doi: 10.1016/j.apm.2014.03.007.

[212] Y. M. Wang, Y. Luo, and Z. Hua, "On the extent analysis method for fuzzy AHP and its applications," *Eur. J. Oper. Res.*, vol. 186, no. 2, pp. 735–747, 2008, doi: 10.1016/j.ejor.2007.01.050.

[213] Z. Yan, X. Wang, and Y. Fu, "Study on Early Warning Model of Coal Mining Engineering with Fuzzy AHP," *Syst. Eng. Procedia*, vol. 5, pp. 113–118, 2012, doi: 10.1016/j.sepro.2012.04.018.

[214] M. Yucesan and G. Kahraman, "Risk evaluation and prevention in hydropower plant operations: A model based on Pythagorean fuzzy AHP," *Energy Policy*, vol. 126, no. September 2018, pp. 343–351, 2019, doi: 10.1016/j.enpol.2018.11.039.

[215] N. Zhang, K. Zhou, and X. Du, "Application of fuzzy logic and fuzzy AHP to mineral prospectivity mapping of porphyry and hydrothermal vein copper deposits in the Dananhu-Tousuquan island arc, Xinjiang, NW China," *J. African Earth Sci.*, vol. 128, pp. 84–96, 2017, doi: 10.1016/j.jafrearsci.2016.12.011.

[216] Y. Zhu and H. Lei, "Fuzzy AHP Analysis on Enterprises' Independent Innovation Capability Evaluation," *Phys. Procedia*, vol. 24, pp. 1285–1291, 2012, doi: 10.1016/j.phpro.2012.02.192.

[217] R. Singha and K. Gayatri, "Government policy and performance: A study of Indian

engineering industry," 2010.

[218] S. Athreye and S. Kapur, "Industrial concentration in a liberalising economy: A study of Indian manufacturing," *J. Dev. Stud.*, vol. 42, no. 6, pp. 981–999, 2006, doi: 10.1080/00220380600774764.

[219] R. Kanda, "Indian Manufacturing Sector: A Review on the Problems & Declining Scenario of Indian Industries," *Int. J. Sci. Res.*, vol. 4, no. 4, pp. 1039–1042, 2015, [Online]. Available: https://www.ijsr.net/archive/v4i4/SUB153201.pdf.

[220] Y. Mehta and A. J. Rajan, "Manufacturing Sectors in India: Outlook and Challenges," in *Procedia Engineering*, 2017, vol. 174, pp. 90–104, doi: 10.1016/j.proeng.2017.01.173.

[221] M. Sharma and R. Kodali, "Development of a framework for manufacturing excellence," *Measuring Business Excellence*, vol. 12, no. 4. pp. 50–66, 2008, doi: 10.1108/13683040810919962.

[222] S. Luthra, D. Garg, and A. Haleem, "Identifying and ranking of strategies to implement green supply chain management in Indian manufacturing industry using analytical hierarchy process," *J. Ind. Eng. Manag.*, vol. 6, no. 4, pp. 930–962, 2013, doi: 10.3926/jiem.693.

[223] K. Dhyani and A. Saxena, "Make in india v. made in china," *J. Contemp. Issues Law*, vol. 3, no. 3, pp. 1–11, 2015.

[224] A. Lees and S. Khatri, "Made in India: Are you ready for outsourced contract manufacturing," *Journal of Commercial Biotechnology*, vol. 16, no. 3. pp. 258–265, 2010, doi: 10.1057/jcb.2010.11.

[225] K. Wowk *et al.*, "Evolving academic culture to meet societal needs," *Palgrave Communications*, vol. 3, no. 1. Springer US, pp. 1–7, 2017, doi: 10.1057/s41599-017-0040-1.

[226] R. Carbone and J. S. Armstrong, "Note. Evaluation of extrapolative forecasting methods: Results of a survey of academicians and practitioners," *J. Forecast.*, vol. 1, no. 2, pp. 215–217, 1982, doi: 10.1002/for.3980010207.

[227] J. Wright, L. Cushman, and A. Nicholson, "Reconciling industry and academia: Perspectives on the apparel design curriculum," *Educ. + Train.*, vol. 44, no. 3, pp. 122–128, 2002, doi: 10.1108/00400910210424300.

[228] J. M. Bartunek and S. L. Rynes, "Academics and Practitioners Are Alike and Unlike: The Paradoxes of Academic-Practitioner Relationships," *Journal of Management*, vol. 40, no. 5. pp. 1181–1201, 2014, doi: 10.1177/0149206314529160.

