Evaluating barriers to implementing green supply chain management: An example from an emerging economy

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A fuzzy-based VIKOR framework for evaluating barriers to implementing green supply chain management: An example from an emerging economy

Abstract

This study proposes a fuzzy-based VIKOR (VIseKriterijumska Optimizacija I Kompromisno Resenje) framework for evaluating barriers to implementing green supply chain management (GSCM) in the context of an emerging economy. The methodology uses a mix method approach combining literature review and opinions of some selected managers from the plastic industry of Bangladesh to identify four main-barriers and twenty-five sub-barriers relevant to GSCM implementation. Fuzzy-VIKOR approach was applied to aid in the analysis of the barriers in the plastic industry of Bangladesh. The findings of the study show the order/rank of intensity and severity of the main-barriers to implementing GSCM practices in the plastic industry of Bangladesh as follows: “inadequate knowledge and support”, “insufficient technology and infrastructure”, “financial constraints and unsupportive organizational”, and “operational policies”. The results also show the rankings of the sub-barriers under each main barriers. This research contributes to the literature in a number of ways. First, it identifies multi-levels of barriers to GSCM implementation. Secondly, it identifies and proposes alternative action plans (strategies) to help mitigate and implement GSCM practices. Though this study has significant contributions, a number of limitations do exist. The barriers in this study were identified using the extant literature review and industrial managers’ opinions. A more scientific approach and empirical validation is required, especially in the plastic manufacturing industry of Bangladesh to identify more new challenging barriers. However, this study can provide managers with a better understanding of the barriers to implementing GSCM practices and motivate the researchers to further extend the investigation on the insights for developing strategic plans for implementing GSCM practices in the plastic industry of Bangladesh.

Keywords: Green supply chain; Barriers; Fuzzy theory; VIKOR; Plastic processing; Emerging economy.

1. Introduction

Environmental damage and degradation, the negative impacts of human activities has received growing attention over the last few decades (Zhang et al., 2019; Abdel-Baset et al., 2019; Govindan, et al., 2015; Kusi-Sarpong et al., 2015; Badri Ahmadi et al. 2017). Sustainable development through green initiatives has gained considerable attention due to global pressure, business to business demand, legislature, consumers' awareness, environmental policies and societal issues (Dallasega & Sarkis, 2018; Ali et al., 2017; Moktadir et al., 2018b; Moktadir et al., 2017; Moktadir et al., 2018c). International organizations, national policies, industries, and academicians are giving much importance to green initiatives to reduce environmental degradation and energy wastage. Incorporating green initiatives into the conventional supply chains is a growing trend (Kumar et al., 2019; Batista et al., 2018; S. Kumar et al., 2016; Kumar et al., 2019). The goal of green initiatives is to help organizations reduce energy waste, conserve biodiversity and eco-system and also protect the environment (Colicchia et al., 2017; Sinaga et al., 2019; Alahmad et al., 2011; Carbone & Moatti, 2018). Green supply chain operations are gaining popularity in current industrial setting. Manufacturing organizations are incorporating green activities into their supply chains as a means to protect the environment, ensure a promising profit and increase production to gain acceptance, popularity and reliability in the highly competitive local and global business environment (Badi and Murtagh 2019; Maditati et al., 2018; Choudhary and Sangwan 2019; Rahmani & Yavari, 2019). GSCM (green supply chain management) can be defined as the process of using eco-friendly inputs or green materials, and converting these inputs into green outputs that can be retrieved and reused after their life cycle comes to an end thus, creating a promising and eco-friendly supply chains (Nasrollahi, 2018; Zhang et al., 2019; Vivek and Sanjay Kumar 2019; Huo et al., 2019; Khan et al., 2018). This eco-materials transformation into green outputs retrievable or reusable at end-of-life stages are supported by green equipment and green technology manufacturing or production processes which ensure less emission of carbon dioxide and less energy loss (Dube et al., 2012; Rajabion et al., 2019; Sameer Kumar et al., 2012). GSCM is important in reducing the total negative environmental impact of any manufacturing plant involved in supply chain operations which can contribute to sustainable development and ensure performance enhancement (Chin et al., 2015; Gunasekaran et al., 2015; Ninlawan et al., 2010). Incorporating green concept into the traditional supply chain operations is challenging. Greening the supply chains involve all the activities of the operations which include: sourcing, transportation, logistics, packaging, distribution, warehouse, production, materials, infrastructure etc. (Ahi & Searcy, 2013; Seman et al., 2012a,b). Greening all these parts of the supply chain of a company increases the firm's competitiveness in the market (Ahi & Searcy, 2013). Companies can build a good reputation and image by implementing green activities in their management and supply chains. GSCM practices ensure economic benefits for the manufacturers and companies.

Green practices in the supply chain have enormous benefits for the manufacturers and companies. Green supply chain and operations initiatives are very famous in the developed nations (Chan et al., 2012; Dües et al., 2013). In some cases, adopting GSCM practices is a legislative requirement in the developed countries (Jabbour at al., 2015; Sarkis, 2012). However, in the developing country, adopting green practices in the supply chains is still in the embryonic stage (Jakhar et al., 2019). In Bangladesh, green activities of the supply chains are not well practiced. Yet due to global pressure, investors' pressure, government legislation, changing corporate philosophy, the manufacturing industries of Bangladesh have started to adopt green practices in their management, operations and supply chains. However, there are many difficulties faced by these organizations in an attempt to fully implement these GSCM practices. These difficulties results in failures posing serious barriers to GSCM implementation. Identifying these barriers is an important and initial step to take.

Many researches and studies have been carried out on finding out the barriers to implementing GSCM practices in different industries and countries. For example, Jayant et al. (2014) investigated the barriers to the implementation of GSCM practices in the Indian manufacturing industry whereas Mehrabi et al. (2012) studied the barriers to GSCM implementation in the petrochemical industry of Iran among others. Yet, the literature and expert opinions have shown that the green concept is not well practiced in the plastic manufacturing sector of Bangladesh. There are several barriers to implementing GSCM in the plastic industry of Bangladesh. These barriers are making it difficult for the manufacturing plants of plastic industry to implementing GSCM. Yet, no research has been conducted to identify and propose a means or an approach to dealing with these barriers when implementing GSCM practices in the plastic industry of Bangladesh. This research gap is the motivation towards identifying and analysing the barriers to implementing GSCM practices in the plastic industry of Bangladesh. Understanding these barriers and their intensity and severities can help clarify and aid in their removal and management. To address this research gap in literature and practice, this study focuses on determining, analysizing and ranking the barriers and propsing alternative actions plans to aid in implementing GSCM practices in the plastic industry of Bangladesh.

More specifically, the objectives of this study are summarized as follows:

1. To identify significant barriers to implementing GSCM practices for the plastic manufacturing industry of Bangladesh.
2. To evaluate and rank the barriers aided by a fuzzy-VIKOR approach in plastic manufacturing industry of Bangladesh.
3. To assess and rank the alternative action plans for the smooth implementation of GSCM in the manufacturing industry of Bangladesh.

The contributions of this study are manifold and include: (1) identifying multi-levels of barriers to GSCM implementation from a combination of comprehensive literature review and industrial managers' opinions from the plastic manufacturing industry of Bangladesh; (2) identifying and proposing alternative strategic action plans (strategies) to help mitigate and implement GSCM practices in the plastic industry of Bangladesh; (3) introducing and integrating fuzzy theory and VIKOR method to develop a multi-criteria decision aiding tool capable of determining criteria importance weights and selecting optimal alternatives among others; and (4) applying this methodology and tools using empirical data for a multi-case studies involving some manufacturing companies of the plastic industry in Bangladesh.

GSCM barriers evaluation is a multidimensional and multi-criteria decision problem involving many and conflicting choices which therefore requires adequate tools to support the decision (Kusi-Sarpong et al., 2016a, 2019a). This study involves two key decisions – evaluation and ranking of barriers and; evaluation and ranking of alternative strategies with respect to the barriers. There exist in the literature, many MCDM tools/techniques such as ANP, AHP, DEMATEL, TOPSIS, ELECTRE etc (Mardani et al., 2015; Zavadskas et al., 2014) available for aiding the evaluation and ranking of barriers and alternatives. Amongst these, AHP happens to be the most heavily used MCDM in the literature (cf. Mardani et al., 2015) for evaluating and ranking criteria and alternative mainly due to its so-called ease of use but fails to consider the uncertainty and ambiguity of human judgement in decision-makers elicitation of their perceptions.

In this study, fuzzy set theory is instead introduced to aid in the evaluation and ranking of the barriers not just due to its ease of use but also because it considers uncertainty and ambiguity of human judgment decision-making process. Fuzzy set theory is of the view that fundamental factors in human perceptions and judgments are not numbers (contrary to AHP position), but rather phonetic terms of the fuzzy set (Büyüközkan & Ifi, 2012; Bai et al., 2016). Linguistic variables are therefore used to capture decision-makers preferences in terms of weights and then converted into fuzzy numbers to further obtain a more accurate crisp value. Therefore, fuzzy set theory was chosen over other methods because of these unique strengths.

VIKOR is also introduced to aid in the evaluation and ranking of alternative strategies with respect to the barriers. VIKOR has the advantage of providing an optimized solution in case of complex and conflicting situations and in cases where criteria have different units of measurement. It provides optimized solution that is closest to the ideal solution using compromise priority approach (Opricovic and Tzeng, 2004; Wu and Liu, 2011; Rostamzadeh et al., 2015). Another important strength of the VIKOR method over other methods such as TOPSIS (very rigid), is the flexibility given to the decision-makers exercising the judgements to be able to adjust the maximum set utility value which is between 0-1, to see how the results may change and decide on an optimal solution- test for analysis. These strengths make VIKOR method a very unique method and an option for this study.
However, VIKOR method just like any other compromise ranking and distance based methods, faces the limitation of requiring additional information about the criteria weights (in this study, barriers weights), the relative weights of the barriers obtain from fuzzy set method are further integrated into the VIKOR model to overcome this limitation and offering a complimentary power contributing to decision making application.

The remainder of the study is organized as follows: Section 2 briefly describes green supply chain management (GSCM), the plastics industries of Bangladesh, reviews of existing and related works, and barriers to GSCM implementation in Bangladesh. The proposed research methodology is outlined in Section 3; and Section 4 describes the solution methodology. An industrial case study investigation of the barriers aided by fuzzy-VIKOR method is given in Section 5. Analysis and discussion of results is provided in Section 6. Finally, conclusion remarks, managerial implications and future directions of the study are elaborated insection 7.

2. Literature review and background

In this section the literature review on GSCM, practices of GSCM in the plastic manufacturing industry, existing works on barriers analysis and the barriers to GSCM implementation are presented.

2.1 Green supply chain management (GSCM)

Environmental sustainability and ecological balance have been prime concern among environmentalists, researchers and practitioners. Due to the emerging degradation of the environment and wastage of energy, the industries and manufacturers are encouraged to adopt green and sustainable measures to protect the environment (Chiou et al., 2011; Helo & Ala-Harja, 2018; Srivastava, 2007; Vachon & Klassen, 2008). Green activities focus on the environmental conditions which promote sustainable development (Chin et al., 2015; Rao, 2002; Zaid et al., 2018; Zhu et al., 2007). Economic growth, rapid industrialization and new technology usage result in an increased waste generation and inadequate disposal system. These conditions are the causes of air pollution, deforestation, land degradation, an imbalance in bio-diversity etc. These environmental degradation and energy wastage have a tremendous impact on environment i.e. poor health, less agriculture production, climate change etc. (Ho et al., 2009; Perotti et al., 2012; Kusi-Sarpong et al., 2016b; Kusi-Sarpong et al., 2019a). GSCM focuses on the reduction of the negative environmental impacts by redesigning procurement, manufacturing system and proper waste processing and reverse logistics infrastructure (Chan et al., 2012; de Vargas Mores et al., 2018; Fortes, 2009; Kusi-Sarpong et al., 2019b). The industries and manufacturers are facing local and global pressures to adopt green initiatives in the emerging supply chain structure and management (Luthra et al., 2015; Sarkis, 2012). GSCM is a concept to facilitate the deployment of environmental initiatives into the supply chains from the organizational sourcing to the end product, ensuring less energy waste, less environmental degradation etc. GSCM ensures a promising and a long-lasting relationship with the suppliers and consumers with the long run commitment to promoting green initiatives (Diabat & Govindan, 2011; Perotti et al., 2012; Petljak et al., 2018). Incorporating green initiatives into the supply chains ensures reduction of wastage and energy loss. The action plans for green supply chain can be categorised into three areas – strategy, environment and logistics (Ahi & Searcy, 2013; Falatoonitoosi et al., 2013). The main concern of GSCM is the sustainability and protection of the environment. Logistics activities are considered vital part of green supply chains. Logistics activities such as selection of raw materials, distribution channel, warehouse, reverse logistics and waste processing management are the primary concerns of green initiatives of the whole supply chain (Govindan et al., 2014; Sarkis et al., 2018; Testa & Iraldo, 2010). GSCM helps the industries increase efficiency by reducing resources and energy loss (Agyemang et al., 2016, 2018).

The present economy of the world is largely dependent on manufacturing and production (Agyemang et al., 2019). But due to the emerging needs, manufacturers are giving utmost priority to mass production giving less priority to the environmental sustainability (Ho et al., 2009; Petljak et al., 2018; Tseng et al., 2013). Yet, ecological balance is a must for the existence of human being. Energy is limited therefore reduction in energy use can result in dramatic positive consequences in the long run (Kaviani et al., 2019). Local and global advocacy groups and governments are very much concerned about the present condition of the world. Therefore, they are giving pressures to the industries to adopt GSCM practices in their management and operations (Tseng et al., 2019; Zhu et al., 2007; Zhu & Cote, 2004).

