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**Article**

## Categorizing the barriers in adopting sustainable supply chain initiatives: A way-forward towards business excellence

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## OPERATIONS, INFORMATION & TECHNOLOGY | RESEARCH ARTICLE

# Categorizing the barriers in adopting sustainable supply chain initiatives: A way-forward towards business excellence

Muhammad Nazam<sup>1</sup>, Muhammad Hashim<sup>2\*</sup>, Sajjad Ahmad Baig<sup>3</sup>, Muhammad Abrar<sup>3</sup>, Hakeem Ur Rehman<sup>4</sup>, Muhammad Nazim<sup>5</sup> and Ali Raza<sup>2</sup>

**Abstract:** Sustainable supply chain initiatives (SSCI) increasingly attract the interest of industrialists, policy makers and academia in achieving business excellence. There is a tremendous pressure from stakeholders to adopt sustainable supply chain practices in manufacturing of hygienic products. Agro-based industries in emerging economies like Pakistan are at initial stage in tackling with many barriers to implement (SSCI). The purpose of this study is to categorise the barriers and formulate a multi-criteria decision-making (MCDM) framework based on fuzzy analytical hierarchy process (FAHP) which effectively handles the subjectivity and complexity of experts' inputs. The top seven barriers regarding the implementation of (SSCI) in this study were identified namely: (1) lack of sustainable outsourcing, (2) lack of sustainable production and distribution, (3) fear and resistance towards sustainable competitiveness and innovation, (4) trust deficit on sustainable buyer-supplier relationship, (5) lack of sustainable marketing and organizational culture, (6) difficulty in sustainable knowledge sharing (7) complexity in adopting sustainable technology practices. The key findings highlight that lack of sustainable outsourcing factor is key barrier for adopting (SSCI). Finally, the sensitivity analysis is applied to confirm the suitability among the ranked barriers. The outcome of this



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### ABOUT THE AUTHOR

Dr. Muhammad Nazam is an Assistant Professor at Institute of Business Management Sciences, University of Agriculture, and Faisalabad, Pakistan. He received the PhD in Management Sciences and Engineering from Sichuan University, China. Nazam's research focuses on fuzzy set theory, operations and supply chain management, knowledge management, reverse logistics, etc. His works have been published in peer-reviewed reputed national and international journals such as the *Journal of Enterprise Information Management*, *Journal of Industrial Engineering and Management*, *International Journal of Information Systems and Supply Chain Management*, *International Journal of Supply and Operations Management*, *Journal of Managerial Sciences and International Journal of Advanced and Applied Sciences*. He also published chapters in well-reputed international conference proceedings.

### PUBLIC INTEREST STATEMENT

Industries in emerging economies like Pakistan are at initial stage in tackling with many barriers to implement sustainable supply chain initiatives (SSCI). The purpose of this study is to categorize the barriers and formulate a multi-criteria decision-making (MCDM) framework based on fuzzy analytical hierarchy process (FAHP) which effectively handles the subjectivity and complexity of experts' inputs. This research contributes to literature, relevant to the identification and prioritization of key barriers for achieving business excellence. This study provides several theoretical as well as practical implications. This study depicts way forward and policy commitments for the managers in the concerned industries and stakeholders. The outcome of this research would be supportive measures for the stakeholders by providing insights on barriers to implement (SSCI) concept for achieving sustainable development goals in line towards business excellence.

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**Subjects: Agriculture and Food; Environment & Business; Supply Chain Management**

**Keywords: supply chain initiatives; barriers; fuzzy AHP**

## 1. Introduction

In the emerging supply chain environment, the term sustainable supply chain initiatives (SSCI) is gaining immense popularity across the globe in order to capture the attention of researchers as well as practitioners. In order to manage supply chain operations, the organizations emphasise to implement sustainable procurement practices to enhance sustainability-related initiatives in a supply chain (Li & Lin, 2006). Implementation of (SSCI) has been considering significant attention for the agricultural production and distribution system for the achievement of the key objectives of minimizing wastage and improving perishable nature of products (Mumtaz et al., 2018; Nazam et al., 2019; Siddiqui et al., 2012). The paradigm of (SSCI) is advanced paradigm in the business world and nowadays businesses are not only depended on the profit maximization but also on other factors in line towards achieving sustainability (Mau, 2002).

