CHAPTER 7

CONCLUSIONS AND FUTURE WORK

In the present competitive environment, ‘green purchasing’ which involves green supplier evaluation and selection is a strategic practice in the process industries to confront the economic and environmental challenges in the raw material procurement. Raw material purchasing through green suppliers not only uplifts the economic condition but also sustains the environmental competence in the business operations. The green supplier evaluation and selection process is a multi-criteria decision making process because several uncertain economic and environmental criteria are involved in the purchase activity. In this research work, effective decision framework was developed and applied for green supplier evaluation and selection process in various case process industries and is presented in preceding chapters. This chapter presents the summary of the research findings and the contribution made in this research. Moreover, the limitations arrived in this research work and possible direction for the future work is provided in this chapter.

7.1 SUMMARY OF THE RESEARCH FINDINGS

In this research work various decision models and solution methodologies have been proposed for green supplier evaluation and selection in process industries and the findings of the whole research are summarised in this section as follows:
Preliminarily, an extensive literature review work was carried on the multi-criteria decision making approaches for green supplier evaluation and selection in literatures from 1997 to 2014 as a base work of this research and it has been found that individual methodological approaches were used more than the integrated methodological approaches and environmental criterion were not precisely focused in many articles. The most widely used multi-criteria decision making approach was analytic hierarchy process and most widely considered environmental criteria was environmental management system. Moreover, from the previous supply chain management studies in process industries, lack of green supplier selection model and environmental framework development for environmental competencies in process industries is identified.

Environmental protection and hazardous substance management are major challenges in the chemical sector like plastic processing industry and supplier selection is a critical task because numerous environmental criteria are involved. In this research work, 11 main criteria and 60 sub criteria were selected for criteria framework development after wide range of studies on literature and discussion with expert members. An individual methodological approach, fuzzy axiomatic design was identified as appropriate methodology to handle the large number of fuzzy based criteria evaluation and green supplier evaluation data. The proposed methodology was applied to assist the purchase team to find the best green supplier to supply environmentally comply raw material to the case plastic process industry. Moreover, the proposed approach was not only used to find the best green supplier but also used to analyse the unsatisfied performance of the potential alternative supplier. This could be helpful to advice the potential alternate green suppliers to improve their failure performance on the specified criteria.
Food processing industries are considered to be a critical and potential industrial sector because environmental benign food supply chain is an essential one to fulfil the basic needs of the society and it involves huge demands. In this research work, an effective green supplier evaluation and selection model was proposed in the second case study of food processing industry’s raw material procurement for new product development. Food safety and quality assurance was identified as potential criteria in this study due to the clean and safe processing of food products and an integrated approach of fuzzy analytic hierarchy process (FAHP) and preference ranking organization method for enrichment evaluations (PROMETHEE) technique were selected for priority weight calculation of criteria and green supplier ranking respectively under expert member perception on criteria and potential suppliers performances. In this research, the following advantages were found in methodology applications: FAHP pairwise comparison was used to overcome the different feeling in the classical AHP pairwise comparison of criteria evaluation and PROMETHEE technique was used to avoid the trade-off compromises between supplier performance on low preference and high preference criteria and, PROMETHEE GAIA plane was found to be a powerful tool to analyse the dependencies and independencies of the criteria and alternatives. Finally, the proposed methodology was applied to help the purchase professionals to find the best green alternative.

Recently, the low carbon economy has been the predominant topic worldwide and paper processing industries are found to be fourth largest industrial sector in terms of energy consumption and carbon accounting. In this research work, an appropriate green supplier model was developed for a paper processing industry as a part of carbon reduction project in the raw material procurement. An integrated methodology of fuzzy Technique for Order of Preference by Similarity to Ideal Solution (FTOPSIS) and multi-
objective linear programming (MOLP) was identified as a suitable methodology for best green supplier selection and order allocation among the potential alternative under uncertain heterogeneous multi criteria decision making process which considers the decision makers priority weights in the solution method. The identified criteria which are pertinent to the green supplier selection in paper processing industry are cost, quality, delivery, recycle capability and GHGE emissions. FTOPSIS was applied to find the best green alternative and MOLP was used to allocate the supply order quantity among the potential alternative and the applied methodology proved the noticeable reduction in the carbon reduction in material procurement by considering the recycle factor. Moreover, FAHP and FSAW were applied to compare the green supplier ranking results and various mathematical programming such as weighted additive model (WAM), extended relaxed normalized goal programming (E-RNGP), weighted max-min model (WMM) for fuzzy multi-objective linear programming (FMOLP). were applied to find the optimum order allocation quantity among the potential suppliers.