[229] D. Yong, "Plant location selection based on fuzzy TOPSIS," *Int. J. Adv. Manuf.*

Technol., vol. 28, no. 7–8, pp. 839–844, 2006, doi: 10.1007/s00170-004-2436-5.

[230] S. S. Raghuwanshi and R. Arya, "Renewable energy potential in India and future agenda of research," *Int. J. Sustain. Eng.*, vol. 12, no. 5, pp. 291–302, 2019, doi: 10.1080/19397038.2019.1602174.

[231] J. Charles Rajesh Kumar and M. A. Majid, "Renewable energy for sustainable development in India: Current status, future prospects, challenges, employment, and investment opportunities," *Energy. Sustain. Soc.*, vol. 10, no. 1, pp. 1–36, 2020, doi: 10.1186/s13705-019-0232-1.

[232] O. P. Akkas, M. Y. Erten, E. Cam, and N. Inanc, "Optimal Site Selection for a Solar Power Plant in the Central Anatolian Region of Turkey," *Int. J. Photoenergy*, vol. 2017, p. 7452715, 2017, doi: 10.1155/2017/7452715.

[233] G. Raina and S. Sinha, "Outlook on the Indian scenario of solar energy strategies: Policies and challenges," *Energy Strateg. Rev.*, vol. 24, no. February, pp. 331–341, 2019, doi: 10.1016/j.esr.2019.04.005.

[234] S. K. Gupta and R. S. Anand, "Development of Solar Electricity Supply System in India: An Overview," *J. Sol. Energy*, vol. 2013, pp. 1–10, 2013, doi: 10.1155/2013/632364.

[235] K. J. Ngandu, "Facility Location and Supply Chain Performance of the Mobile Telecommunication Firms in Kenya By Kabena Jessie Ngandu : D61 / 75376 / 2012 Project Submitted in Partial Fulfillment of the Requirements for the Award of the Degree of Master of Business Admin," no. November, 2014.

[236] R. Z. Farahani, M. SteadieSeifi, and N. Asgari, "Multiple criteria facility location problems: A survey," *Appl. Math. Model.*, vol. 34, no. 7, pp. 1689–1709, 2010, doi: 10.1016/j.apm.2009.10.005.

[237] J. J. Buckley, "Fuzzy hierarchical analysis," *Fuzzy Sets Syst.*, vol. 17, no. 3, pp. 233–247, 1985, doi: 10.1016/0165-0114(85)90090-9.

[238] "Construction Costs," *Designing Buildings Wiki*, 2015. https://www.designingbuildings.co.uk/wiki/Construction_costs (accessed Nov. 02, 2020).

[239] FE Knowledge Desk, "Inflation," *financial express*. https://www.financialexpress.com/what-is/inflation-meaning/1618981/#:~:text=What is Inflation%3F-,Inflation refers to the rise in the prices of most,commodities and services over time. (accessed Nov. 02, 2020).

[240] S. P. Srivastava and S. P. Srivastava, "Solar Energy and Its Future Role in Indian Economy," *Int. J. Environ. Sci. Dev. Monit.*, vol. 4, no. 3, pp. 81–88, 2013, [Online].

Available: https://www.ripublication.com/ijesdmspl/ijesdmv4n3_18.pdf.

[241] Avatrade, "What is Currency Strength?," 2017. https://www.avatrade.com/education/trading-for-beginners/currency-strength (accessed Nov. 02, 2020).

[242] R. Patnaik, "Impact of Industrialization on Environment and Sustainable Solutions - Reflections from a South Indian Region," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 120, no. 1, 2018, doi: 10.1088/1755-1315/120/1/012016.

[243] G. A. Miller, "The magical number seven, plus or minus two: Some limits on our capacity for processing information.," *Psychol. Rev.*, vol. 101, no. 2, pp. 343–352, 1994, doi: 10.1037/0033-295x.101.2.343.

[244] W. Contributors, "Fuzzy number," *Wikipedia, The Free Encyclopedia*, 2009. .

[245] H. Mohammadi, I. Nouri, and E. Mohammad, "Applying Fuzzy DEMATEL Method to Analyze Supplier Selection Criteria (Case Study: WagonPars Company)," *Int. Res. J. Financ. Econ.*, no. 115, 2013.