Pakistan as an agricultural country focuses to strengthen the entire structure of agro-based firms and developing the policies for socio-economic and eco-friendly aspects. As air pollution, social constraints and economic crises are affecting the available resources for the industries to operate in an uncertain supply chain environment (Hashim et al., 2017). As for as concerned the corporate social responsibility in the organizational environment, it is a basic requirement to promote the supply chain function which eventually influences the workers' health and safety by improving the community development in line towards sustainability (Klassen & Vereecke, 2012). The economic measures are the crucial factors to consider the organizational profitability and performance as it directly fluctuates the profit indexing of the organizations. In recent years, for importers and exporters sustainability has been considered as an important issue as it can facilitate the industrialist to increase the trade surplus of Pakistani firms (Nazam et al., 2015). For creating umbrella of sustainable business environment, industries in developing countries need to consider environmental, economic and social issues in end to end supply chain (Liu et al., 2018).

*RQ1: What are the barriers, faced by Pakistani agro-based industries for achieving sustainability in the supply chain?*

The concept of (SSCI) can be elaborated in the simplest form as the tremendous efforts performed in operating the end to end supply chain in meeting the environmental, economic and social needs for a longer time span (Majumdar & Sinha, 2018). The initiatives of supply chain management (SCM) have been considered as prerequisite for attaining the competitive edge globally through increasing the profits of the organizations (Carter & Dresner, 2001), (Carter & Rogers, 2008). In the last century, the innovations and uniqueness in the products only emphasized on the waste minimization, solely for the economic aspects but it did not pay the attention on the ecological and social aspects. (Wu et al., 2011). The conventional (SCM) initiatives have been shifting towards the (SSCI) initiatives in most of the Asian organizations (Gollagher et al., 2010). In this perspective, it is a core obligation of the researchers to recognize the research gaps and barriers that hinders the (SSCM) initiatives in the emerging economies like Pakistan, Iran, Sri Lanka, Nepal, Indonesia, Thailand, China and India. In order to gain maximum benefits, the industries need to integrate the overall supply chain operations through supply chain networking and designing system (Dan & Liu, 2000; Darnell et al., 2008; Nourmohamadi Shalke et al., 2018). The synergistic networking of sustainable goals and supply chain objectives leads the organizations towards achieving the competitiveness globally (Thuong et al., 2018).

Undeniably, the discipline of (SSCI) is nowadays in its early developmental phases, both academically and professionally (Singh & Kant, 2008). The researchers' need to put attention on applying multi-item latent constructs, analyzing their content validity and increasing them through survey-based techniques and approaches (Diabat & Govindan, 2011). Nazam et al (2015) developed the tool to assess the risk, relevant to supply chain initiatives adoption in the textile sector of Pakistan. (Zhu et al., 2008). According to the best of our knowledge, the literature have fewer research papers about the emerging economies like Pakistan (Rasool et al., 2016).

*RQ2: Why only a few supply chain actors can benefit from the sustainable practices?*

Sustainable supply chain management is a systematic process of implementing tools of sustainability to achieve the goals of enhancement of supply chain performance and competitiveness. The reasons behind implementation of the concept of sustainability are to achieve the desirable targets within or outside of the organization by developing feasible supply chain environment in order to maintain balance among the different tasks and practices of the different groups (Christopher & Holweg, 2011). Therefore, it is revealed that in order to improve (SSCI) implementation in (SSC) successfully, viable approach must be developed and prioritizes the barriers in a procedural way.

*RQ3: How to prioritize barriers using fuzzy AHP approach?*

It is essential significant to rank the barriers so that company's s may formulate policies to eradicate the barriers of (SSCI) implementation in achieving competitive edge. Identification and prioritization of the barriers is considered as multi-attribute decision-making (MADM) problem. It is very difficult to gain inputs through human judgments in decision making due to unclear and inconsistent values. Therefore, in this case, fuzzy logic is the best tools which follow fuzzy set theory to handle problems, characterized by vagueness and unclear expressions. (Saaty, 1980) Computed important barrier weights. At last, a real life case study is illustrated to depict the practical application of the developed model.

The remainder of this paper is structured as follows. Section 2 extensively reviews the previous studies related to barriers in sustainable supply chain. The solution methodology is presented in Section 3. The proposed framework for modelling the barriers of (SSCI) adoption is described in section 4. The results of analysis of research are elaborated in section 5. Finally, the concluding remarks are elaborated in section 6.

## **2. Literature review**

This section describes the preliminary details, discussed in this research along with the literature support. A detailed description of each subsection follows.

### **2.1. Sustainable supply chain management**

Recently, sustainability has been grabbing attention from both academia and industry (Sarkis et al., 2010). The concept of sustainability in a SC is considering a key business issue, affecting the organizational performance with respect to environmental risk, social risk, and financial risk (Majumdar & Sinha, 2018). A sustainable supply chain creates more value creation opportunities and offers significant competitive edges for organizations in process improvements.