Many studies and researches are being conducted on the concept of GSCM. However, most of these works have been carried out in the context of developed countries (Tseng et al., 2019). These works can provide a framework for further study of GSCM practices in emerging economies context. Previous researchers have identified many dimensions of green supply chain concept. Beamon (1999) investigated the comparison between tradition supply chain and green supply chain. He argued that traditional supply chain is a one-directional strategy where raw materials are converted to final products for the end customers. He, on the other hand further stated that, green supply chain is more focused on the environmental issues which are a multi-dimensional strategy. In their study, Govindan et al.(2014) examined the barriers to implementing GSCM in Indian industries. Luthra et al.(2011) investigated the barriers to implementing GSCM practices in the Indian automobile industries. Ojo et al.(2014) studied the substantial barriers to implementing GSCM in the Nigerian construction industries.

GSCM practices are of two categories including: internal GSCM practices and external GSCM collaboration practices. Green marketing and branding, green policy, green technology in production process, green shipping methods belong to the internal activities of GSCM. Collaboration with suppliers, customers and other parties regarding the long-term commitment of green initiatives are considered as external activities of GSCM (Fang & Zhang, 2018; Lintukangas et al., 2016; Nikbakhsh, 2009; Zhu et al., 2012). Green design (eco-design), green packaging, green procurement, green sourcing, green production, green material selection, green supplier selection, green logistics i.e. green transportation, green warehouse, green recycling, green logistics, green purchasing, green marketing, green policy, green shipping, circular economy, waste processing facility are all modern concepts of GSCM (Amemba et al., 2013; Ivascu et al., 2015; Vachon & Klassen, 2006).

Greening all these activities and contents of supply chain ensures the sustainability of the environment. Establishing internal and external practices of GSCM ensures the long-term relationship with the supplier for green sourcing of materials, smooth operations in the manufacturing plants to reduce energy waste, production of eco-friendly products for the consumers and also ensures guaranteed returns after the end of the product life cycle all ensuring the survival of the initiative (Dheeraj & Vishal, 2012; Govindan et al., 2014; Hervani et al., 2005; Song & Gao, 2018). Continuous improvement and innovations in greening the processes of the supply chains will help mitigate the environmental risks. There are lots of barriers which hinder the implementation of GSCM practices (Cosimato & Troisi, 2015; Mangla et al., 2018; Muduli et al., 2013). Continuous research and needful actions will help industries handle these barriers and establish action plans for introducing green initiatives into their traditional supply chains.

2.2 The current state and practices of Bangladesh plastic industry

The Bangladesh plastic industry started as far back as 1960 (BPGMEA report, 2011). Since then the industry has played a major role in the economy of Bangladesh. For example, there was a significant growth of this industry during 1980-1990 (Proshad et al., 2017). The plastic industry has become an important industrial sector in Bangladesh in the last few decades (Pavel & Supinit, 2017, BPGMEA report, 2011). Due to the growth and export potential of this sector, Bangladesh government is facilitating the development of this area. However, the industry suffers from numerous environmental problems ranging from heavy reliance on finite resources for plastic production, additive effects on both wildlife and humans, and usage increasingly generating global waste management problems (Thompson et al., 2009). For example, during plastic production, polymer resins are mixed with various additive including phthalates plasticizer, bisphenol A, carbon, silica, etc. to improve performance (Thompson et al., 2009).

Many of such additive chemicals are very toxic and hazardous and are not only emitted to the environment during the production of plastic products (Pavel & Supinit, 2017) but may also result in dangerous and hamrful products flowing to consumers (Bai et al., 2019) which leach out of the plastic products when in use (Thompson et al., 2009; Wagner & Oehlmann, 2009). For example, phthalates plasticizer and bisphenol A are easily detachable when in dust, air and aquatic (Rudel et al., 2001, 2003). They have hazardous impacts on the environment, more specifically to wildlife and humans (Meeker et al., 2009; Oehlmann et al., 2009). Another very severe environmental issue occurs during the production of Polyethylene Terephthalate (PET). The production of a PET (Polyethylene Terephthalate) bottle releases about 100 times air pollutants than by the same amount of glass production (Wagner & Oehlmann, 2009; *Plastic Pollution*, 2017). The presence of these gases in the atmosphere is a serious detrimental to both humans and wildlife health.

In terms of waste management problems created by the Bangladesh plastic industry, it is reported that, plastic contributes approximately 80% of the country's waste which is equivalent to 800,000 tonnes, of which around 200,000 tonnes go into ocean and river of Bangladesh (Proshad et al., 2017; Earth Day Network, 2018). Marine debris, which includes plastic wastes, is polluting coastal areas. As a result, the environment, wildlife and human health in the Bay of Bengal are being highly affected by these wastes (Mainali et al., 2018). Most of the currently used plastic materials are non-biodegradable and the end used plastic materials decompose at different rate, of which most of them requires 15 years, 100 years or even more than 100 years (Proshad et al., 2017). Bangladesh is facing serious water pollution by plastic waste. The plastic wastes in the water bodies disturb the natural flow and limits the ability of fish to reproduce and destroys helpful organisms (Proshad et al., 2017). As a result of these negative adverse effects by the plastic industry, and due to that fact that plastics are extremely helpful to our daily lives and economic development, there is a strong pressure on the industry by various stakeholder groups including social activists and governmental agencies to lower the pollution level to protect the environment and natural resources (Esa Abrar Khan, 2017). Therefore, there is the need for the plastic industry to transit from its current environmental unfriendly operations to a more environmentally sustainable supply chain operation.

Transitioning the plastic industry from its current negative environmental position to a more environmental-friendly operations requires that green practices be introduced and incorporated into the plastic industry's supply chain operations. Green initiatives can help the plastic industry change their overall operational requirements and management systems such as green sourcing, green logistics, green production, green packaging etc. (Jabbour et al., 2015; Fahimnia et al., 2015; Vilarinho at al., 2018). For example, Hi-tech machineries required for green production will ensure low or minimal emission of hazardous gases and elements to the environment which is safe for air, water and overall environment. This study aims at to identifying the barriers and ranking them and, finding out the suitable action plans for the smooth implementation of GSCM practices in the plastic industry of Bangladesh.

2.3 Review of existing and related works

Industries are facing obligations to adopt green initiatives in the supply chains due to the emerging pressure from government and international community to protect the environment (Govindan et al., 2014; Min & Kim, 2012; Zhu & Sarkis, 2004; Orji et al., 2019). Green practices are widely utilized in the industries of the developed countries. Adopting green practices in the manufacturing sector of some developed countries is mandatory (Bhattacharya et al., 2014; Cosimato & Troisi, 2015; Song & Gao, 2018; Subramanian & Gunasekaran, 2015). Research on different aspects of green concept of the supply chains is being conducted worldwide to flourish the green practices of the environment. Green practices are not widely practiced in the manufacturing sector of Bangladesh. There is little or no significant research on GSCM practices in Bangladesh. The plastic industry deals with the production of plastic made products which include various grades of plastic elements. The industries pay little attention to the environmental pollution resulting from for example emission of hazardous gasses and elements. This demotivation may have resulted from some difficulties hindering these organizations initiatives to greening their operations and supply chains. Rigorous research is needed to identify the barriers hindering the implementation of GSCM practices in the plastic industry of Bangladesh. This lack of research gap simulates this study to identify and analyze the barriers to implementing GSCM practices in the plastic industry of Bangladesh. To achieve the goal of this study, the concept of green and barriers to implementing GSCM practices need to be critically reviewed from previous researches. Previous research on green supply chains and barriers to implementing GSCM practices in other industries will set the stage for conducting research on barriers and GSCM practices in the plastic industry of Bangladesh context. Mathiyazhagan et al., (2016) identified most influential thirty-eight barriers to implementing GSCM practices in the plastic processing industries of India. Satapathy, (2017) investigated barriers for plastic recycling of the plastic industry of India. Muduli et al., (2013) addressed barriers to implementing GSCM in Indian mining industries in their research work. Beamon, (1999) discussed an overview of the design of GSCM practices in his study. Table 1 summarizes the existing works on the concept of GSCM and barriers to implementing GSCM practices in other industries.

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2.4 Barriers to green supply chain management practices

Barriers in different aspects of technology, infrastructure, organizational policy, knowledge, financial matters are the main hindrance to implementing green initiatives along the supply chains of plastic industry of Bangladesh. This study mainly focuses on the identification and analysis of the barriers in different areas for implementing GSCM practices. Introducing green technologies and activities is a pressing need because of the immense local and global pressures for organizations to transit toward sustainability (Hsu et al., 2013; Youn et al., 2012). Green businesses are the solution to the present degradation of the environment (Page, 2013; Tseng et al., 2014; Yi, 2014; Ying & Zhou, 2012). Going green reduces energy consumption and carbon-dioxide (CO_2) emission to the environment and ensures environmental sustainability (Wang et al., 2013; Zhu & Sarkis, 2004). However, GSCM implementation in a comparatively new business environmental is somewhat arduous task. Identifying the barriers that hinder the implementation of GSCM practices in traditional supply chains can motivate and provide a solution to the industrial and decision-makers to initiate action plans for implementing GSCM practices smoothly. With a combination of literature reviews and opinions from relevant industrial managers, the most critical, main barriers and sub-barriers to implementing GSCM practices in the plastic industry of Bangladesh were identified. The purposive sampling approach was carried out to consider the four case companies and four industrial managers representing each company. In purposive sampling technique, the case companies and their associated respondents are not taken randomly but based on the purpose of the case and their potential contributions to the study (Bai et al., 2017; Bai et al., 2019; Maalouf & Gammelgaard, 2016). A number of barriers and sub-barriers were initially identified through rigorous literature review. The identified barriers were listed and put together in a semi-structured questionnaire form, and sent to these industrial managers for their opinions in refining them by putting 'yes' (acceptance) or 'no' (rejection). A threshold is agreed (consensus is reached) and any barrier that meets or exceeds the set threshold after the analysis are maintained, otherwise deleted. On the basis of the manager's opinions and analysis, the main barriers and sub-barriers were selected for the final evaluation. These barriers include four main barriers and twenty-five sub-barriers. The main barriers include Insufficient Technology & Infrastructure; Inadequate Knowledge & Support; Unsupportive Organizational & Operational Policy; and Financial Constraints. This study now overviews these barriers based on literature review.

2.4.1 Insufficient technology & infrastructure (B1)

Green activities of supply chain require many innovative technologies and infrastructures. Green technologies in the supply chain are gaining popularity in the present time (Vachon & Klassen, 2006). Green manufacturing practice is an essential part of green supply chain practice (Dornfeld, 2012; Luthra et al., 2014). Insufficient green technology in the manufacturing processes can casue greater emission of hazardous elements, produce gases to the environment, and cause unnecessary energy loss (Ahi & Searcy, 2013; Colicchia et al., 2017; Yang et al., 2013). The lack of advanced technology (B11) can potentially hinder the implementation of GSCM practices (Yang et al., 2013; Zhou, 2009). In Bangladeshi, the adoption of GSCM is not mandatory for the manufacturing sector and as such not well practiced in most of the manufacturing companies (Ghosh & Shah, 2015; Marshall et al., 2015; Savino et al., 2015; Tseng & Chiu, 2013). This results in the lack of shared knowledge of the best GSCM practices (B12) among Bangladesh manufacturing companies which is one of the barriers to the GSCM implementation. In the plastic industry of Bangladesh, there is a lack of R & D practices for product recovery system (B13) which is one of the potentially significant barriers to the implementation of GSCM practices (Cosimato & Troisi, 2015; Wu, 2013). The lack of R & D facilities within the plastic industry of Bangladesh could prevent the discovery of green solutions and initiatives which may hinder the implementation of GSCM practices (Dubey et al., 2015; Mingqiang, 2011). The lack of technical expertise (B14) is another critical barrier that could hinder the promotion of green initiatives and increase the level of complexity in recovery operations (B15) towards the implementation of GSCM practices in the plastic industry of Bangladesh (Laosirihongthong et al., 2013; Muduli et al., 2013). Many plastic manufacturing companies in Bangladesh do not use modern manufacturing technologies, storage and transportation facilities for their operations (Diabat & Govindan, 2011; Zhu & Geng, 2013). The lack of modern technologies, facility of storage and transportation (B16) can significantly inhibit the implementation of a comprehensive GSCM practices in the plastic industry of Bangladesh (Diabat & Govindan, 2011; Perotti et al., 2012; Pimenta & Ball, 2015).

2.4.2 Inadequate knowledge & support (B2)

Introducing and practicing green initiatives in the traditional supply chains needs adequate knowledge on green supply chain concept, proper training, and support (Islam et al., 2017; Seuring & Müller, 2008; Tseng & Chiu, 2013). The lack of knowledge on green practices

(B21) can significantly hinder the implementation of GSCM practices (Kumar et al., 2015; Mehrabi et al., 2012). The supply chain practitioners of the plastic industry of Bangladesh give relatively little attention and importance to environmental issues as a result of their current lack of knowledge on the importance of GSCM. Due to lack of environmental knowledge (B22) on green issues, the manufacturing sectors in Bangladesh are comfortable with the use of environment polluting materials and processes, which does have serious economic repercussions (Laosirihongthong et al., 2013; Tseng & Chiu, 2013). Many manufacturing companies from the Bangladeshi plastic industry are still using the most out moulded technologies for their operations which do have adverse effect on the environment (Tay et al., 2015; Vachon, 2007). The plastic industry of Bangladesh provides little opportunity for employee training on GSCM practices limiting their knowledge-based to the traditional supply chain operations (Lintukangas et al., 2013; Muduli & Barve, 2013). This lack of employee training on GSCM practices (B23) in Bangladesh manufacturing sector is a serious hindrance to the implementation of GSCM practices in the plastic industry (Kabra et al., 2015; Walker et al., 2008; Zhao et al., 2017). This subsequently limits these employee capabilities and competences on green products awareness creation for customer patronage. The lack of customer awareness on green products (B24) is a significant barrier to green product patronage and sustenance and smooth implementation of GSCM practices (Kumar & Chandrakar, 2012; Sarkis et al., 2011). Due to the lack of tax knowledge on returned products (B25) by the plastic manufacturing sector of Bangladesh, the industry is not motivated to introduce re-manufacturing system into their supply chain operations to gain some financial benefits through the tax incentive to support the GSCM implementation (Ahi & Searcy, 2013; Testa & Iraldo, 2010; Wang & Sarkis, 2013). Another potential barrier to the successful adoption of GSCM practices in the plastic industry of Bangladesh is the lack of interest and support from top management to adopt GSCM (B26) within their supply chain operations (Nadine, 2013; Shen et al., 2013). Top management support is one of the fundamental barriers in almost all companies and industries hindering the successful implementation of programs, the plastic industry of Bangladesh is no exception.