[246] Y. M. Wang, J. B. Yang, D. L. Xu, and K. S. Chin, "On the centroids of fuzzy numbers," *Fuzzy Sets Syst.*, vol. 157, no. 7, pp. 919–926, 2006, doi: 10.1016/j.fss.2005.11.006.

[247] R. C. Berkan and S. L. Trubatch, *Fuzzy Systems Design Principles Building Fuzzy IF-THEN Rule Bases*, First. Standard Publishers Distributors, 2000.

[248] A. Kaufmann and M. M. Gupta, *Introduction to Fuzzy Arithmetic Theory and Applications*. Van Nostrand Reinhold Company Inc., 1985.

[249] J. D. Nixon, P. K. Dey, and P. A. Davies, "Which is the best solar thermal collection technology for electricity generation in north-west India? Evaluation of options using the analytical hierarchy process," *Energy*, vol. 35, no. 12, pp. 5230–5240, 2010, doi: 10.1016/j.energy.2010.07.042.

[250] K. S. Taber, "The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education," *Res. Sci. Educ.*, vol. 48, no. 6, pp. 1273–1296, 2018, doi: 10.1007/s11165-016-9602-2.

[251] R. Verma and B. D. Sharma, "Fuzzy Generalized Prioritized Weighted Average Operator and its Application to Multiple Attribute Decision Making," *Int. J. Intell. Syst.*, vol. 29, pp. 26–49, 2014, doi: 10.1002/int.21626.

[252] Z. Yue and Y. Jia, "A group decision making model with hybrid intuitionistic fuzzy information," *Comput. Ind. Eng.*, vol. 87, pp. 202–212, 2015, doi: 10.1016/j.cie.2015.05.016.

[253] G. Kabir and M. Ahsan Akhtar Hasin, "Multiple criteria inventory classification using

fuzzy analytic hierarchy process," *Int. J. Ind. Eng. Comput.*, vol. 3, no. 2, pp. 123–132, 2012, doi: 10.5267/j.ijiec.2011.09.007.

[254] C. G. E. Boender, J. G. de Graan, and F. A. Lootsma, "Multi-criteria decision analysis with fuzzy pairwise comparisons," *Fuzzy Sets Syst.*, vol. 29, no. 2, pp. 133–143, 1989, doi: 10.1016/0165-0114(89)90187-5.

[255] D. Y. Chang, "Applications of the extent analysis method on fuzzy AHP," *Eur. J. Oper. Res.*, vol. 95, no. 3, pp. 649–655, 1996, doi: 10.1016/0377-2217(95)00300-2.

[256] R. Csutora and J. J. Buckley, "Fuzzy hierarchical analysis: The Lambda-Max method," *Fuzzy Sets Syst.*, vol. 120, no. 2, pp. 181–195, 2001, doi: 10.1016/s0165-0114(99)00155-4.

[257] C. C. Lin, W. C. Wang, and W. Der Yu, "Improving AHP for construction with an adaptive AHP approach (A3)," *Autom. Constr.*, vol. 17, no. 2, pp. 180–187, 2008, doi: 10.1016/j.autcon.2007.03.004.

[258] T. L. Saaty, "A scaling method for priorities in hierarchical structures," *J. Math. Psychol.*, vol. 15, no. 3, pp. 234–281, 1977, doi: 10.1016/0022-2496(77)90033-5.

[259] H. A. Donegan and F. J. Dodd, "A note on saaty's random indexes," *Math. Comput. Model.*, vol. 15, no. 10, pp. 135–137, 1991, doi: 10.1016/0895-7177(91)90098-R.

[260] J. A. Alonso and M. T. Lamata, "Consistency in the analytic hierarchy process: A new approach," *Int. J. Uncertainty, Fuzziness Knowlege-Based Syst.*, vol. 14, no. 4, pp. 445–459, 2006, doi: 10.1142/S0218488506004114.

[261] H. K. Chan, X. Wang, and A. Raffoni, "An integrated approach for green design: Life-cycle, fuzzy AHP and environmental management accounting," *Br. Account. Rev.*, vol. 46, no. 4, pp. 344–360, 2014, doi: 10.1016/j.bar.2014.10.004.

[262] J. Caha and A. Drazna, "Examples of fuzzy AHP package application (ver. 0.9.5)," 2019. https://cran.r-project.org/web/packages/FuzzyAHP/vignettes/examples.html (accessed Apr. 17, 2020).