#### *2.1.1. Green perspective*

Nowadays, the scope of environmental concerns in a supply chain is growing rapidly for achieving the specified business goals (Ferretti et al., 2007). Accomplishing the eco-based objectives, there is a need to implement greener concept in the different phases of SC such as supply chain network, managing procurement, production and distribution, sales and selling, marketing and services. Walton et al (1998) suggested that it is very important to formulate the well-integrated eco-friendly policies for

the management of businesses in order to accomplish the corporate green goals. The previous studies on green perspective highlighted that due to awareness and emerging needs of eco-consciousness in industrial enterprises, regulatory bodies, groups and individuals have been trying to adopt environmental friendly policies that incorporate environmental requirements. Therefore, green supply chain management (GSCM) is an important phenomenon to instill the environmental thinking into the minds of supply chain professional in improving the traditional supply chain management.

### *2.1.2. Social perspective*

The social factor is one of the significant factors to measure the corporate social responsibility (CSR) performance of an organization because it directly influences the occupational health and safety of labours. Therefore, social factors are taken as the significant components of any organization as the success of any organization based on the constructs of corporate social responsibility measurement (Klassen & Vereecke, 2012). Due to the awareness of social responsibility concept, it is required to moderate the supply chain management operations which affect the occupational human health and work safety by considering welfare and development of community.

### *2.1.3. Economic perspective*

The insertion of economic concept into the supply chain process helps to boost up the economic performance to sustain in the competitive marketplace (Mangla et al., 2017). After social, environmental aspects, the economic perspective is considered as one of the most significant factors to compute the organizational performance as it influences the profitability of an organization (Rao & Holt, 2005). The economic perspectives of an organization focus on the SC optimization in maximizing the profitability through decreasing the procurement expenses and cost of operations (Gollagher et al., 2010). Keeping in view the concept of economic, the organizations need to emphasis on the efficient supply chain management to increase the supply chain surplus by reducing the cost of raw material and cost of production.

## **2.2. Sustainable supply chain initiatives implementation: barriers**

It is evident from literature that research on (SSCI) concentrates on specialized dimensions such as sustainable procurement, internal operations and external physical distribution management, competitive edge in innovations, maintain relations with buyer and supplier, sustainable marketing and organizational culture, sustainable knowledge sharing and technology in the end to end SC process (Beamon, 1999). Tackling the barriers to implement sustainability aspect in small and medium enterprises is quite different as compared to big organizations in different dimensions, as few research studies suggest that implementation of (SSCM) in SMEs is unhurried and complex (Sarkis et al., 2010). In the recent years, mostly Agro-based industries in Pakistan realize the essence of barriers, encountering the industrial supply chain. Modelling the barriers are very important for the sustainability of any organization and eradicating on these obstacles is considering the core process. Only a few Pakistani industries have adopted the sustainable supply chain strategies in the business processes through combination with SC actors (Nazam et al., 2019). The chances of success regarding adoption of sustainable initiatives are not satisfactory due to dominance of key barriers. In this regard, few of the researches evaluate (SSCI) implementation in the Pakistani scenario but they could not evaluate evidence into barriers encountered against (SSCI) implementation. Almost all types of countries have their own environmental, social and economic policies and legislations (Zhu et al., 2008).

### *2.2.1. Review of existing and related works*

Industries in emerging economies like Pakistan are facing obligations to implement sustainable supply chain initiatives or practices in improving the supply chain operations for achieving business excellence (Nazam et al., 2015; Lis et al., 2020; Caldera et al., 2019). In the developed countries, the concept of sustainable supply chain initiatives are very popular and industrialist are well-aware, whereas in the developing countries they have lack of awareness. The adoption of sustainable initiatives in manufacturing as well as service industries is crucial for procuring and producing the products (Sivakumar et al., 2018; Bhanot et al., 2017).



Singh et al. (2020) conducted barrier analysis in implementing green lean practices in manufacturing industries were discussed in this study. Lis et al (2020) conducted a detailed review analysis conducted on mapping sustainable supply chain management practices. Rahman et al (2020) investigated barriers to implementing green supply chain management considering sustainable goals. Caldera et al (2019) evaluated the enablers and barriers for successful implementation of sustainable business practice in “lean” SMEs. Sivakumar et al (2018) developed a DEMATEL approach for evaluating barriers for sustainable end-of-life practices. Bhanot et al (2017) suggested an integrated approach for analysing the enablers and barriers of sustainable manufacturing. Gandhi et al (2016) evaluated the factors in achieving sustainable supply chain goals using a case study approach based on DEMATEL. Luthra et al (2015) investigated and evaluated barriers to implement green supply chain management. Reefke et al (2014) developed decision-making model system in sustainable supply chain. Seuring (2013) conducted an extensive review of literature for sustainable supply chain management. Wee et al (2012) conducted analysis to formulate strategies for development in eradicating the barriers. Carvalho et al (2011) had focussed on development of lean, agile, resilient and green divergences and strategies for achieving business goals in a sustainable way.