2.4.3 Unsupportive organizational & operational policy (B3)

Unsupportive organizational and operational policies can significantly hinder the implementation of new concepts and programs within the entire organization (Malcon & Martinez 2012; Sulistio & Rini, 2015). Deficient organizational structure of the companies to adopt GSCM (B31) can potentially hinder the implementation of green practices in the supply chains (Jayant & Azhar, 2014; Kumar et al., 2015). The lack of government supportive policies for GSCM (B32) implementation is another barrier faced by Bangladeshi's plastic manufacturing sector to implementing green practices in their supply chains (Patil & Dolas, 2015; Sulistio & Rini, 2015). If stakeholders of supply chains do not support each other during the implementation of GSCM practices, then, the program will be challenging for the individual companies and may be bound to fail (Seman et al., 2012a,b; Zhu et al., 2008a). The lack of support from supply chain stakeholders (B33) is pressing barrier to the smooth implementation of GSCM practices (Lintukangas et al., 2013; Tay et al., 2015). The plastics industries of Bangladesh have few recycling facilities within their business structure. As a result of the lack of recycling and reuse facilities of organizations (B34), the industries are unable to enjoy the profitability of green activities (Govindan et al., 2014; Mutingi, 2013). In addition, the plastic industry of Bangladesh is not working within any international standard. Due to the lack of international environmental certification (e.g. ISO 14001) (B35), the plastics industries are facing difficulties in achieving international recognition, thereby are unable to penetrate the international market and increase market share (Chiarini, 2012; Curkovic & Sroufe, 2011; Nishitani, 2010). Lack of standard practices for GSCM (B36) is another potential hindrance to the implementation of green activities in the supply chains. Current Bangladeshi government's rules and regulations do not support and motivate greening of organizations and their supply chains. This lack of legislation requirement (B37) demotivates firms and is considered a potential barrier to implementing GSCM practices in the plastic industry of Bangladesh (Kumar et al., 2015; Min & Kim, 2012; Vachon & Klassen, 2006).

2.4.4 Financial constraints (B4)

Greening the supply chains require different modern and high-tech green technologies, infrastructure and eco-designs, which require huge financial investment (Lin, 2011; Teixeira et al., 2016; Vachon, 2007). Financial constraint is considered a significant barrier to the implementation of GSCM practices in the plastic processing industries of Bangladesh. Due to cost implication (B41) involved in acquiring green technologies and modernizing their supply chains processes, the plastic manufacturing industries of Bangladesh are faced with difficulties in achieving their green agenda (Ho et al., 2009; Tippayawong et al., 2015; Zhu et al., 2008b). The plastic industry of Bangladesh are facing immense difficulties to implementing GSCM practices due to the un-availability of bank loans to encourage green product (B42) for the consumers (Dubey et al., 2015; Ojo, 2014). Another potential hindrance faced by the Bangladeshi's plastic industry toward the implementation of GSCM practices is the uncertainty related to economic issues (B43) (Olugu et al., 2011; Rao & Holt, 2005; Richey et al., 2010). Cost of disposal of hazardous products (B44) is significantly huge, with this huge cost implication causing the uncertainty of implementing GSCM practices (Kushwaha, 2010; Sambrani & Pol, 2016). The green supply chain concept is a novel phenomenon that the plastic industry of Bangladesh is not fully aware of and the associated economic benefits they seek to gain by greening their supply chains (Art, 2010; Li et al., 2015). This lack of knowledge of economic benefits (B45) that the companies seek to gain is considered to be one of the potential barriers hindering GSCM implementation. Organizations perceive GSCM implementation as a program with high initial and operating cost with no short-term benefits and so are demotivated to such initiative (Chin et al., 2015; Zhu & Sarkis, 2004). The perceived high initial and operating cost (B46) of greening the supply chains is a significant barrier to implementing GSCM practices in the plastics industries of Bangladesh (Sameer Kumar et al., 2012; Mutingi, 2013; Ojo et al., 2014).

The major four barriers and twenty-five sub-barriers are summarizedinTable2.

<Take in Table 2 about here>

2.5 Alternative action plans for smooth GSCM implementation

For the smooth implementation of GSCM practices in the plastic industry of Bangladesh, four alternative action plans are proposed. Based on the study of barriers and success factors from the relevant literature and expert opinions, these alternative action plans are put together to aid in the smooth implementation of GSCM in the case company. The identified barriers are the weak points in case of implementing GSCM practices. Taking these barriers into account, the relevant action plans are determined which are almost opposite to the barriers. These action plans will strategically become the strong point for the smooth implementation of GSCM practices in the case company. The proposed action plans are as follows:

Action Plan 1- Top management's full and continuous commitment and support and organizing awareness programs (A1):

One of the major barriers identified is 'Inadequate knowledge & support (B2)' in implementing green supply chain management. Organizations need continuous support from the top management through proper training and awareness programs to identify the loop-holes and implement green supply chain management practices.

Action Plan 2- Development and introduction of infrastructure and cleaner technology (A2): This research finds out that, 'Insufficient technology & infrastructure (B1)' is another major barrier. Undoubtedly, introduction of developed infrastructure and modern technology in the organizations is a must to establish green supply chain management practices.

Action Plan 3- Provision of substantial financial support to initiate and implementation GSCM programs (A3):

It is obvious that 'Financial constraints (B4)' impose huge hindrance in implementing GSCM practices. Therefore, it is a necessary action plan to provide sustainable financial support to implement GSCM programs.

Action Plan 4-Development of organizational and operational policies towards greening initiatives and practices (A4): Through literature review, this research points out that 'Unsupportive organizational & operational policy (B3)' is one of the significant barriers in implementing GSCM practices. Development of organizational and operational policies may play a positive role in implementing GSCM practices.

Top management's continuous commitment and support will encourage industries to adopt GSCM practices and motivate them to organize various customer awareness programs for green products and green activities (Gunasekaran et al., 2015; Luthra et al., 2015). Another important enabler of GSCM practices is the development and introduction of infrastructure and cleaner technology across supply chains (Mutingi, et al., 2014; Tachizawa et al., 2015; Wu et al. 2011). Financial support plays a crucial role in enabling the implementation of GSCM practices in a more comprehensive manner and the development of organizational and operational policies to ensure the smooth implementation of GSCM practices (Balasubramanian & Shukla, 2017; Martusa, 2013; Sarkis, 2012)

3. Proposed research methodology

To achieve the objectives of this study, a review of existing literature on GSCM was conducted to identify potential barriers to the implementation of GSCM. These potential barriers were listed/tabulated and submitted to a number of industrial managers from the relevant industries for their review and refinement to get the barriers focused on the manufacturing sector context. From the outcomes of the reviewed of current literature and opinions from the managers of the relevant industries, the most influential barriers to GSCM practices were selected for the plastic industry of Bangladesh. In this study, four evaluators (industrial managers) were selected from four plastics processing companies in Bangladesh (see Dou et al. (2014); Gupta and Barua, (2018); Rezaei et al. (2018) that used four or even fewer experts). The case companies (and by extension their respective respondent managers) were purposively selected based on their high interest in wanting to identify and evaluate the barriers to implementing GSCM in their supply chains in order to mitigate them. The case companies (leading plastic processing companies in Bangladesh) are facing tremendous pressure from national and international organizations and global market to incorporate green activities into their supply chain operations. They are facing problem in implementing GSCM practices due to the presence of several barriers. So this study can help them identify and assess the barriers to implementing GSCM practices and mitigating them accordingly. Table 3 shows the characteristics/details of the four purposively selected industrial managers and their purposively selected plastic manufacturing companies in Bangladesh involved in the refinement and evaluation of the barriers and alternative action plans in this study.

<Take in Table 3 about here>

This study consists of four major barriers and twenty-five sub-barriers. The identified barriers and sub-barriers to GSCM implementation are presented in Table 2. By defining linguistic scale with corresponding fuzzy scale to evaluate barriers and another linguistic scale with corresponding fuzzy scale to evaluate and rank alternatives, aggregated fuzzy weights of barriers and aggregated fuzzy ranking of alternatives are constructed to form fuzzy decision matrices. After the de-fuzzification of the aggregated fuzzy values of alternatives and finding the relevant values, precise calculations are performed to achieve the ranking of the major barriers along with the individual ranking of the sub-barriers. The ranking of the alternative action plans is also completed. The systematic graphical research framework is illustrated in Fig 1.

<Take in Fig. 1 about here>

4. Fuzzy-VIKOR methodology

4.1 Fuzzy Set

In different conditions, imprecision, subjectivity, human perception, crisp numbered information are inadequate. Fuzzy set (FS) theory (Zadeh, 1965; Zadeh, 1976) was introduced with the view that the fundamental factors in human perception and judgment are not numbers, but rather phonetic terms of the fuzzy set. FS theory was taken into account to address the ambiguity and imprecision of human judgment by using linguistics scale. FS theory was first utilized by Bellman and Zadeh (1970) in decision-making problems. Fuzzy based MCDA (multi-criteria decision analysis) tools utilize linguistic variables to obtain decision maker's (DMs) view in terms of weights and then converted into fuzzy numbers (Büyüközkan & Ifi, 2012; Rostamzadeh et al., 2015; Shen et al., 2013). FS theory gives more extensive results than classic set theory in real life decision-making problems (Çağman et al., 2010; Deschrijver & Kerre, 2003; Zimmermann, 2010). FS theory is explained below to solve proposed decision-making problem.

Definition 1: (Fuzzy set): Let Z be the universal set of discourse, $Z=\{z_1, z_2, z_3, ...z_n\}$ .A FS"*A* of *Z*" is a set of order pairs $\{(z_1, f_A(z_1)), (z_2, f_A(z_2)), (z_3, f_A(z_3)), ...(z_n, f_A(z_n))\}$ where $f_A : Z \rightarrow [0,1]$ is the function of *A*, and $f_A(z_i)$ denotes for the membership degree of z_i in *A*.

Definition 2: (Fuzzy number): A tilde ' ~ ' over a symbol indicates the symbol of a FS. TFNs (triangular fuzzy numbers) are easy and realizable for DMs. Therefore, in this study, TFNs are used to evaluate the GSCM implementing barriers. A TFN *M* is given in **Fig. 2**. A TFN is indicated as *(l, m, u)* where *l>m>u*, with *l* as the smallest conceivable value, *m* as the middle value, and *u* as the biggest conceivable value. Each TFN has linear portrayals to its left side and right side with the end goal that its membership function can be composed as ***Eq. (1):***

$$\mu(z/\widetilde{M}) = \begin{cases} 0, & z < l \\ (z-l)/(m-l), & l \le z \le m \\ (u-z)/(u-m), & m \le z \le u \\ 0, & z > u \end{cases} \quad (1)$$

<Take in Fig. 2 about here>

A fuzzy number can simply be given by its comparing left and right portrayal of every level of membership as appeared in ***Eq. (2):***

$$\overline{M} = \overline{M}^{l(y)}, \overline{M}^{r(y)} = (l + (m-l)y, u + (m-u)y), y \in [0,1] \quad (2)$$

Definition 3. *Let* G = (l,m,u) *and* $H = (o,p,q)$ are two TFNs. Then the basic mathematical operations of TFN are explained as follows:

$$G + H = (l,m,u) + (o,p,q) = (l+o, m+p, u+q) \quad (3)$$

$$G - H = (l,m,u) - (o,p,q) = (l-o, m-p, u-q) \quad (4)$$

$$G \times H = (l,m,u) \times (o,p,q) = (lo, mp, uq) \quad (5)$$

$$G \div H = \frac{(l,m,u)}{(o,p,q)} = \left(\frac{l}{q}, \frac{m}{p}, \frac{u}{o}\right) \quad (6)$$

$$(k,k,k) \times (l,m,u) = (kl, km, ku), k > 0, k \in R. \quad (7)$$

$$G^{-1} = (l,m,u)^{-1} = \left(\frac{1}{u}, \frac{1}{m}, \frac{1}{l}\right) \quad (8)$$

Definition 4. *Let* G $= (l,m,u)$ *and* $H = (o,p,q)$ are two TFNs (see **Fig. 3**). The distance between fuzzy numbers A and B is computed as follows:

$$d(G,H) = \sqrt{\frac{1}{3}\left[(l-o)^2 + (m-p)^2 + (u-q)^2\right]} \quad (9)$$

<*Take in Fig. 3 about here*>

Definition 5. Let a group decision-making has *K* evaluators, and the fuzzy rating of evaluators D_k (k = 1,2,. ., K) can be denoted as a positive TFN R_k (k = 1,2,. .,K) with membership function FR_k (z). Therefore, the aggregated fuzzy rating can be explained as:

$$R = (l,m,u); k = 1,2,3,.....K \quad (10)$$

$$where, l = \min_k \{l_k\}_k, m = 1/k \sum_{k=1}^{k} m_k, u = \max_k \{u_k\}_k.$$

4.2 The VIKOR method

The VIKOR method was developed for the optimization of complex multi-criteria systems (Opricovic, &Tzeng, 2004). The method is used for ranking and selecting from a set of alternatives using conflicting criteria. Its analysis is based on compromise ranking approach. The compromising ranking of multi-criteria measure is developed from the *Lp*-matric used as an aggregated function in a compromising programming method (Opricovic, & Tzeng, 2004, 2007). The *J* alternatives are represented as $a_1, a_2, ..., a_J$. For all alternatives a_J, the rating of the i^{th} aspect is represented by f_{ij}, i.e.f_{ij}, if the value of i^{th} criterion function for the alternative a_J: *n* is number of criteria.