[263] W. C. Wedley, "Consistency prediction for incomplete AHP matrices," *Math. Comput. Model.*, vol. 17, no. 4–5, pp. 151–161, 1993, doi: 10.1016/0895-7177(93)90183-Y.

[264] G. D. Klaus, "AHP and the Magical Number Seven Plus or Minus Two," *2014*. https://bpmsg.com/ahp-and-the-magical-number-seven-plus-or-minus-two/ (accessed Apr. 22, 2020).

[265] H. Akoglu, "User's guide to correlation coefficients," *Turkish J. Emerg. Med.*, vol. 18, no. 3, pp. 91–93, 2018, doi: 10.1016/j.tjem.2018.08.001.

[266] R. Van Der Berg, "Kendall's Tau -Simple Introduction," 2012. https://www.spss-tutorials.com/kendalls-tau/#kendalls-tau-interpretation] (accessed Jun. 24, 2020).

[267] N. Sellappan and K. Palanikumar, "Modified Prioritization Methodology for Risk Priority Number in Failure Mode and Effects Analysis," *Int. J. Appl. Sci. Technol.*, vol. 03, no. 04, pp. 27–36, 2013.

[268] DPIIT, "Sectors," *Department for Promotion of Industry and Internal Trade, India.*, 2014. https://www.makeinindia.com/sectors (accessed May 02, 2020).

[269] T. Rooks, "'Make in India' looking to take on China's tech industry," *Deutsche Welle*, 2020. https://p.dw.com/p/3cVLY (accessed May 22, 2020).

[270] S. Agrawal, A. Jamwal, and S. Gupta, *Effect of COVID-19 on the India Economy and Supply Chain*. Open Access to Scientific Information Research Gate, 2020.

[271] D. Ivanov, "Predicting the impacts of epidemic outbreaks on global supply chains: A simulation-based analysis on the coronavirus outbreak (COVID-19/SARS-CoV-2) case," *Transp. Res. Part E Logist. Transp. Rev.*, vol. 136, p. 101922, 2020, doi: https://doi.org/10.1016/j.tre.2020.101922.

[272] N. Inamdar, "Coronavirus: Can India replace China as world's factory?," *BBC*, 2020. https://www.bbc.com/news/world-asia-india-52672510 (accessed Jun. 25, 2020).

[273] Y. Liu, J. M. Lee, and C. Lee, "The challenges and opportunities of a global health crisis: the management and business implications of COVID-19 from an Asian perspective," *Asian Bus. Manag.*, vol. 19, no. 3, pp. 277–297, 2020, doi: 10.1057/s41291-020-00119-x.

[274] Business Today, "Coronavirus lockdown 4.0: PM Modi announces economic package worth Rs 20 lakh crore; 10% of GDP," *Business Today*, 2020.

[275] S. Majumdar, "Make in India Versus Made in China," *The Millenium Post*, 2014. http://www.millenniumpost.in/make-in-india-versus-made-in-china-40689 (accessed Jun. 24, 2020).

[276] R. A. Green, "Can ' Make in India ' Make Jobs? the Challenges of Manufacturing Growth and High – Quality Job Creation in India," 2014. [Online]. Available: https://www.bakerinstitute.org/media/files/files/9b2bf0a2/Econ-pub-MakeInIndia-121514.pdf.

[277] A. Alinezad, A. Seif, and N. Esfandiari, "Supplier evaluation and selection with QFD and FAHP in a pharmaceutical company," *Int. J. Adv. Manuf. Technol.*, vol. 68, no. 1–4, pp. 355–364, 2013, doi: 10.1007/s00170-013-4733-3.

[278] R. K. Singh, A. Gunasekaran, and P. Kumar, "Third party logistics (3PL) selection for cold chain management: a fuzzy AHP and fuzzy TOPSIS approach," *Ann. Oper. Res.*, vol. 267, no. 1–2, pp. 531–553, 2018, doi: 10.1007/s10479-017-2591-3.

[279] M. Yazdi, "Hybrid Probabilistic Risk Assessment Using Fuzzy FTA and Fuzzy AHP in

a Process Industry," *J. Fail. Anal. Prev.*, vol. 17, no. 4, pp. 756–764, 2017, doi: 10.1007/s11668-017-0305-4.