Similarly, few researchers empirically examined the sustainable supply chain risk and integration practices in Pakistan. The results suggest that overcoming on sustainable supply chain risks and related barriers can increase the performance of firms. Nazam et al (2019) evaluated and prioritized key barrier in (SSCI) implementation in textile sector of Pakistan through survey conducted using comprehensive questionnaire from the industrial experts of different sectors by using fuzzy analytical hierarchal process (FAHP). Rasool et al (2016) conducted research on adoption of (SSCM) practices in the clothing and apparel industry of Pakistan and suggested that barriers affect success rate of industries. The empirical studies on new perspectives of sustainable concept of supply chain is grabbing attention throughout the globe to strengthen the environmental, social and economic aspects of businesses. Sustainable supply chain initiatives are not commonly implemented in the manufacturing and distribution sector of Pakistan. Pakistan is an agricultural country and most of the industries are agro-based, which need to be implemented sustainable practices in order to satisfy the domestic as well as global customer needs. The traditional agro-based industries are not much concerned in reducing pollution, wastages and inefficiencies. In this perspective, an empirical research is needed to categorize the barriers facing in the implementation of sustainable supply chain initiatives. This problematic scenario simulates the researchers of this study to categorize and evaluate the certain barriers in implementing SSCM practices. A preview of previous research studies on sustainable supply chain initiative barrier analysis as shown in Table 1.

This research problem deals in achieving the below-mentioned objectives in line with sustainable goals; 1) determination of the potential barriers in (SCM) relevant to sustainability in the agro-based perspectives 2) evaluation of the identified barriers to prioritize by calculating intensity of barriers weight through fuzzy AHP in implementation of sustainable initiatives 3) suggestions regarding implementation of sustainability aspect to ensure sustained industrial supply chain environment. Based on the above research highlights, this research scenario is divided in four level hierarchal decision processes which are given in Figure 1. The four levels of hierarchical phases includes targets as followings: Level-I) selecting the overall purpose of selected problem, Level-II) showing category of major barriers, Level-III) representing the divisions of sub-barriers and Level IV) suggesting the way-forward for achieving business excellence.

### 3. Solution methodology

This section describes the modelling procedure of the proposed framework and also discusses the questionnaire development process for seeking inputs from experts. In order to categorize the barriers in implementation of supply chain initiatives considering a multi criteria decision-making (MCDM) problem based on fuzzy set theory. The fuzziness related problems based on human judgment for accurate and timely decision making. For tackling the fuzziness of expert inputs, the fuzzy triangular

**Table 1. A glimpse of previous research studies on sustainable supply chain initiative barriers analysis**

<b>Authors</b>	<b>Nature of contributions</b>
Singh et al., 2020	Barriers analysis in implementing green lean practices in manufacturing industries were discussed in this study.
Lis et al., 2020	A detailed review analysis conducted on mapping sustainable supply chain management practices.
Rahman et al., 2020	This research investigated barriers to implementing green supply chain management considering sustainable goals.
Caldera et al., 2019	This study evaluated the enablers and barriers for successful implementation of sustainable business practice in “lean” SMEs.
Sivakumar et al., 2018	In this research authors developed a DEMATEL approach for evaluating barriers for sustainable end-of-life practices.
Bhanot et al., 2017	This research suggested an integrated approach for analysing the enablers and barriers of sustainable manufacturing.
Gandhi et al., 2016	Authors evaluated the factors in achieving sustainable supply chain goals using a case study approach based on DEMATEL.
Luthra et al., 2015	In this research study a detailed barriers analysis was conducted to implement green supply chain management.
Reefke et al., 2014	The authors developed decision making model system in sustainable supply chain.
Seuring, 2013	In this research the author conducted an extensive review of literature for sustainable supply chain management.
Wee et al., 2012	The authors made analysis to formulate strategies for development in eradicating the barriers.
Carvalho, 2011	This research work focused on development of lean, agile, resilient and green divergences and strategies for achieving business goals in a sustainable way.

numbers are used to capture the subjective input and convert these inputs into numerical form. Nowadays, categorizing and eradicating the barriers in an uncertain supply chain environment is considering a decision problem which includes set of criterion. To tackle the vagueness and subjectivity, this research study proposed the framework based on the fuzzy set theory.

In the light of the previous literature and through discussion with the industrial experts, a comprehensive questionnaire was formulated and distributed among respondents of industries in Pakistan. Afterwards, the circulated questionnaires were analyzed and the barriers confronted by various industries were determined. From the list of scrutinized barriers, the potential barriers were chosen and ranked by applying fuzzy AHP technique.