The *Lp*-matric is given below**:**

$$L_{pi} = \left\{ \sum_{j=1}^{n} W_j \left[\left(\frac{f_j^* - f_{ij}}{f_j^* - f_j^-} \right) \right] \right\}^{1/p} \quad 1 \le p \le +\alpha; i = 1, 2, 3, ...I. (11)$$

In the VIKOR methodology, to evaluate and rank the MCDA problems, ($L_{1,i}$ *as* S_i) and ($L_{\infty,I}$ *as* R_i) are utilized. The result acquired by min S_i is with a maximum group utility ("majority" rule), and the result acquired by min R_i *i*s with a minimum individual regret of the "opponent" (Sanayei et al., 2010). The algorithm of fuzzy VIKOR method can be explained by the following steps (Jingzhu & Xiangyi, 2008; Opricovic & Tzeng, 2004, 2007; Yazdani & Graeml, 2014).

Step 1. Define the research objectives of MCDA problems and define the existing problem to validate the research objectives. In this research, the research objective is to examine and rank GSCM implementing barriers with respective to plastic processing industry considering some relevant case companies.

Step 2. In compliance with this step and for the purpose of the study, decision groups are formed with four decision makers from some relevant case companies and determine the finite set of attributes. In this study, four main categories of GSCM implementing barriers, twenty-five sub barriers under the maincategory of barriers and four alternatives was considered. The discussion of the identified major GSCM implementing barriers using the sub-barriers are given in section 2.4 and tabulated in **Table 2**.

Step 3. To assess the barriers, a linguistic scale with corresponding fuzzy scale is define and for evaluating and ranking the alternatives with respect to each barrier another linguistic scale with corresponding fuzzy scale is defined. These scales are introduced to the decision-makers to evaluate barriers and rank alternatives. Fuzzy decision-making scale and fuzzy rating scale are shown in Fig. 4 and Fig. 5 respectively.

<Take in Fig. 4 & 5 about here>

Step 4. With the help of a group of decision-makers, individual linguistic responses are obtained and then converted into fuzzy responses. Thereafter, aggregated fuzzy weights of barriers and aggregated fuzzy ranking of alternatives are obtained. Then, a fuzzy decision matrix is formed. The aggregated fuzzy weights of barriers and aggregate fuzzy rating of alternatives with respect to each barrier is evaluated as follows (x_{ij}):

$$x_{ij} = (x_{ij1}, x_{ij2}, x_{ij3}) \quad (12)$$

Where, $x_{ij1} = \min\{x_{ij1}\}_k, x_{ij3} = \max\{x_{ij3}\}_k$ and the aggregated fuzzy weights w_j of each barrier can be computed as follows:

$$W = (\overline{w}_1, \overline{w}_2, \overline{w}_3) \; (13)$$

Where:

$$w_{j1} = \min\{w_{jk1}\}_k, w_{j2} = 1/k\sum_{k}^{k} w_{jk2}, w_{j3} = \max\{w_{jk3}\}_k$$

A decision matrix, D, of $m \times n$ dimension is defined as in Eq. (14):

$$D = A_i \begin{pmatrix} A_i \overline{x}_{11} & \overline{x}_{1j} & \overline{x}_{1n} \\ \vdots & \ddots & \vdots \\ A_i \overline{x}_{m1} & \overline{x}_{mj} & \overline{x}_{mn} \end{pmatrix} (14)$$

Where, $x_{ij}, \forall_{ij}$ is fuzzy numbers with a TFN as $\overline{x}_{ij} = l_{ij}, m_{ij}, u_{ij}$. The fuzzy weights can be explained by the Eq. (15):

$$W = (\overline{w}_1 ... \overline{w}_j ... \overline{w}_n); \overline{w}_j = \overline{\alpha}_1, \overline{\beta}_j, \overline{\chi}_n (15)$$

Step 5. The fuzzy decision matrices are de-fuzzify to determine better crisp values of each barrier. In this research work, center of area (COA) de-fuzzification method and process was followed to determine the best non-fuzzy performance (BNP) value. In general, mean of maximal (MOM), center of area (COA), and α -cut are three basic methods of BNP. The COA was chosen because of its practicability and simplicity. In COA method, there is no need for any evaluator to perform the basic operations. COA methods of triangular fuzzy performance score $\bar{h}_{ai} = (lh_{ai}, mh_{ai}, uh_{ai})$ can be used to evaluate BNP value and the below equation is applied to assess BNP value:

$$\text{BNP: } x_{ai} = lh_{ai} + \frac{(uh_{ai} - lh_{ai}) + (mh_{ai} - lh_{ai})}{3}, \forall a \quad (16)$$

Step 6. Find the f_j^* values and the f_j^- values of all listed barrier ratings, *j = 1, 2, . . . , n.*

$$f_j^* = \max\{f_{ij}\} \quad (17)$$

$$f_j^- = \min\{f_{ij}\} \quad (18)$$

Where, f_j^* is the positive value for the j^{th} barrier, and f_j^- is the negative value for the j^{th} barrier. If one associates all f_j^*, it will have the ideal mix, which gets the most noteworthy scores comparable to f_j^-.

Step 7. Calculate the values of S_i and R_i *(i=1, 2, . . . m*) using following Eqs.:

$$S_i = \sum_{j=1}^{n} W_j \left[\frac{f_j^* - f_{ij}}{f_j^* - f_j^-} \right] \quad (19)$$

$$R_i = \max_j \left[W_j \left(\frac{f_j^* - f_{ij}}{f_j^* - f_j^-} \right) \right] \quad (20)$$

Where S_i indicates the distance of i^{th} alternative to the positive result, and R_i indicates the distance of i^{th} alternative to the negative result. Likewise, W_j are the weights of criteria, which are communicated in their relative significance.

Step 8. Calculate the values of Q_i *(i = 1,2, . . . , m*) using **Eq. (21):**

$$Q_i = v \frac{S_i - S^*}{S^- - S^*} + (1-v) \frac{R_i - R^*}{R^- - R^*} \quad (21)$$

Where, $S^{-} = \max_i S_i, R^{-} = \max_i R_i, S^{*} = \min_i S_i, R^{*} = \min_i R_i$ and v is the weight of strategy of the majority of criteria or the maximum group utility. In this research, we considered $v = 0.5$.

Step 9. This step ranks the alternative action plans. With the help of step (8) calculated Q_i value, the action plans are ranked and based on this rank, a decision can be formulated.

Step 10. Determine as a compromise solution of alternative which is ranked the best by the measure of minimum estimation of *Q* satisfied by the two conditions below;

C1. The alternative $Q(A^{(1)})$ has a satisfactory preferred standpoint if $Q(A^{(2)}) - Q(A^{(1)}) \geq 1/n\text{-}1$ where $A^{(2)}$ is the option with the second position in the positioning rundown and *n* is the number of alternatives

C2. The alternative $Q(A^{(1)}$ is steady inside the decision-making process on the off chance that it is likewise best positioned in S_i and R_i.

Step 11. Select the best alternative by picking $Q(A^{(m)})$ as a best trade-off arrangement with the base estimation of Q_i in regards to above conditions

5. An industrial multi-case study with the application of Fuzzy –VIKOR method

The developed methodology and framework has been applied to a real multi-case study and used to rank the major barriers with the sub-barriers to implementing GSCM practices using four plastic manufacturing companies in Bangladesh. These plastic manufacturing companies are facing numerous obstacles to implementing green activities in their traditional supply chains. These case companies demand the identification and ranking of barriers (major- and sub-barriers) to implementing GSCM practices and the strategic action plans for the smooth implementation. In this study, the major barriers and sub-barriers were initially identified through relevant literature and previous studies. Then, four evaluators (industrial managers), one each from the four selected plastic manufacturing companies are involved for the refinement (developing the barriers), evaluation and ranking of the barriers with a fuzzy-VIKOR approach.

The application of theproposed method to the multi-case is given below:

Step 1: The main objective of this stage is defined and is the evaluation of the most influential GSCM implementing barriers in the context of plastic processing industry. The listed major barriers appear in **Table 1.**

Step 2: To evaluate the importance of each GSCM implementing barriers and rating of the alternatives, in this research, four industrial managers are employed with the help of a seven-point linguistics scale given in **Figures 3** and **4** respectively. The linguistics scale had corresponding fuzzy scale which is triangular fuzzy numbers.

Step 3: In this step, with the help of the four decision-makers (industrial managers), the main- and sub-barriers, and alternatives comparisons with respect to the barriers are evaluated. The evaluation of the barriers is given in **Tables 4** and **5** respectively.

<Take in Table 4 and 5 about here>

Step 4: The fuzzy evaluation matrix for the barriers weights and action plans are obtained and are shown in **Tables 6 and 7** respectively. The fuzzy values of the sub-barriers are also shown in **Table 8**. Then, using **Eqs. (12)** and **(13),** fuzzy aggregated values of action plans and importance weights are determined and are also shown in **Table 9**.

<Take in Tables 6 - 9 about here>

Step 5: In this step, the fuzzy aggregated values of action plans (alternatives) rates are de-fuzzified using **Eq. (16)** and are shown in **Table 10**.

Step 6: Using **Eqs. (17)** and **(18),** the best f_j^* and the worst f_j^- values are determined and are also shown in **Table 10 (Columns 8 & 9 respectively)**.

<Take in Table 10 about here>

Step 7, 8 and 9: Using **Eqs. (19) - (21),** the values of S, R and Q for all proposed action plans were determined and are shown in **Table 11**. In this study, the weight of the maximum group utility (v) is considered as**0.5**.

<Take in Table 11 about here>

Step 10: In this stage, final positioning of the action plans by *S*, *R* and *Q* in descending order are re-assessed and displayed in **Table 12**. In light of the crisp Q_i value, the positioning of the alternatives in descending order is completed as *A2*> *A1*> *A4*>*A3*. In this stage, the best alternativeis observed to be *A2*. Additionally, both *C1* and *C2* conditions are fulfilled, which implies that QA4-QA1≥1/4-1 and also *A2* is best positioned by *R* and *S*.

<Take in Table 12 about here>

Step 11: According to importance weight of barriers and sub- barriers from the four decision-makers (industrial managers) from the four case companies, *A2* is the best and initial action plan selected for implementing GSCM practices in the plastic processing industry.

6. Results analysis and discussion

Barriers to GSCM implementation are evaluated and ranked and the alternative action plans also evalauted and ranked for smooth GSCM implementation for the plastic manufacturing industry of Bangladesh in this study. The proposed methodology has been systematically implemented to evaluate and rank the barriers and sub-barriers to GSCM implementation as well as rank the alternative action plans.

The final main barriers and sub-barriers evaluation ranking results of the study can be found in Table 13. Based on the normalized values (weights), the main barriers to GSCM implementation for the case companies are ranked as follows: 'inadequate knowledge & support (B2)' with the weight of 0.279 is ranked the highest, making it the most influential barrier, followed by 'insufficient technology & infrastructure (B1)' with the weight of 0.274 ranked second in terms of severity of imposing barrier, 'financial constraints (B4)'with the weight of 0.257 is ranked third and 'unsupportive organizational & operational policy (B3)' with the weight of 0.19 is ranked the fourth and last in terms of intensity.

< Take in Table 13 about here>

Table 13 also shows the details of the rankings for the sub-barriers under each main barrier. 'Lack of advanced technology (B11)' with the weight of 0.213 is ranked the highest sub-barrier among the 'insufficient technology & infrastructure (B1)'main barrier group. This ranking reveals that 'lack of advanced technology' is the most severe and influencing barrier that hinders the smooth implementation of GSCM practices in the case industry under this main barrier. The 'lack of modern technologies, facility of storage and transportation (B16)' with the weight 0.124 is ranked the least severe barrier among this sub-barrier list. The ranking of the other influencing sub-barriers under this main barrier can also be found in Table 13.

Within the main barrier group 'inadequate knowledge & support (B2)', 'lack of knowledge on green practices (B21)' with the weight of 0.199 is ranked the highest among this sub-barrier group. This means that, lack of knowledge on green practices is considered the most pressing and severe hindrance to the implementation of GSCM practices in the case industry under this main barrier. Within this group, ‘lack of tax knowledge on returned products (B25)’ with the weight of 0.129 is ranked the lowest among the sub-barrier set. This sub-barrier is ranked the lowest maybe because respondent managers considered it effect on the implementation of GSCM practices in the case industry as pretty low. The rest of the sub-barriers under this group ranking can be found in Table 13.

‘Lack of government supportive policies for GSCM (B32)’ with the weight of 0.164 is ranked the highest barrier among the ‘unsupportive organizational & operational policy (B3)’ main barrier group. This means that, the case industry does perceive the lack of governmental support as the greatest hindrance towards enhancing GSCM policies implementation. ‘Lack of recycling and reuse facilities of organizations (B34)’ is ranked as the least among this sub-barrier list. This may mean that, the country may not be reluctant to recycling and reuse of end-of-life products, a system that most developed countries are very much interested to implement. However, with the full support of the government (incentives etc.), these companies will definitely be motivated to take up such initiative. The remaining sub-barriers rankings under this main barrier group can be found in Table 13.

Under the ‘financial constraints (B4)’main barrier group, ‘uncertainty related to economic issues (B43)’ with the weight of 0.195 is ranked the highest, hence considered the most influencing barrier under this main barrier. Thus, implementing green activities in the traditional supply chain imposes many financial related uncertainties. These uncertainties are regarded as influential barriers of financial constraints. The least ranked sub-barrier under this main barrier is ‘cost of disposal of hazardous products (B44)’ with the weight of 0.133. If the cost of disposal is actually not much of a problem to the industry (based on it been ranked the lowest within the group), then the companies may really be interested in implementing GSCM and may need some support. Ranking of the other sub-barriers under this main barrier is presented in Table 13.