[280] I. Ertuğrul and N. Karakaşoğlu, "Comparison of fuzzy AHP and fuzzy TOPSIS methods for facility location selection," *Int. J. Adv. Manuf. Technol.*, vol. 39, no. 7–8, pp. 783–795, 2008, doi: 10.1007/s00170-007-1249-8.

[281] P. F. Hsu and B. Y. Chen, "Developing and implementing a selection model for bedding chain retail store franchisee using Delphi and Fuzzy AHP," *Qual. Quant.*, vol. 41, no. 2, pp. 275–290, 2007, doi: 10.1007/s11135-006-9004-z.

[282] R. Kiani Mavi, "Indicators of Entrepreneurial University: Fuzzy AHP and Fuzzy TOPSIS Approach," *J. Knowl. Econ.*, vol. 5, no. 2, pp. 370–387, 2014, doi: 10.1007/s13132-014-0197-4.

[283] S. Lee and K. K. Seo, "A Hybrid Multi-Criteria Decision-Making Model for a Cloud Service Selection Problem Using BSC, Fuzzy Delphi Method and Fuzzy AHP," *Wirel. Pers. Commun.*, vol. 86, no. 1, pp. 57–75, 2016, doi: 10.1007/s11277-015-2976-z.

[284] C. Low and Y. Hsueh Chen, "Criteria for the evaluation of a cloud-based hospital information system outsourcing provider," *J. Med. Syst.*, vol. 36, no. 6, pp. 3543–3553, 2012, doi: 10.1007/s10916-012-9829-z.

[285] S. K. Mangla, P. Kumar, and M. K. Barua, "Flexible Decision Modeling for Evaluating the Risks in Green Supply Chain Using Fuzzy AHP and IRP Methodologies," *Glob. J. Flex. Syst. Manag.*, vol. 16, no. 1, pp. 19–35, 2015, doi: 10.1007/s40171-014-0081-x.

[286] M. Hanine, O. Boutkhoum, A. Tikniouine, and T. Agouti, "An application of OLAP/GIS-Fuzzy AHP-TOPSIS methodology for decision making: Location selection for landfill of industrial wastes as a case study," *KSCE J. Civ. Eng.*, vol. 21, no. 6, pp. 2074–2084, 2017, doi: 10.1007/s12205-016-0114-4.

[287] A. N. Haq and G. Kannan, "Fuzzy analytical hierarchy process for evaluating and selecting a vendor in a supply chain model," *Int. J. Adv. Manuf. Technol.*, vol. 29, no. 7–8, pp. 826–835, 2006, doi: 10.1007/s00170-005-2562-8.

[288] H. P. Fu, K. K. Chu, S. W. Lin, and C. R. Chen, "A study on factors for retailers implementing CPFR - A fuzzy AHP analysis," *J. Syst. Sci. Syst. Eng.*, vol. 19, no. 2, pp. 192–209, 2010, doi: 10.1007/s11518-010-5136-8.

[289] C. K. Kwong and H. Bai, "A fuzzy AHP approach to the determination of importance weights of customer requirements in quality function deployment," *J. Intell. Manuf.*, vol. 13, no. 5, pp. 367–377, 2002, doi: 10.1023/A:1019984626631.

[290] Z. Taha and S. Rostam, "A hybrid fuzzy AHP-PROMETHEE decision support system for machine tool selection in flexible manufacturing cell," *J. Intell. Manuf.*, vol. 23, no.

6, pp. 2137–2149, 2012, doi: 10.1007/s10845-011-0560-2.

[291] C. H. Wang and H. S. Wu, "A novel framework to evaluate programmable logic controllers: a fuzzy MCDM perspective," *J. Intell. Manuf.*, vol. 27, no. 2, pp. 315–324, 2016, doi: 10.1007/s10845-013-0863-6.

[292] S. Deshmukh and V. Sunnapwar, "Fuzzy Analytic Hierarchy Process (FAHP) for Green Supplier Selection in Indian Industries," in *Proceedings of International Conference on Intelligent Manufacturing and Automation*, 2019, vol. Springer, no. October, pp. 583–591, doi: https://doi.org/10.1007/978-981-13-2490-1_63.

[293] A. Gupta, "Energizing boost to Goa's solar power needs," *eqmagpro*, 2018. https://www.eqmagpro.com/energizing-boost-to-goas-solar-power-needs/ (accessed Sep. 17, 2020).