In the final case study, green vendor evaluation and selection model was developed for outsourcing activity in a mining industry. Recently, case mining industry augment its production operation with private participation not only for uplift their profit but also to face the challenges like environmental impacts, corporate social responsibility, and global economy crisis. In this study, mine developer cum operator (MDO) model was chosen as appropriate mining business model among the other two models for the outsourcing business activity in mining industry and an integrated approach of analytic hierarchy process (AHP) and Taguchi loss function was identified as suitable methodology to find the best green vendor in the selected mining business model. The criteria framework was developed based on five benefit criteria and four risk criteria and AHP approach was applied to identify the
relative importance weight of the criteria by using pairwise comparison of the
decision makers’ perception on the criteria importance. In this case research
work, high level reputation of vendors in terms of green production capability,
ISO standard, financial management strength, liability and risk reduction was
considered as more preferential benefit criteria while lack of operational health
and safety implementation was considered as risk criteria. The best green
vendor was identified through Taguchi loss function, where the loss to the
organisation due to the vendor performances against specified target values on
criteria was used to rank the vendor in the selection process.

Moreover, in all the case studies, the decision makers were advised
to use the linguistic scales to represent their perception on criteria importance
and supplier performance on criteria for ease of calculation. The sensitivity
analysis was carried out in all the case research work to study how the changes
in the criteria importance would affect the green supplier selection. In over all,
suitable green supplier evaluation and selection model was developed for all
case process industries in this research work based on the specific industry
based economic and environmental criteria and the best green supplier was
evaluated and selected by using various multi-criteria decision making
approaches. The managerial and methodological comparison of the studies is
presented in Table A7.1. From the studies, it has been observed that, chemical
industries are more concerned about the environmental impacts compared to
the other industries. High numbers of environmental criteria are considered in
green supplier evaluation and selection in plastic industries. Next, paper
industries are giving higher importance for the carbon economy criteria, to
reduce the CO₂ emission by involving the recycle material in their operations.
Mining industries focus more on OHS policy, the green technologies and
green production capability to improve the green production. The food
industries are providing high attention on the food safety factor compared to
other environmental factor because these industries are maintaining the environmental cautious production compared to the other industries. From the research, it is clearly observed that the process industrial sector keenly focuses on the implementation of green practices in their operations to withstand the environmental pressures and compete in the global market.

7.2 RESEARCH CONTRIBUTION

The main contributions of this research work are summarised as follows:

This research helps process industry firms to implement green purchasing practices in effective way not only to improve the economic benefit in their business operations but also to improve the environmental competencies and survival capability in the global market competitiveness.

It aids decision making team to understand and develop the pertinent economic cum environmental criteria framework for green supplier selection process in specified process industry by eliminating the non-pertinent criteria and gather the information on criteria to evaluate the potential green suppliers.

It develops the green supplier evaluation and selection model appropriate to specified process industries using various multi-criteria decision making methodologies and assists the decision making team to select the best green supplier through right sourcing decision and optimum order allocation quantity by ease of operation of methodologies. Moreover, it provides some advantages of methodologies like, analysis of unselected suppliers in FAD, elimination of trade-offs compromise in PROMETHEE, heterogeneous group
decision making in FTOPSIS and identification of supplier performances loss in Taguchi loss function.

It recommends suitable linguistic scale to decision making team to represent their observation on criteria importance and green supplier evaluation under uncertain conditions.

7.3 LIMITATION AND DIRECTION FOR FUTURE WORK

The identified limitations in this research work are presented as follows:

Some of the managerial limitations are,

Only four types of process industries are considered for green supplier evaluation selection process in this research.

Limited numbers of respondents are involved for supplier evaluation and selection process which may cause less dense of information about the criteria and suppliers.

The methodological limitations are,

In FAD approach, the green supplier must meet the functional requirements of all the criteria successfully for the selection. Otherwise he will not be selected even if it failed in one criterion and performed well in all other criteria.

The PROMETHEE GAIA plane accuracy is purely based on the quality of the GAIA plane where lesser the quality, the loss of information is more.
The directions for the future work are,

More number of process industries can be studied for the green supplier evaluation and selection process.

In future research, the information and data related to the supplier selection problem could be collected from numerous respondents of different category of experience, qualification and positions to validate the research.

In future, various MCDM approaches, different business models, increasing number of environmental criteria could be selected and applied to various decision issues in the process industries.

7.4 SUMMARY

This chapter concludes with the research findings, research contribution, limitations of the research and direction for the future work. The developed green supplier evaluation and selection models were applied and validated by respective case process industries.