This research finds out that lack of knowledge about GSCM and proper support from the top management are the main hindrance in implementing GSCM practices in the plastic industry of Bangladesh. As there is less support from the top management, the organizations are unable to manage sufficient technology and infrastructure to implement GSCM practices. In addition, from the findings of this research, it is clear that insufficient technology and infrastructure is one of the major barriers in implementing GSCM practices. It is also found that in this research that, the organizations of plastic industries of Bangladesh don’t sanction budget for training on GSCM practices and purchase high-tech software and infrastructure to implement GSCM practices because of financial constraints. Financial constraints are one of the major barriers in implementing GSCM practices. This research also finds out that unsupportive organizational and operational policy plays a negative role in implementing GSCM practices in the organizations. The organizations are not motivated to implement GSCM practices in their operational processes because of the lack of knowledge on the financial and operational benefits of GSCM practices.

6.1 Results comparison with existing literature

The result of this research work reveals that 'inadequate knowledge & support (B2)' is ranked top as the key barrier that hinders the implementation of GSCM in Bangladesh plastic manufacturing industry. Contrary to the outcome of this study's findings, Singh et al. (2016) investigated the barriers and factors to the implementation of GSCM in the context of Indian manufacturing industry, identified that, 'lack of support from top management' is the key barrier to implementing GSCM. However, they did not consider inadequate knowledge as a barrier in their study. Ojo et al., (2014) investigated the barriers to the implementation of GSCM in Nigerian's construction industry and found that 'lack of knowledge' was one of the major barriers to implementing GSCM. Interestingly and surprisingly, they also found that 'poor commitment by the top management' hindered the implementation of GSCM in Nigerian's construction industry. A study by Moktadir et al. (2018a) revealed that 'lack of awareness of local customers in green products' and 'lack of commitment of top management' are the most influential barriers in implementing sustainable and GSCM in the Bangladeshi leather industry. Govindan et al. (2014) explored the barriers to implementing GSCM in Indian manufacturing industry and found that 'information gap', meaning, lack of knowledge, hampers the implementation of GSCM. The above discussion reaffirms that, 'lack of knowledge and support' may act as a crucial barrier to implementing GSCM in a general context but also to Bangladeshi plastic manufacturing industry.

'Insufficient technology & infrastructure (B1)' was ranked the second on the list of barriers to implementing GSCM in the plastic industry of Bangladesh. Mathiyazhagan et al., (2013) investigated the barriers in implementaing GSCM in the context of Indian auto component manufacturing industries and found that, 'lack of new technology, materials and processes' was one of the most influencial barriers to impelemting GSCM. Sarker et al., (2018) investigated the barriers to implemeting GSCM in the footwear industry of

Bangladesh and identified that ‘insufficient technology and infrastructure’ was the major barriers to the industry. However, many researchers have pointed out that, ‘insufficient technology and infrastucture’ are major barriers to implementing GSCM. For example, Sanjay et al. (2016) indentified that, ‘incompetent technology and inferior facilities for manufacturing’ are major barriers in developing green products as a part of implementing GSCM. In another study by Luthra et al., (2015), they found that, ‘technical obstructions’ played a vital role in hindering the implementation of sustainable and GSCM in Indian automobile sector. Based on the above discussions, we can argued that, ‘insufficient technology & infrastructure’ are the most influencial barriers to implementing GSCM in the general context and more specifically to Bangladeshi plastic industry.

Financial constraints (B4) is ranked third on the list. Financial contriants is also considered in many studies as major barriers to implementing GSCM. Shibin et al. (2016) conducted an extensive literature review and identified that, financial barriers create a major hindrance to implementing GSCM. Nordin et al. (2014) investigated the barriers to implementing GSCM in Malaysian manufacturing firms and found financial barrier as one of the major barriers to GSCM implementation. Another study by Kaur et al (2019) identified that, ‘financial contraints’ is major barriers to implementing GSCM. Ali et al. (2018) in their study, emphasised that financial barriers may inhibit the implementation of sustainable GSCM in Bangladesh computer supply chain. The above literature discussions strongly support and reaffirms the view that financial constraints is indeed a major barrier that may hinders the progress of GSCM implementation in general/many context but also in Bangladesh plastic industry. However, it is very surprising to see financial constraints not ranked first on the list as one might expect that issues regarding funding may be a major issue to the progress of any initiatives in any context. For example, technological infrastructure which was ranked second, could be made possible only if there is enough and available funding, affirming its criticality.

Unsupportive organizational & operational policy (B3)’ happens to be the fourth barriers to Bangladesh GSCM implementation. Simillarly, Al Zaabi et al. (2013) reported in their study that, ‘unsupportive organizational and regulatory policy’ may hinder the implementation of GSCM in India fastener manufacturing industry. Mudgal et al., (2015) argued that, ‘restrictives company policies’ hinder the implementation of GSCM in Indian manufacturing industry. Ali et al., (2018) conducted a study to rank the barriers to implementing GSCM in Bangladeshi computer supply chain and found that ‘unsupportive company policy' is the least influential barrier. All these discussions support the position that 'unsupportive organizational & operational policy' (B3) may possibly inhibit the implementation of GSCM in the plastic industry of Bangladesh.

Overall, these above discussions attempt to make some sorts of comparison of the study's outcome with existing studies. It is clear from these discussions that, this study reaffirms some of the existing outcomes more strongly than other but generally, the above mentioned studies support the four identified barriers as those that may seriously hinder the imeplemtation of GSCM in Bangaldeshi Plastic industry.

6.2. Strategic action plans

The ranking of the barriers and sub-barriers reveals insights of the different hindrance to implementing GSCM practices in the case industry. For the smooth implementation of GSCM practices in the case industry, four alternative action plans were evaluated. The evaluation of the four action plans can aid the case industry and companies to implement GSCM practices smoothly. The outcome of the action plans evaluation can be found in Table 12. From the results presented in Table 12, action plan 2- 'development and introduction of infrastructure and cleaner technology (A2)' with the value of (S=7.29752, R=0.858333, Q=0) is ranked in the topmost position. Action plan 2 is regarded as the most important action plan for mitigating the aforementioned barriers and implementing GSCM. This is followed in the second position by the action Plan 1- 'top management's full and continuous commitment and support and organizing awareness programs (A1)' with the value of (S=10.47438, R=0.9, Q=0.851867). Action Plan 4- 'development of organizational and operational policies towards greening initiatives and practices (A4)' with the value of (S=11.18094, R=0.9, Q=0.930125) is ranked as the third most important action plan. Finally, action Plan 3- 'provision of substantial financial support to initiate GSCM programs implementation (A3)' with the value of (S=11.81181, R=0.9, Q=1) is ranked the fourth and last position and is regarded as the fourth most important action plan for addressing the GSCM implementation barriers. Thus, the proposed methodology is implemented successfully to rank and evaluate the main-and their sub-barriers and evaluate the action plans in this research work. Overall, this research identified four action plans to enhance the GSCM implementation in the organizations of the plastic industry of Bangladesh. Development and introduction of high-tech infrastructure along with cleaner technology can immensely enhance the implementation of GSCM practices with the full support and continuous commitment from the top management and proper awareness programs. Development of organizational and operational policies towards greening practices can play a vital role in implementing GSCM practices if there is a provision of substantial financial support from the top management to initiate GSCM implementation. This research work will provide the case industry with some insights of the barriers and action plans to implement GSCM practices.

7. Conclusions

7.1 Contributions and managerial implications

GSCM practices are gaining popularity widely in various manufacturing industries. Due to the emerging pressures from national and international organizations, the manufacturing industries have started to adopt green activities in their traditional supply chains. GSCM practices are widely practiced in the developed countries as against their counterparts in the emerging economies. The plastic manufacturing industry of Bangladesh is taking initiatives to incorporate green activities in their supply chains. Yet due to the lack of research and study on various obstacles and barriers that can inhibit the smooth implementation of GSCM practices, the plastics industries of Bangladesh are facing numerous problems when implementing GSCM practices. This study was initiated to determine the influential barriers to GSCM implementation and propose potential action plans to mitigate these barriers. These barriers and action plans are ranked systematically using the fuzzy-VIKOR approach and appropriate action plans are linked to each barrier for mitigation. The result reveals the identified four major barriers including- insufficient technology and infrastructure, inadequate knowledge and support, unsupportive organizational and operational policy, and financial constraints. However, 'inadequate knowledge and support' was found to be the most influential barrier among the four in implementing GSCM practices. The result also reveals the rankings of the sub-barriers under each major barriers and alternative action plans for the trouble-free implementation of GSCM practices for the plastic industry of Bangladesh. Development and introduction of infrastructure and cleaner technology was considered as the most significant action plan to support the implementation of GSCM practices in the plastics industries of Bangladesh. Green activities reduce energy loss and environmental degradation. Profitability is also ensured by adopting green activities and green technologies in the manufacturing plans.

The contributions and novelty of this study is summarized below:

(1) This study through a combination of literature review and Bangladesh plastic industry managerial inputs, proposes a multi-levels barrier framework composed of four main barriers and twenty five sub-barriers that hinders GSCM implementation. The framework can serve as a theoretical construct for further and future empirical studies on barriers to the plastic manufacturing industry.

(2) This research further contributes to the extant literature by identifying and proposing, four alternative strategic action plans (strategies) to help mitigate the barriers and aid in the implementation of GSCM practices in Bangladesh plastic industry. To best of our knowledge, this paper is one of the very first studies that have attempted to map GSCM strategies to deal with GSCM barriers.

(3) This study integrates fuzzy theory and VIKOR method to develop a multi-criteria decision aiding tool capable of determining criteria importance weights and selecting best alternative strategic actions plans for smooth GSCM implementation; and contributed to the literature by applying this methodology and tools using empirical data from a multi-case studies involving some manufacturing companies of the plastic industry in Bangladesh

(4) This research is a distinctive work such that no existing or previous study has been conducted in identifying barriers to implementing GSCM in the context of Bangladeshi plastic industry. The focused of the study on Bangladesh and its plastic industry is another contribution helping build up studies from emerging economies.

This study's findings will therefore provide significant guidance to the plastic industry of Bangladesh when attempting to implement GSCM practices in their organizations. If the barriers are tackled strategically and the action plans are initiated systematically, the plastic industry of Bangladesh will be able to reduce the unnecessary energy loss and environmental degradation and make some financial gains. The intensity of the barriers significantly affects the successful implementation of GSCM practices. The meaning and insights of the identified barriers will assist the decision makers to either tackle the barriers or to take some precautions for the smooth implementation of GSCM practices. The action plans will assist the policy makers to formulate strategies to make the initiatives to implement GSCM practices. Thus, the insights of the barriers and course of the action plans will assist the policy makers to adopt green activities in their traditional supply chain and make better utilization of resources and energy which will lead to a promising profitability. This study will also motivate researchers to find out strategies to mitigating the barriers to GSCM practices.

7.2 Limitations and further research directions

This study comes with some limitations. These limitations would provide ample grounds for future research and empirical investigations.

From a theoretical perspective, the barriers in this study were identified using the extant literature review and industrial managers' opinions. A more scientific approach and empirical validation is required, especially in the plastic manufacturing industry of Bangladesh. Given that only a handful of managers were asked their opinion, a more robust and scientific evaluation covering a broader set of organizations, plastic manufacturing industries, and regions are necessary to ascertain how much of these barriers are really hindering the implementation of GSCM practices. Progressively, many new challenging barriers may hinder the implementation of GSCM practices. Those barriers can be taken into account and ranked systematically. Based on the new barriers, more action plans can be found out through rigorous literature review and with the consultation with industrial experts and academicians. Those action plans can be ranked to find out the solutions to mitigating the barriers in implementing GSCM practices as a whole.

From a methodological perspective, this study used fuzzy-VIKOR to evaluate the barriers and action plans. These tools although potentially useful, may require more thorough comparative analysis with other tools. For example, other weighting schemes/ models such as the Interpretive Structural Modelling (ISM), the Structural Equation Modelling (SEM) or the Graph Theory and Matrix Approach (GTMA), Analytic Hierarchy Process (AHP), the Fuzzy-AHP, the Grey Relational Analysis, Elimination and Choice Expressing Reality (ELECTRE), and Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE) can also be used to rank the barriers and action plans in the future and similar study, and compared. The methodology and framework developed in this study can be applied to other industries i.e. chemicals, leather, pharmaceuticals, automobile industries etc. to assess and rank the barriers to GSCM practices and potential action plans to mitigate these barriers.

This research is believed to be one of the very first and few studies that focus on the Bangladeshi plastic manufacturing industry. It sets the stage for additional and needed research investigation and practical application of the action plans to mitigate these barriers. Clearly more works in this area is required in the present economic, social and technological context of the country.