### **3.1. Phase 1. Establishing decision group and identifying barriers**

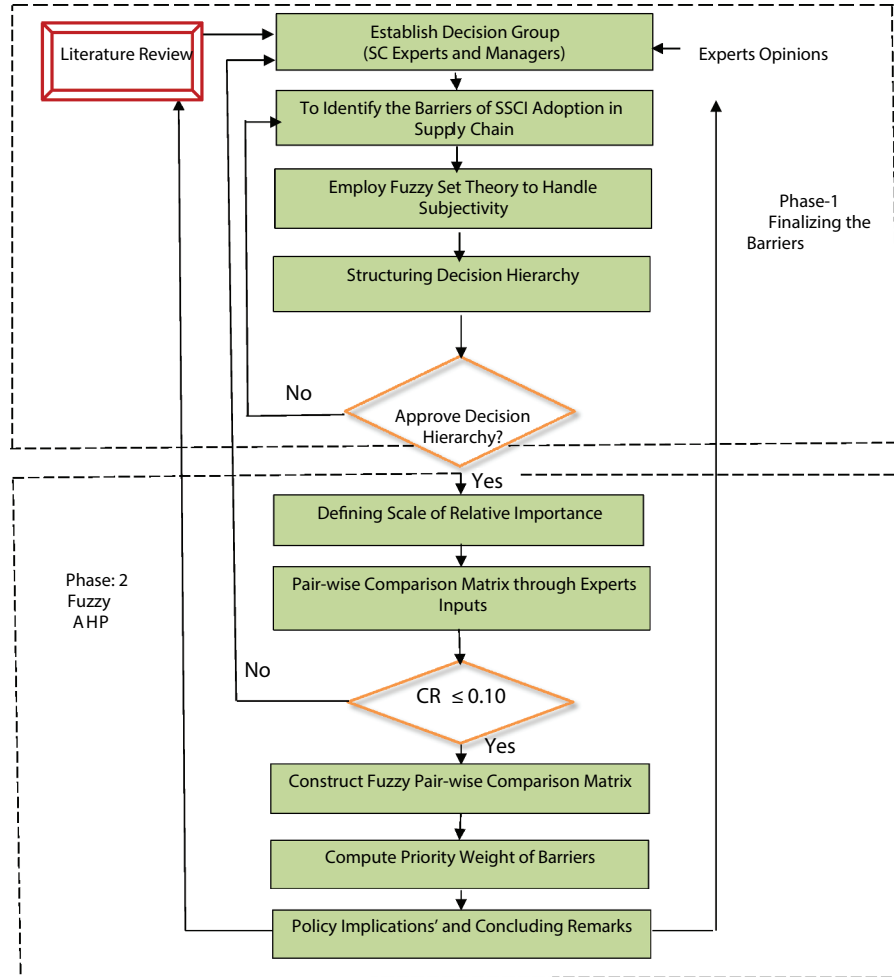
In the first phase, two types of decision groups are established for providing valuable inputs. A first group comprising logistics managers, operation managers, industrial technical experts from all departments formulated for identifying and evaluating the barriers. Afterwards, another group consisting of experts from academia and industry is also constructed to determine the barriers. Then, the criterion of (SSCI) adoption in supply chain is determined through literature review and by the inputs of the experts. Afterwards, the hierarchical structure is constructed in such a way that objective of the proposed problem come at the level 1, main criterion in the level 2 sub criterion at 3<sup>rd</sup> level and way-forward are in the 4<sup>th</sup> level.

### **3.2. Phase 2. Overview of fuzzy AHP**

The AHP was initially first time, developed by Saaty and further extends to fuzzy AHP by integrating through using fuzzy logic and fuzzy triangular variables (Saaty, 1980). Fuzzy AHP is a flexible decision-making tool for prioritization of different criterion and sub-criterion. The fundamental



**Figure 1. Proposed fuzzy AHP model.**



**Table 2. Scale used for intensity of importance to construct the pairwise comparison matrix**

Intensity of importance	Fuzzy number	Linguistic variables	Triangular fuzzy numbers (TFNs)
1	$\tilde{1}$	Equally	(1, 1, 3)
3	$\tilde{3}$	Weekly	(1, 3, 5)
5	$\tilde{5}$	Strongly	(3, 5, 7)
7	$\tilde{7}$	Very strongly	(5, 7, 9)
9	$\tilde{9}$	Extremely	(7, 9, 11)

purpose of this method is to facilitate decision-making process when a set of qualitative and quantitative criteria to be considered for evaluation. This technique uses fuzzy set theory and fuzzy scales to determine the relative importance of the criterion by making comparison with other criterion to formulate pairwise matrix. Later, a fuzzy pair-wise comparison matrix can be formulated and output of criterion is also highlighted by taking fuzzy factors. Afterwards, the linguistics expression can be converted into numerical values, using arithmetic operators. The fuzzy AHP includes the followings four steps, namely:

*Step 1. Computing the weights of barriers using Triangular Fuzzy numbers (TFNs)*

**Table 3. Pairwise comparison matrix of the major criterion used in SSCI**

	SO <sub>1</sub>	SPD <sub>2</sub>	SCI <sub>3</sub>	SBSR <sub>4</sub>	SMOC <sub>5</sub>	SKSC <sub>6</sub>	ST <sub>7</sub>
SO <sub>1</sub>	1.00	2.00	3.00	2.00	3.00	2.00	3.00
SPD <sub>2</sub>	0.50	1.00	3.00	2.00	3.00	2.00	2.00
SCI <sub>3</sub>	0.33	0.33	1.00	2.00	2.00	2.00	2.00
SBSR <sub>4</sub>	0.50	0.50	0.50	1.00	3.00	2.00	3.00
SMOC <sub>5</sub>	0.33	0.33	0.50	0.33	1.00	2.00	2.00
SKS <sub>6</sub>	0.50	0.50	0.50	0.50	0.50	1.00	2.00
ST <sub>7</sub>	0.33	0.50	0.50	0.33	0.50	0.50	1.00

The evaluation scale of weights using (TFNs) are applied to determine the fuzzy weights for the pairwise comparison matrix by using the 9-point scale of Saaty (Saaty, 1980), based on linguistic expressions shown in Tables 3 and 4. The experts choose linguistic as well as numerical values from these tables for criteria weight computation.

*Step 2. Developing the fuzzy pair-wise comparison matrices.*

The fuzzy pair-wise comparison matrix is constructed to calculate weight of barriers. The fuzzy numbers are applied to show the intensity of significance of one barrier over the other and resultantly, fuzzy judgmental matrix is obtained for every criterion. Table 2 represents the scale for intensity of importance, applied in comparison matrices.

*Step 3. Calculating the weight of barriers and sub-barriers*

The experts were assigned to provide their valuable inputs in the form of linguistic variables, using Table 2. These linguistic variables further transformed and evaluated for getting the values of the weights of criterion using arithmetic operators. The main phases of solution methodology are given in Figure 2.

*Step 4. Applying consistency test for pair-wise comparison matrix*

This step emphasized on the testing of consistency among criterion by the computation of the normal consistent ratio (CR). The consistency ratio can be computed by using the below steps. In the first step, compute the Eigen vector and  $\lambda_{Max}$  for every matrix having order  $n$ . The second step used to compute the final consistency ration, where RI is the random index, depending on the size of the matrix. Following equation is used to compute the consistency index (CI) for the matrices having order  $n$  and also the consistency ratio (CR) taking the below formulas:

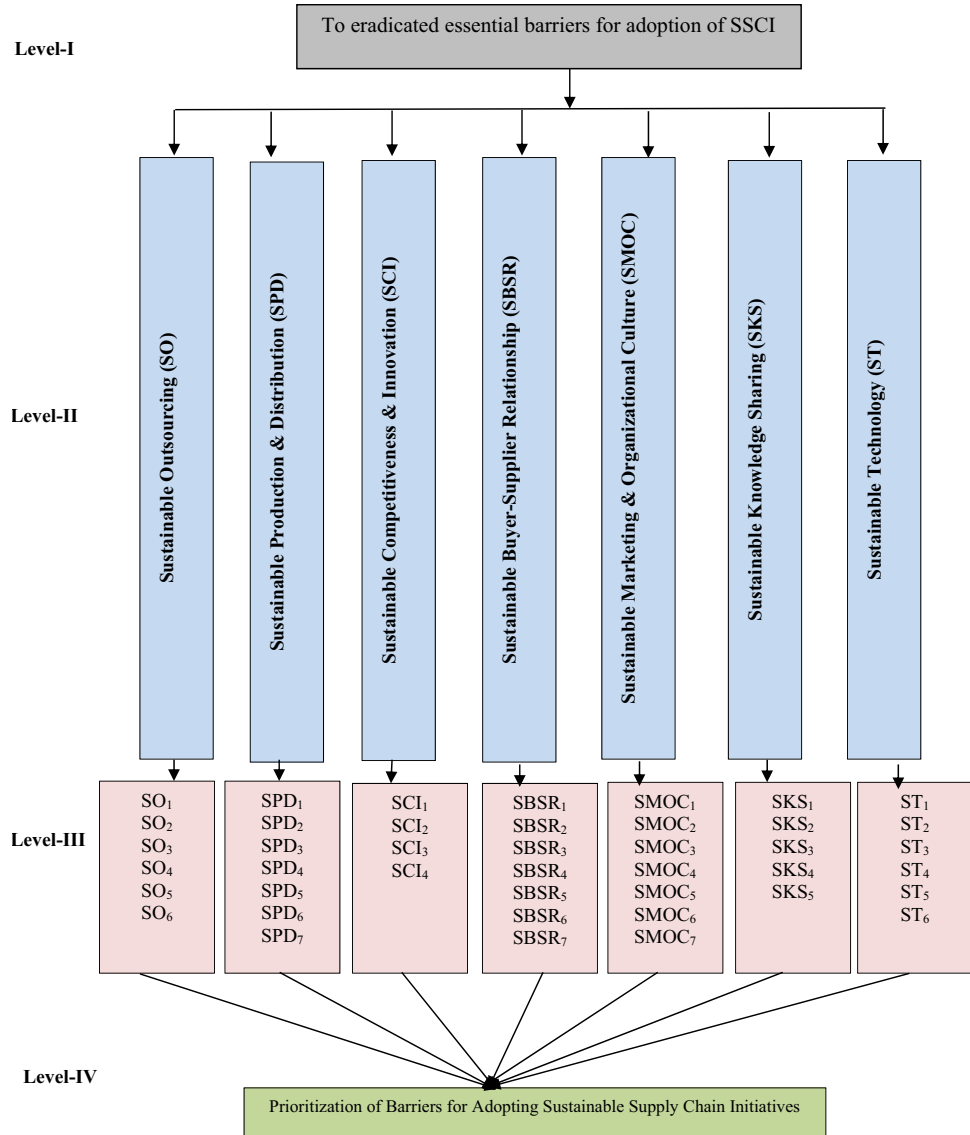
$$\text{Consistency Index (CI)} = (\lambda_{max} - n) / (n - 1)$$