[294] B. O. Saracoglu *et al.*, "A framework for selecting the location of very large photovoltaic solar power plants on a global/supergrid," *Energy Reports*, vol. 4, pp. 586–602, 2018, doi: 10.1016/j.egyr.2018.09.002.

[295] G. Khan and S. Rathi, "Optimal Site Selection for Solar PV Power Plant in an Indian State Using Geographical Information System (GIS)," *Int. J. Emerg. Eng. Res. Technol.*, vol. 2, no. 7, pp. 260–266, 2014, [Online]. Available: www.ijeert.org.

[296] S. Ozdemir and G. Sahin, "Multi-criteria decision-making in the location selection for a solar PV power plant using AHP," *Meas. J. Int. Meas. Confed.*, vol. 129, no. December, pp. 218–226, 2018, doi: 10.1016/j.measurement.2018.07.020.

[297] H. Yousefi, H. Hafeznia, and A. Yousefi-Sahzabi, "Spatial site selection for solar power plants using a gis-based boolean-fuzzy logic model: A case study of Markazi Province, Iran," *Energies*, vol. 11, no. 7, 2018, doi: 10.3390/en11071648.

[298] M. Uyan, "Optimal site selection for solar power plants using multi-criteria evaluation: A case study from the Ayranci region in Karaman, Turkey," *Clean Technol. Environ. Policy*, vol. 19, no. 9, pp. 2231–2244, 2017, doi: 10.1007/s10098-017-1405-2.

[299] D. Kereush and I. Perovych, "Determining Criteria for Optimal Site Selection for Solar Power Plants," *Geomatics, Landmanagement Landsc.*, vol. 4, no. 4, pp. 39–54, 2017, doi: 10.15576/gll/2017.4.39.

[300] A. Sharma and G. Singh, "Optimal Site Selection And Efficiency For Solar PV Power Plant," *Int. J.*, vol. 6, no. 1, pp. 84–90, 2018.

[301] L. Krpan, V. Šteko, and Ž. Koren, "Model for selecting locations for construction of solar power plants," *Gradjevinar*, vol. 64, no. 9, pp. 741–748, 2012, doi: 10.14256/jce.721.2011.

[302] S. Garud and I. Purohit, "Making solar thermal power generation in India a reality –

Overview of technologies , opportunities and challenges," *Energy*, pp. 1–9, 2012.

[303] C. T. Chen, "Extensions of the TOPSIS for group decision-making under fuzzy environment," *Fuzzy Sets Syst.*, vol. 114, no. 1, pp. 1–9, 2000, doi: 10.1016/S0165-0114(97)00377-1.

[304] I. Howson, "fuzzify: Convert Real Value Numbers to Triangular Fuzzy Numbers," 2019. https://rdrr.io/cran/fuzzyreg/man/fuzzify.html (accessed Dec. 08, 2020).

LIST OF PUBLICATIONS

International Journals

[1] "Potential Based Ranking of Sectors Identified in 'Make in India' Initiative Using Fuzzy AHP: The Academicians' and Industry Professionals' Perspective", *International Journal of System Assurance Engineering and Management, Springer.* **Submitted 27 June 2020 / Revised 26 November 2020 / Accepted 05 December 2020 / Published 08 February 2021 https://doi.org/10.1007/s13198-020-01044-0**

[2] "On Solving Large Data Matrix Problems in Fuzzy AHP", *Expert Systems with Applications, Elsevier. (SCI/SCOPUS)* **Submitted 23 April 2020 / 1st Revision submitted 01 July 2021**

[3] "A Novel Fuzzy Set Based Approach for Ranking by Pair-wise Comparisons in Higher Order Matrix: Case of Ranking Factors Affecting Facility Location" **Ready to be communicated**

[4] "Locating Solar Power Plant Using Fuzzy MCDM: Case Study in Goa, India" **Ready to be communicated**

[5] "Risk Based Ranking Approach to Address the Dynamic Behaviour of Factors Affecting Facility Location in India" **To be communicated**

International Conferences

[1] "A Framework for Identifying Factors Affecting Facility Location in Developing Countries Using PESTLE",*International Conference on Manufacturing and Industrial Engineering, MGM J. N. E.C., Aurangabad, September 2017.* **Accepted and Presented**

[2] "Identification and Ranking of Factors Affecting Facility Location: A 'Make in India' Challenge", *4th International Conference on Industrial Engineering, SVNIT, Surat, December 2017.* **Accepted and Presented**