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Figures

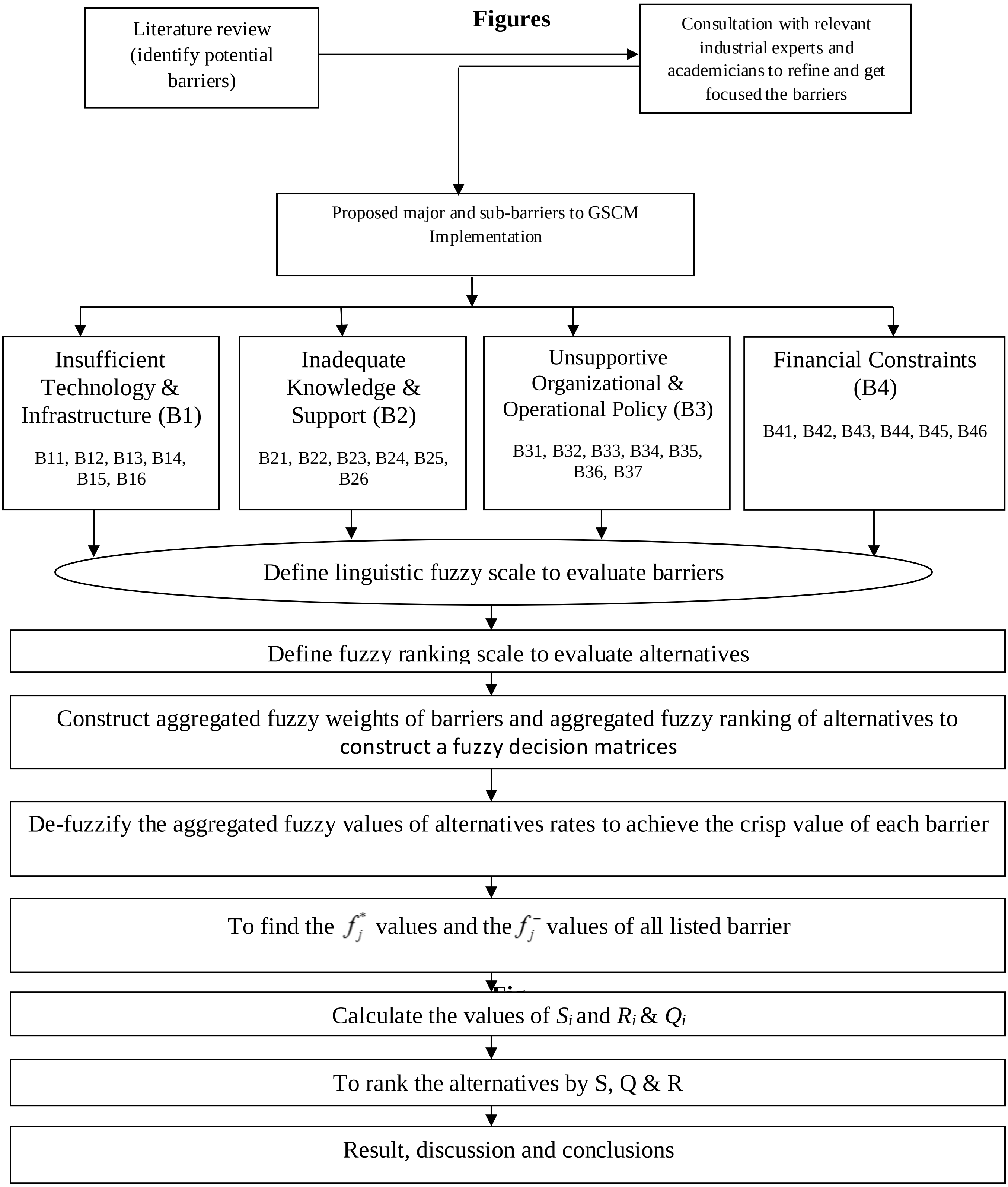

Fig.1. Proposed research framework

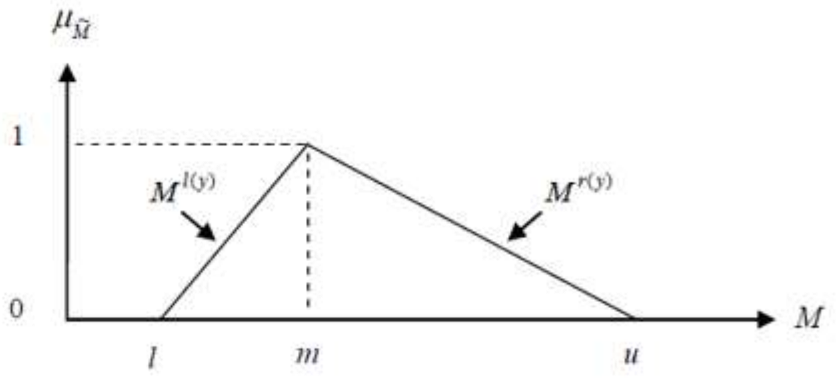

Fig. 2: Triangular Fuzzy Number, $\tilde{M}$ (Ashrafzadeh et al., 2012).

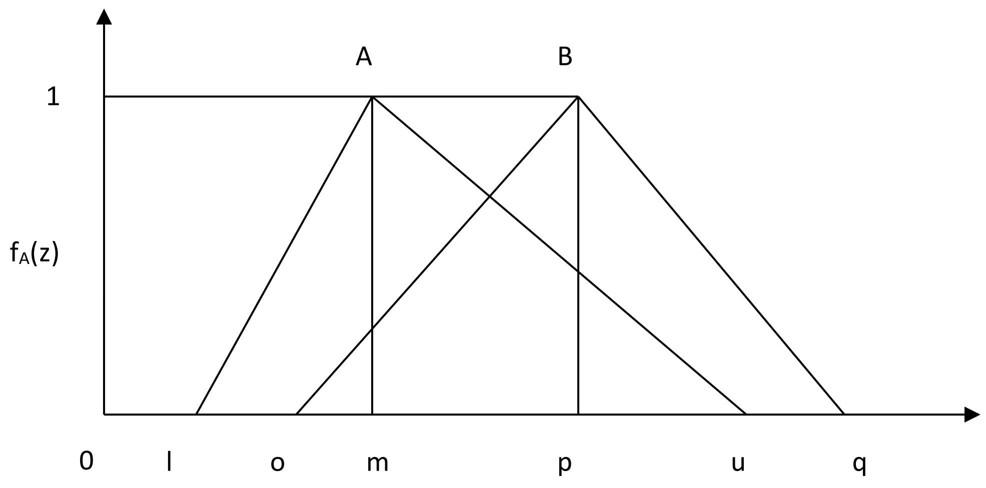

Fig. 3: Two triangular fuzzy numbers.

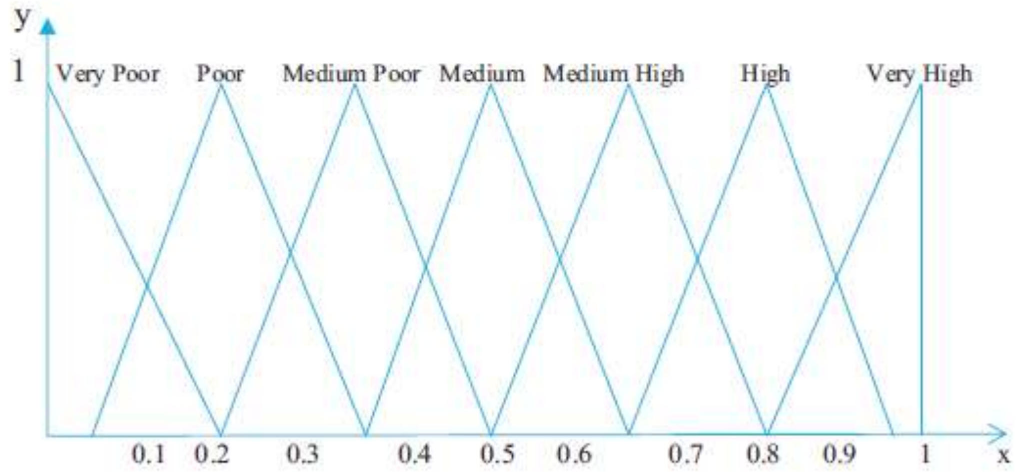

Fig. 4: Linguistic variables for importance weight of each criterion (Rostamzadeh et al., 2015).

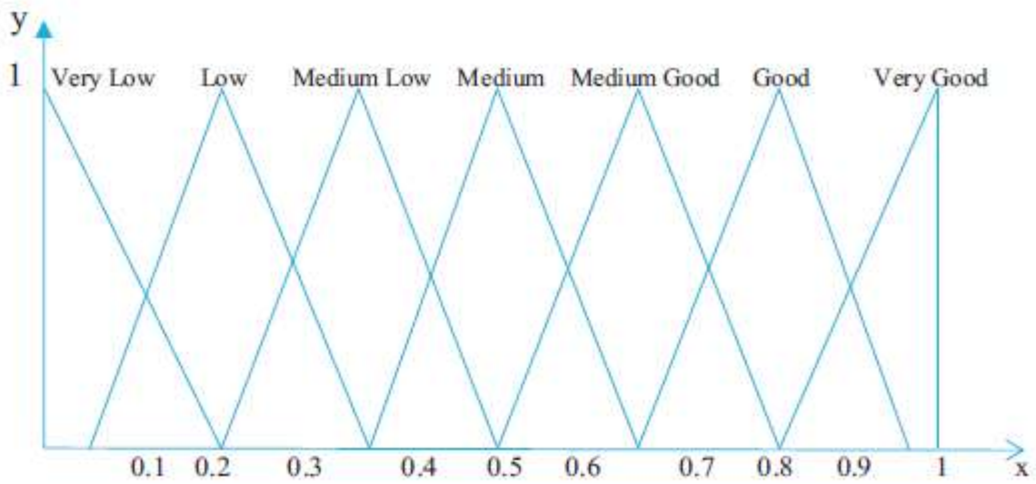

Fig. 5: Linguistic scale for variables (Rostamzadeh et al., 2015)

List of Tables

Table 1: Some existing works on green supply chain barriers analysis

Authors	Nature of contributions
Mehrabi et al., (2012)	Barriers to implementing GSCM practices in petrochemical industries are highlighted in this study.
K Muduli et al., (2013)	Barriers to implementing GSCM in the mining industries of India are discussed in this research.
Gleim et al., (2013)	This research investigated individual barriers that affect consumers' evaluations of the green products which are found in retail outlets.
Ghazilla et al., (2015)	Drivers and barriers in implementing green manufacturing practices in the SMEs are discussed in this study in the Malaysian context.
Abdullah et al., (2016)	This study focuses on the barriers to introducing innovative green processes in the manufacturing industry in the Malaysian context.
Shen et al., (2017)	A comparative study on significant barriers to green procurement in Chinese real estate development is presented in this research.
Sirisawat and Kiatcharoenpol, (2018)	This research work assesses the solution for reverse logistics practices using Fuzzy AHP-TOPSIS approaches.
Kaur et al., (2018)	This research investigates the barriers of GSCM in the domain of manufactuing frims from Canadian context using DEMATEL approach.
Kaur and Awasthi, (2018)	In this study, authors show the various study conducted on barriers of GSCM.
Agyemang et al., (2018)	This study examines the barriers to green supply chain redesign in the context of West Africa cashew industry.
Tumpa et al.,(2019)	Authors investigate the barriers to GSCM in an emerging economy context
Majumdar and Sinha, (2019)	In this study barriers to green textile supply chain management in Southeast Asia are analysied using interpretive structural modeling
Kaur et al., (2019)	A peroto study is conducted to investigate the critical barriers to GSCM

	practices in this study.
Sindhwani et al., (2019)	This study conducts to know the interdependencies among barriers of lean green agile manufacturing system in the developing country context.
Tseng et al., (2019)	In this study, authors investigate literature on GSCM for knowing the trends and future challenges in researches.

Table 2: Simplified meanings of each barrier with identification code

Major Barriers	**Sub-Barriers**	**Simplified Meanings**	**Relevant Literature**
1. Insufficient Technology & Infrastructure (B1)	1. Lack of advanced Technology (B11)	Green manufacturing processes need lots of advanced and modern green technologies. Lack of advanced technologies hinder the implementation of GSCM practices	(Dallasega & Sarkis, 2018; Sarkis, Zhu, & Lai, 2011; Testa & Iraldo, 2010; Ying & Zhou, 2012)
	2. Lack of shared knowledge of the best GSCM practices (B12)	The contemporary industries need to share their experience and expertise of the best practices of GSCM, without which implementation of GSCM in a new environment is difficult.	
	3. Lack of R & D practices for product recovery system (B13)	Lack of high-tech R&D facilities for reverse logistics and product recovery hinders the GSCM implementation.	
	4. Lack of technical expertise (B14)	Without proper technical knowledge gathered from experience and training, handling machines and other sophisticated technologies are difficult.	
	5. Complexity in	Reverse logistics, waste	

	recovery operations (B15)	management and recovery operations need sophisticated technology and its handling process is also complicated. This complicated process hinders GSCM practices.	
	6. Lack of modern technologies, facility of storage and Transportation (B16)	GSCM needs green storage and green transportation system, without which its implementation is not possible.	
2. Inadequate Knowledge & Support (B2)	1. Lack of knowledge on green practices (B21)	Knowledge of green concepts of the supply chain is essential for GSCM practices. Lack of knowledge on green practices hinders its implementation smoothly.	(Carbone & Moatti, 2018; Fahimnia, Sarkis, & Davarzani, 2015; Zhu & Sarkis, 2004; Zhu, Sarkis, & Lai, 2008)
	2. Lack of environmental knowledge (B22)	Environmental issues are important parts of GSCM practices. Without adequate knowledge on the environmental issue, it's hard to implement GSCM practices.	
	3. Lack of employee training on GSCM practices (B23)	Training from home and abroad on green issues of the supply chain is required for the smooth implementation of the GSCM practice. Lack of proper training hinders GSCM implementation.	
	4. Lack of customer awareness on green product (B24)	Without customers' awareness about GSCM, its implementation is quickened and flourished.	
	5. Lack of tax knowledge on	Reverse logistics and remanufacturing of returned	

	returned products (B25)	products and reselling them have separate taxation structure. Lack of knowledge on the proper taxation system hinders the GSCM implementation.	
	6. Lack of interest and support from top management to adopt GSCM (B26)	Top management needs to take prompt actions and initiatives to foster green activities in the supply chain. Without top management's interest and support, implementation of GSCM practices is difficult.	
3. Unsupportive organizational &operational Policy (B3)	1. Deficient organizational structure of the companies to adopt GSCM (B31)	Manufacturing industries need to incorporate favorable structure for GSCM implementation i.e. green warehouse, favorable organizational policies, without which smooth implementation of GSCM practices is difficult.	(Dashore & Sohani, 2013; Jayant & Azhar, 2014; Ying & Zhou, 2012; Zaid, Jaaron, & Talib Bon, 2018)
	2. Lack of Government Supportive policies for GSCM (B32)	Government policies are the driving force to implement any rules and regulations strictly. Lack of govt. supportive policies on GSCM hinders the implementation of GSCM practices smoothly.	
	3. Lack of support from supply chain stakeholders (B33)	All the parties involved in the whole supply chain must take part in adopting green activities in the supply chain. Implementation of GSCM practices is difficult if any one of the parties lacks in supporting green activities.	
	4. Lack of recycling	Recycling and reuse facilities are	