$$\text{Consistency Ratio (CR)} = \text{CI} / \text{RI}$$

**Table 4. Ranking of categories of barriers in implementing SSCI**

Barrier categories	Criterion Weight	Ranking
SO	0.2735	1
SPD	0.2118	2
SCI	0.1374	4
SBSR	0.1377	5
SMOC	0.1425	3
SKS	0.0871	6
ST	0.0622	7

**Figure 2. Decision hierarchy of SSCI initiatives.**



**3.3. Scenario of research methodology**

The purpose of this research is to scrutinize the high ranked barriers and suggest the corrective actions for the adoption of sustainability perspective in agro industries. In order to accomplish this aim, the proposed scenario of research methodology in this research is having fuzzy AHP model as given in Figure 2. This research proposed problem scenario having two phases.

*Phase 1:* Initially, a group of two decision makers are established. In the first group, logistics managers, operations managers, and industrial technical experts from all departments having enriched experience of supply chain is formulated for identifying and evaluating the barriers. Afterwards, a second group consisting of experts from academia and industry for seeking information, regarding sustainability aspects is also constructed for identification and evaluation of the solutions. This is appended by the opinion of group members, and finally, the hierarchical model is formulated.

*Phase 2:* The fuzzy AHP method is applied to compute the barriers weightage in this phase. In this case, pairwise comparison matrices are formulated in getting the weights vectors, which is shown in Table 3. The ranking of the barrier categories calculated through final pairwise comparison matrix as given in Table 4.

#### **4. Proposed fuzzy AHP framework**

The overall objectives of this study were to recognize the barriers in adopting sustainable supply chain initiatives.

##### **4.1. Practical application of proposed model**

The objectives of this research were linked to determine the issues and prospects faced by decision makers in solving the real life problems under uncertain environment. The basic aim of this research was to develop the sustainability-roadmap for the barriers which may affect the productivity of the industries. This section includes four components: (i) application of the proposed model, (ii) conducting survey for identification of barriers relevant to implementation of sustainable supply chain initiatives, (iii) identification of key barriers for (SSCI) implementations using fuzzy AHP, (iv) analysis of results of key barriers category using sensitivity analysis.

###### *4.1.1. Phase 1: performing field survey to determine the barriers*

The cross-sectional research tool was developed in order to conduct survey to collect data from the different agro-based industries in Pakistan. The pre-testing questionnaire was distributed among the respondents of industry after taking the experts inputs; the highly significant potential barriers were recognized, applying fuzzy AHP technique.

###### *4.1.2. Phase 2: evaluation of potential barriers for (SSCI) adoptions using fuzzy AHP*

This research was conducted to collect data from the main agro-based industries of Pakistan and the participating organizations respondents were provided inputs in the form of the pair-wise comparison. The weight of barriers was computed using Saaty's methodology of 9-point scale values as given in Table 2. The tables were used as providing the experts feedback to the SC initiatives and after this consistency test was applied to check the consistency between main and sub barriers. Thus, the pair-wise comparison matrix for the major barrier category is given in Table 3 and Table 4, and the summary of sub-criteria pairwise comparison matrixes are given in Table 5. The structural hierarchy of proposed problem is given in Figure 3.