	and reuse facilities of organizations (B34)	essential parts of green activities. GSCM implementation is badly disrupted if the organizations don't give much effort in recycling and reuse facilities.	
	5. Lack of international environmental certification (e.g. ISO 14001) (B35)	Manufacturing industries need to achieve sustainability certification i.e. ISO 14001 if they want to maintain the compliance of the international standard. Without this certification, manufacturers implement GSCM practices correctly.	
	6. Lack of standard practices for GSCM (B36)	Industries intending to implement GSCM practices need to know the standard practices of green activities. As the contemporary industries don't practice green activities in a standard way, there is a knowledge gap of standard practices for GSCM.	
	7. Lack of Legislation requirement (B36)	Lack of govt. rules and regulations and organizational policies hinder the implementation of GSCM practices in the industries.	
4. Financial Constraints (B4)	1. Cost implication (B41)	Huge investment is needed to purchase & install technology, machine and construct green infrastructure for GSCM. This cost related constraint hinders the GSCM implementation.	(Khiewnavawongsa & Schmidt, 2014; Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013; Petljak, Zulauf,
	2. Un- availability of bank loans to	Financial institutions i.e. banks are not aware of the profitability of	

	encourage green products (B42)	green activities. Industries don't find loan facilities for green activities from the banks easily. This situation hinders GSCM practices severely.	Štulec, Seuring, & Wagner, 2018; Walker, Di Sisto, & McBain, 2008)
	3. Uncertainty related to economic issues (B43)	The profitability of green activities has not been assessed. But green activities lead to profitability. Industries are not yet aware of the profitability of green activities of the supply chain.	
	4. Cost of disposal of hazardous products (B44)	Disposal of dangerous products needs high-tech machine and experts. Due to the high cost of disposal of hazardous waste, GSCM implementation becomes uncertain.	
	5. Lack of knowledge of economic benefits (B45)	Green activities lead to economic gain. But due to unavailability of assessment of the profitability of green businesses, industries have less idea of economic profit of GSCM practices	
	6. Perceived high initial and operating cost (B46)	For incorporating green activities into the traditional supply chain, the industries need to purchase high-tech technology, machine and build green infrastructure. All of these lead to high initial and operating cost which hinders the GSCM practices.	

Table 3: Characteristics of four respondent managers and their companies

Manager 1 & Company 1	
Position	Supply chain manager
Role of area	Procurement, sourcing, distribution
Working experiences	15 years' active working experiences
Type of the company	Plastics chair, table, bottle, plastic utensils manufacturing
Manager 2 & Company 2	
Position	Operations manager
Role of area	Manufacturing and production
Working experiences	10 years' active professional experiences
Type of the company	Plastic bottling (manufacturing) as third party
Manager 3 & Company 3	
Position	Logistics manager
Role of area	Transportation and distribution
Working experiences	12 years' professional experiences
Type of the company	Plastic utensils manufacturing and export
Manager 4 & Company 4	
Position	Technology manager
Role of area	Production, manufacturing and ERP
Working experiences	14 years' technical experiences
Type of the company	Plastic packaging manufacturing

Table 4: Important weight of barriers and sub-barriers from four evaluators

Barriers	**Decision Makers**			
	E1	**E2**	**E3**	**E4**
B1	H	H	VH	H
B2	VH	VH	VH	H

B3	MH	M	MH	M
B4	VH	H	MH	MH
B11	VH	VH	H	VH
B12	H	H	VH	H
B13	M	M	MH	M
B14	MH	MH	M	MH
B15	M	M	H	M
B16	M	M	M	M
B21	VH	VH	VH	VH
B22	MH	VH	MH	H
B23	MH	H	H	MH
B24	MH	MH	M	H
B25	M	MH	M	MH
B26	VH	VH	H	VH
B31	H	VH	VH	H
B32	VH	VH	H	VH
B33	H	H	VH	H
B34	M	M	M	MH
B35	MH	M	MH	M
B36	H	H	H	H
B37	MH	MH	MH	H
B41	VH	H	VH	H
B42	H	H	H	MH
B43	VH	VH	VH	H
B44	MH	M	MH	M
B45	MH	H	MH	MH
B46	MH	MH	MH	MH

Table 5: Ratings of the alternatives with respect to the main barriers assessed by evaluators

		B1	**B2**	**B3**	**B4**
E1	**A1**	MG	G	MG	MG
	A2	G	G	MG	G
	A3	ML	MG	MG	M
	A4	MG	MG	M	MG
E2	**A1**	G	MG	G	MG
	A2	G	G	G	MG
	A3	ML	MG	MG	M
	A4	MG	MG	MG	M
E3	**A1**	G	G	MG	G
	A2	G	G	G	G
	A3	MG	ML	M	MG
	A4	MG	G	MG	G
E4	**A1**	MG	G	G	G

	A2	G	G	G	MG
	A3	ML	MG	M	ML
	A4	MG	G	G	MG

Table 6: Important weight of barriers and sub-barriers from four evaluators (Fuzzy Value)

Barriers	E1	E2	E3	E4
B1	(0.7, 0.8,0.9)	(0.7,0.8,0.9)	(0.8,0.9,1)	(0.7,0.8,0.9)
B2	(0.8,0.9,1)	(0.8,0.9,1)	(0.8,0.9,1)	(0.7,0.8,0.9)
B3	(0.6,0.7,0.8)	(0.35,0.5,0.65)	(0.6,0.7,0.8)	(0.35,0.5,0.65)
B4	(0.8,0.9,1)	(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.6,0.7,0.8)
B11	(0.8,0.9,1)	(0.8,0.9,1)	(0.7,0.8,0.9)	(0.8,0.9,1)
B12	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.8,0.9,1)	(0.7,0.8,0.9)
B13	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.6,0.7,0.8)	(0.35,0.5,0.65)
B14	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.35,0.5,0.65)	(0.7,0.8,0.9)
B15	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.7,0.8,0.9)	(0.35,0.5,0.65)
B16	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)
B21	(0.8,0.9,1)	(0.8,0.9,1)	(0.8,0.9,1)	(0.8,0.9,1)
B22	(0.6,0.7,0.8)	(0.8,0.9,1)	(0.6,0.7,0.8)	(0.7,0.8,0.9)
B23	(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.6,0.7,0.8)
B24	(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.35,0.5,0.65)	(0.7,0.8,0.9)
B25	(0.35,0.5,0.65)	(0.6,0.7,0.8)	(0.35,0.5,0.65)	(0.6,0.7,0.8)
B26	(0.8,0.9,1)	(0.8,0.9,1)	(0.7,0.8,0.9)	(0.8,0.9,1)
B31	(0.7,0.8,0.9)	(0.8,0.9,1)	(0.8,0.9,1)	(0.7,0.8,0.9)
B32	(0.8,0.9,1)	(0.8,0.9,1)	(0.7,0.8,0.9)	(0.8,0.9,1)
B33	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.8,0.9,1)	(0.7,0.8,0.9)
B34	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.6,0.7,0.8)
B35	(0.6,0.7,0.8)	(0.35,0.5,0.65)	(0.6,0.7,0.8)	(0.35,0.5,0.65)
B36	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.7,0.8,0.9)
B37	(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.7,0.8,0.9)
B41	(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.7,0.8,0.9)
B42	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.6,0.7,0.8)
B43	(0.8,0.9,1)	(0.8,0.9,1)	(0.8,0.9,1)	(0.7,0.8,0.9)
B44	(0.6,0.7,0.8)	(0.35,0.5,0.65)	(0.6,0.7,0.8)	(0.35,0.5,0.65)
B45	(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.6,0.7,0.8)
B46	(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.6,0.7,0.8)

Table 7: Ratings of the alternatives with respect to the main barriers assessed by evaluators (Fuzzy values)

		B1	B2	B3	B4
	A1	(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.6,0.7,0.8)
	A2	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.7,0.8,0.9)
E1	**A3**	(0.2,0.3,0.4)	(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.35,0.5,0.65)

	A4	(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.35,0.5,0.65)	(0.6,0.7,0.8)
	A1	(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.6,0.7,0.8)
	A2	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.6,0.7,0.8)
	A3	(0.2,0.3,0.4)	(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.35,0.5,0.65)
E2	**A4**	(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.35,0.5,0.65)
	A1	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.7,0.8,0.9)
	A2	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.7,0.8,0.9)
	A3	(0.6,0.7,0.8)	(0.2,0.3,0.4)	(0.35,0.5,0.65)	(0.6,0.7,0.8)
E3	**A4**	(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.7,0.8,0.9)
	A1	(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.7,0.8,0.9)
	A2	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.6,0.7,0.8)
	A3	(0.2,0.3,0.4)	(0.6,0.7,0.8)	(0.35,0.5,0.65)	(0.2,0.3,0.4)
E4	**A4**	(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.6,0.7,0.8)

Table 8: Ratings of the alternatives with respect to the sub-barriers assessed by evaluator (Fuzzy Value)

E1					
		A1	**A2**	**A3**	**A4**
B11		(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.7,0.8,0.9)
B12		(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.7,0.8,0.9)
B13		(0.2,0.3,0.4)	(0.2,0.3,0.4)	(0.35,0.5,0.65)	(0.35,0.5,0.65)
B14		(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.7,0.8,0.9)
B15		(0.2,0.3,0.4)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.2,0.3,0.4)
B16		(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.2,0.3,0.4)
B21		(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.7,0.8,0.9)
B22		(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.35,0.5,0.65)	(0.6,0.70.8)
B23		(0.2,0.3,0.4)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)
B24		(0.2,0.3,0.4)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.6,0.7,0.8)
B25		(0.2,0.3,0.4)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)
B26		(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.7,0.8,0.9)
B31		(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)
B32		(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.7,0.8,0.9)
B33		(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.6,0.7,0.8)
B34		(0.2,0.3,0.4)	(0.2,0.3,0.4)	(0.2,0.3,0.4)	(0.35,0.5,0.65)
B35		(0.35,0.5,0.65)	(0.2,0.3,0.4)	(0.2,0.3,0.4)	(0.2,0.3,0.4)
B36		(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)
B37		(0.35,0.5,0.65)	(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.6,0.7,0.8)
B41		(0.35,0.5,0.65)	(0.6,0.7,0.8)	(0.35,0.5,0.65)	(0.6,0.7,0.8)
B42		(0.2,0.3,0.4)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.2,0.3,0.4)
B43		(0.35,0.5,0.65)	(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.6,0.7,0.8)
B44		(0.2,0.3,0.4)	(0.2,0.3,0.4)	(0.2,0.3,0.4)	(0.2,0.3,0.4)
B45		(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.6,0.7,0.8)
B46		(0.2,0.3,0.4)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.2,0.3,0.4)

Table 8: Ratings of the alternatives with respect to the sub-barriers assessed by evaluator (Fuzzy Value) (continues)

E2					
		A1	**A2**	**A3**	**A4**
B11		(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.7,0.8,0.9)
B12		(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.7,0.8,0.9)
B13		(0.2,0.3,0.4)	(0.35,0.5,0.65)	(0.2,0.3,0.4)	(0.35,0.5,0.65)
B14		(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.7,0.8,0.9)
B15		(0.2,0.3,0.4)	(0.35,0.5,0.65)	(0.2,0.3,0.4)	(0.35,0.5,0.65)
B16		(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.2,0.3,0.4)	(0.2,0.3,0.4)
B21		(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.7,0.8,0.9)
B22		(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.35,0.5,0.65)
B23		(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.6,0.7,0.8)	(0.35,0.5,0.65)
B24		(0.6,0.7,0.8)	(0.35,0.5,0.65)	(0.2,0.3,0.4)	(0.6,0.7,0.8)
B25		(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.2,0.3,0.4)
B26		(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.6,0.7,0.8)
B31		(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.2,0.3,0.4)
B32		(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.7,0.8,0.9)
B33		(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.7,0.8,0.9)
B34		(0.2,0.3,0.4)	(0.2,0.3,0.4)	(0.2,0.3,0.4)	(0.2,0.3,0.4)
B35		(0.2,0.3,0.4)	(0.2,0.3,0.4)	(0.35,0.5,0.65)	(0.2,0.3,0.4)
B36		(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)
B37		(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.35,0.5,0.65)
B41		(0.6,0.7,0.8)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.6,0.7,0.8)
B42		(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.2,0.3,0.4)
B43		(0.6,0.7,0.8)	(0.35,0.5,0.65)	(0.6,0.7,0.8)	(0.6,0.7,0.8)
B44		(0.2,0.3,0.4)	(0.2,0.3,0.4)	(0.35,0.5,0.65)	(0.2,0.3,0.4)
B45		(0.35,0.5,0.65)	(0.6,0.7,0.8)	(0.3,0.5,0.65)	(0.35,0.5,0.65)
B46		(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.2,0.3,0.4)	(0.2,0.3,0.4)

Table 8: Ratings of the alternatives with respect to the sub-barriers assessed by evaluator (Fuzzy Value) (continues)

E3					
		A1	**A2**	**A3**	**A4**
B11		(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.7,0.8,0.9)
B12		(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.6,0.7,0.8)
B13		(0.2,0.3,0.4)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.2,0.3,0.4)
B14		(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.7,0.8,0.9)
B15		(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.2,0.3,0.4)	(0.35,0.5,0.65)
B16		(0.2,0.3,0.4)	(0.2,0.3,0.4)	(0.35,0.5,0.65)	(0.2,0.3,0.4)
B21		(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.7,0.8,0.9)

B22		(0.35,0.5,0.65)	(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.7,0.8,0.9)
B23		(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.6,0.7,0.8)
B24		(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.6,0.7,0.8)	(0.2,0.3,0.4)
B25		(0.2,0.3,0.4)	(0.35,0.5,0.65)	(0.2,0.3,0.4)	(0.35,0.5,0.65)
B26		(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.7,0.8,0.9)
B31		(0.2,0.3,0.4)	(0.2,0.3,0.4)	(0.35,0.5,0.65)	(0.2,0.3,0.4)
B32		(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.6,0.7,0.8)
B33		(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.6,0.7,0.8)
B34		(0.2,0.3,0.4)	(0.35,0.5,0.65)	(0.2,0.3,0.4)	(0.2,0.3,0.4)
B35		(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.2,0.3,0.4)
B36		(0.2,0.3,0.4)	(0.35,0.5,0.65)	(0.2,0.3,0.4)	(0.35,0.5,0.65)
B37		(0.6,0.7,0.8)	(0.35,0.5,0.65)	(0.6,0.7,0.8)	(0.35,0.5,0.65)
B41		(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.6,0.7,0.8)
B42		(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)
B43		(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.6,0.7,0.8)	(0.6,0.7,0.8)
B44		(0.2,0.3,0.4)	(0.2,0.3,0.4)	(0.35,0.5,0.65)	(0.2,0.3,0.4)
B45		(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.35,0.5,0.65)
B46		(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.2,0.3,0.4)	(0.2,0.3,0.4)

Table 8: Ratings of the alternatives with respect to the sub-barriers assessed by evaluators (Fuzzy Value) (continues)

E4					
		A1	**A2**	**A3**	**A4**
B11		(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.6,0.7,0.8)
B12		(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.7,0.8,0.9)
B13		(0.35,0.5,0.65)	(0.2,0.3,0.4)	(0.2,0.3,0.4)	(0.6,0.7,0.8)
B14		(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.6,0.7,0.8)
B15		(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.2,0.3,0.4)
B16		(0.2,0.3,0.4)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.2,0.3,0.4)
B21		(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.6,0.7,0.8)
B22		(0.6,0.7,0.8)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.6,0.7,0.8)
B23		(0.6,0.7,0.8)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)
B24		(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.2,0.3,0.4)	(0.6,0.7,0.8)
B25		(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.2,0.3,0.4)
B26		(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.7,0.8,0.9)
B31		(0.2,0.3,0.4)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.2,0.3,0.4)
B32		(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.6,0.7,0.8)
B33		(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.7,0.8,0.9)
B34		(0.2,0.3,0.4)	(0.2,0.3,0.4)	(0.2,0.3,0.4)	(0.35,0.5,0.65)
B35		(0.35,0.5,0.65)	(0.2,0.3,0.4)	(0.2,0.3,0.4)	(0.2,0.3,0.4)
B36		(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.6,0.7,0.8)	(0.2,0.3,0.4)
B37		(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.35,0.5,0.65)	(0.6,0.7,0.8)
B41		(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.35,0.5,0.65)

B42		(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.2,0.3,0.4)
B43		(0.6,0.7,0.8)	(0.35,0.5,0.65)	(0.6,0.7,0.8)	(0.35,0.5,0.65)
B44		(0.2,0.3,0.4)	(0.35,0.5,0.65)	(0.2,0.3,0.4)	(0.2,0.3,0.4)
B45		(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.35,0.5,0.65)	(0.35,0.5,0.65)
B46		(0.2,0.3,0.4)	(0.2,0.3,0.4)	(0.35,0.5,0.65)	(0.35,0.5,0.65)

Table 9: Aggregated Fuzzy values of alternative rate and subjective importance weights

Barriers	**W_j**	**A1**	**A2**	**A3**	**A4**
B1	(0.7,0.825,1)	(0.6,0.75,0.9)	(0.7,0.8,0.9)	(0.2,0.4,0.8)	(0.6,0.7,0.8)
B2	(0.7,0.875,1)	(0.6,0.775,0.9)	(0.7,0.8,0.9)	(0.2,0.6,0.8)	(0.6,0.75,0.9)
B3	(0.35,0.6,0.8)	(0.6,0.75,0.9)	(0.6,0.775,0.9)	(0.35,0.6,0.8)	(0.35,0.675,0.9)
B4	(0.6,0.775,1)	(0.6,0.75,0.9)	(0.6,0.75,0.9)	(0.2,0.5,0.8)	(0.35,0.675,0.9)
B11	(0.7,0.875,1)	(0.6,0.775,0.9)	(0.6,0.775,0.9)	(0.6,0.775,0.9)	(0.6,0.775,0.9)
B12	(0.7,0.825,1)	(0.6,0.725,0.8)	(0.6,0.75,0.9)	(0.6,0.775,0.9)	(0.6,0.775,0.9)
B13	(0.35,0.55,0.8)	(0.2,0.35,0.65)	(0.2,0.4,0.65)	(0.2,0.4,0.65)	(0.2,0.5,0.8)
B14	(0.35,0.725,0.9)	(0.6,0.775,0.9)	(0.6,0.75,0.9)	(0.6,0.75,0.9)	(0.6,0.775,0.9)
B15	(0.35,0.575,0.9)	(0.2,0.4,0.65)	(0.35,0.5,0.65)	(0.2,0.4,0.65)	(0.2,0.4,0.65)
B16	(0.35,0.5,0.65)	(0.2,0.4,0.65)	(0.2,0.45,0.65)	(0.2,0.45,0.65)	(0.2,0.3,0.4)
B21	(0.8,0.9,1)	(0.6,0.775,0.9)	(0.7,0.8,0.9)	(0.6,0.775,0.9)	(0.6,0.775,0.9)
B22	(0.6,0.775,1)	(0.35,0.675,0.9)	(0.35,0.675,0.9)	(0.35,0.6,0.8)	(0.35,0.675,0.8)
B23	(0.6,0.75,0.9)	(0.2,0.5,0.8)	(0.35,0.5,0.6)5	(0.35,0.55,0.8)	(0.35,0.55,0.65)
B24	(0.35,0.675,0.9)	(0.2,0.5,0.8)	(0.35,0.5,0.65)	(0.2,0.45,0.65)	(0.2,0.6,0.8)
B25	(0.35,0.6,0.8)	(0.2,0.4,0.65)	(0.35,0.5,0.6)5	(0.2,0.45,0.65)	(0.2,0.4,0.65)
B26	(0.7,0.875,1)	(0.6,0.775,0.9)	(0.6,0.775,0.9)	(0.6,0.725,0.9)	(0.6,0.775,0.9)
B31	(0.7,0.85,1)	(0.2,0.4,0.65)	(0.2,0.45,0.65)	(0.35,0.5,0.65)	(0.2,0.35,0.65)
B32	(0.7,0.875,1)	(0.6,0.725,0.9)	(0.6,0.725,0.8)	(0.6,0.75,0.9)	(0.6,0.75,0.9)
B33	(0.7,0.825,1)	(0.6,0.75,0.9)	(0.6,0.725,0.9)	(0.6,0.775,0.9)	(0.6,0.75,0.9)
B34	(0.35,0.55,0.8)	(0.2,0.3,0.4)	(0.2,0.35,0.4)	(0.2,0.3,0.4)	(0.2,0.4,0.65)
B35	(0.35,0.6,0.8)	(0.2,0.45,0.65)	(0.2,0.35,0.4)	(0.2,0.4,0.65)	(0.2,0.3,0.4)
B36	(0.7,0.8,0.9)	(0.2,0.45,0.65)	(0.35,0.5,0.65)	(0.2,0.5,0.8)	(0.2,0.45,0.65)
B37	(0.6,0.725,0.9)	(0.35,0.65,0.8)	(0.35,0.65,0.8)	(0.35,0.65,0.8)	(0.35,0.6,0.8)
B41	(0.6,0.75,0.9)	(0.35,0.65,0.8)	(0.35,0.65,0.8)	(0.35,0.625,0.8)	(0.35,0.65,0.8)
B42	(0.6,0.775,0.9)	(0.2,0.45,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.2,0.35,0.4)
B43	(0.7,0.875,1)	(0.35,0.6,0.8)	(0.35,0.55,0.8)	(0.6,0.725,0.9)	(0.35,0.65,0.8)
B44	(0.35,0.6,0.8)	(0.2,0.3,0.4)	(0.2,0.35,0.65)	(0.2,0.4,0.65)	(0.2,0.3,0.4)
B45	(0.6,0.725,0.9)	(0.35,0.6,0.8)	(0.35,0.65,0.8)	(0.35,0.55,0.65)	(0.35,0.55,0.8)
B46	(0.6,0.7,0.8)	(0.2,0.4,0.65)	(0.2,0.45,0.65)	(0.2,0.4,0.65)	(0.2,0.35,0.65)

Table 10: De-fuzzified Aggregated Fuzzy values of alternative rate

Barriers	**W_j**	**Normalized W_j**	**A1**	**A2**	**A3**	**A4**	**f_j***	**f_j^-**
B1	0.842	0.274	0.750	0.800	0.467	0.700	0.800	0.467
B2	0.858	0.279	0.758	0.800	0.533	0.750	0.800	0.533
B3	0.583	0.190	0.750	0.758	0.583	0.642	0.758	0.583
B4	0.792	0.257	0.750	0.750	0.500	0.642	0.750	0.500
B11	0.858	0.213	0.758	0.758	0.758	0.758	0.758	0.758
B12	0.842	0.209	0.708	0.750	0.758	0.758	0.758	0.708
B13	0.567	0.140	0.400	0.417	0.417	0.500	0.500	0.400
B14	0.658	0.163	0.758	0.750	0.750	0.758	0.758	0.750
B15	0.608	0.151	0.417	0.500	0.417	0.417	0.500	0.417
B16	0.500	0.124	0.417	0.433	0.433	0.300	0.433	0.300
B21	0.900	0.199	0.758	0.800	0.758	0.758	0.800	0.758
B22	0.792	0.175	0.642	0.642	0.583	0.608	0.642	0.583
B23	0.750	0.166	0.500	0.500	0.567	0.517	0.567	0.500
B24	0.642	0.142	0.500	0.500	0.433	0.533	0.533	0.433
B25	0.583	0.129	0.417	0.500	0.433	0.417	0.500	0.417
B26	0.858	0.190	0.758	0.758	0.742	0.758	0.758	0.742
B31	0.850	0.162	0.417	0.433	0.500	0.400	0.500	0.400
B32	0.858	0.164	0.742	0.708	0.750	0.750	0.750	0.708
B33	0.842	0.161	0.750	0.742	0.758	0.750	0.758	0.742
B34	0.567	0.108	0.300	0.317	0.300	0.417	0.417	0.300
B35	0.583	0.111	0.433	0.317	0.417	0.300	0.433	0.300
B36	0.800	0.153	0.433	0.500	0.500	0.433	0.500	0.433
B37	0.742	0.141	0.600	0.600	0.600	0.583	0.600	0.583
B41	0.750	0.171	0.600	0.600	0.592	0.600	0.600	0.592
B42	0.758	0.173	0.433	0.500	0.500	0.317	0.500	0.317
B43	0.858	0.195	0.583	0.567	0.742	0.600	0.742	0.567
B44	0.583	0.133	0.300	0.400	0.417	0.300	0.417	0.300
B45	0.742	0.169	0.583	0.600	0.517	0.567	0.600	0.517
B46	0.700	0.159	0.417	0.433	0.417	0.400	0.433	0.400

Table 11: The values of S and R for all Alternatives

Alternatives	**S**	**R**		**Q**
A1	10.47438	0.9	S^*_j= 7.2975	0.851867
A2	7.29752	0.858333	S^-_J= 11.81181	0
A3	11.81181	0.9	R^*_j= 0.8583	1
A4	11.18094	0.9	R^-_j= 0.9	0.930125

Table 12: The rankings of the alternatives by S, R and Q in ascending order

Alternatives	S		R		Q	Ranking
A2	7.29752	**A2**	0.858333	**A2**	0	**1**
A1	10.47438	**A1**	0.9	**A1**	0.851867	**2**
A4	11.18094	**A4**	0.9	**A4**	0.930125	**3**
A3	11.81181	**A3**	0.9	**A3**	1	**4**

Table 13: Final Evaluation of Ranking

Main Barriers	Main Barrier Ranking	Sub- Barriers	Sub Barriers	Normalized weight	Sub- Barrier Ranking
B1- Insufficient Technology & Infrastructure	**2**	***B11***	Lack of advanced Technology	0.213	**1**
		B12	lack of shared knowledge of the best GSCM practices	0.209	**2**
		B13	Lack of R & D practices for product recovery system	0.14	**5**
		B14	Lack of technical expertise	0.163	**3**
		B15	Complexity in recovery operations	0.151	**4**
		B16	Lack of facility of modern technologies, storage and Transportation	0.124	**6**
B2- Inadequate Knowledge & Support	**1**	***B21***	Lack of knowledge on green practices	0.199	**1**
		B22	Lack of environmental knowledge	0.175	**3**
		B23	Lack of employee training on GSCM practices	0.166	**4**
		B24	Lack of customer awareness on green products	0.142	**5**
		B25	Lack of tax knowledge on returned products	0.129	**6**
		B26	Lack of interest and support from top management to adopt GSCM	0.19	**2**

B3- Unsupportive Organizational & operational Policy	**4**	***B31***	Deficient structure of the companies to adopt GSCM	0.162	**2**
		B32	Lack of Government Supportive policies for GSCM	0.164	**1**
		B33	Lack of support from supply chain stakeholders	0.161	**3**
		B34	Lack of recycling and reuse facilities of organizations	0.108	**7**
		B35	Lack of international environmental certification (e.g. ISO 14001)	0.111	**6**
		B36	Lack of standard practices for GSCM	0.153	**4**
		B37	Lack of Legislation Requirement	0.141	**5**
B4- Financial Constraints	**3**	***B41***	Cost implication	0.171	**3**
		B42	Un- availability of bank loans to encourage green products	0.173	**2**
		B43	Uncertainty related to economic issues	0.195	**1**
		B44	Cost of disposal of hazardous products	0.133	**6**
		B45	Lack of knowledge of economic benefits	0.169	**4**
		B46	Perceived high initial and operating cost	0.159	**5**