##### **4.2. Results analysis of key barriers category**

The results from Table 5 depict that the sustainable outsourcing barrier found as the top priority barrier as compared to other barrier categories. As the outsourcing in the SC is very important for manufactures which inhibit the adoption of (SSCI). The detailed summary results of each major barrier categories and sub-barriers, is elaborated in the below sections.

###### *4.2.1. Sustainable outsourcing*

Out of seven major barrier categories, this category of the barriers namely, SO<sub>1</sub> (facing problems in maintaining sustainable suppliers) is the important key barrier (Table 6). The weight of SO<sub>2</sub> depicts that the most of the agro-based companies do not have appropriated procurement approaches for checking their suppliers' sustainability initiatives. Therefore, due to the lack of direction and legislation on the sustainable management, firms are unable to measure the intensity of barriers which need to be measured. It is difficult to check suppliers' sustainable performance. Next is the lack of complexity in monitoring suppliers' eco-practice (SO<sub>2</sub>) barrier. The succeeding barrier is the lack of environmental partnership with suppliers (SO<sub>3</sub>). The lack of Govt. support for adoption of sustainable policies barriers (SO<sub>4</sub>) acts is next to (SO<sub>2</sub>) barrier. Another important barrier is no proper appreciation/benefit system for suppliers (SO<sub>5</sub>). The last barrier includes the problem of having reliance upon the sustainable relationship with green supplier (SO<sub>6</sub>). The (SO<sub>6</sub>) barrier's weight and rank demonstrate that the industries need to emphasize on the sustainable relationship with green supplier that helps the organizational environment.

###### *4.2.2. Sustainable production and distribution*

Based on the literature, this research investigated the certain key points, including barriers and sustainable production and distribution in the sustainable development so forth. In this category, (SPD<sub>1</sub>) usage of hazardous raw material in production process is the most highly ranked barriers.

**Table 5. Results summary of main barriers and sub-barriers with respect to the case scenario**

Main Barriers	Barriers weight	Sub-barriers	Consistency ratio (CR)	Ratio weight	Final weight	Rating
<b>SO</b>	0.2735	SO1	0.0640	0.3497	0.0957	1
		SO2		0.2410	0.0659	2
		SO3		0.1360	0.0372	6
		SO4		0.1326	0.0363	9
		SO5		0.0857	0.0234	16
		SO6		0.0550	0.0150	25
<b>SPD</b>	0.2118	SPD1	0.0988	0.2692	0.0570	4
		SPD2		0.2172	0.0460	5
		SPD3		0.1611	0.0341	12
		SPD4		0.1322	0.0280	13
		SPD5		0.0927	0.0196	20
		SPD6		0.0663	0.0140	28
		SPD7		0.0612	0.0130	29
<b>SCI</b>	0.1374	SCI1	0.0996	0.4779	0.0657	3
		SCI2		0.2561	0.0352	11
		SCI3		0.1376	0.0189	22
		SCI4		0.1284	0.0176	23
<b>SBSR</b>	0.1425	SBSR1	0.0862	0.2493	0.0355	10
		SBSR2		0.2574	0.0367	8
		SBSR3		0.1701	0.0242	14
		SBSR4		0.1138	0.0162	24
		SBSR5		0.0986	0.0141	27
		SBSR6		0.0549	0.0078	35
		SBSR7		0.0559	0.0080	34

(Continued)

**Table 5. (Continued)**

Main Barriers	Barriers weight	Sub-barriers	Consistency ratio (CR)	Ratio weight	Final weight	Rating
<b>SMOC</b>	0.0871	SMOC1	0.0988	0.2557	0.0223	17
		SMOC2		0.1365	0.0119	30
		SMOC3		0.1621	0.0141	26
		SMOC4		0.2294	0.0200	18
		SMOC5		0.0757	0.0066	37
		SMOC6		0.0751	0.0065	38
		SMOC7		0.0654	0.0057	39
<b>SKS</b>	0.0854	SKS1	0.0901	0.2303	0.0197	19
		SKS2		0.4301	0.0367	7
		SKS3		0.1340	0.0114	31
		SKS4		0.1220	0.0104	32
		SKS5		0.0836	0.0071	36
<b>ST</b>	0.0622	ST1	0.0876	0.3060	0.0190	21
		ST2		0.1630	0.0101	33
		ST3		0.0357	0.0022	42
		ST4		0.3837	0.0239	15
		ST5		0.0696	0.0043	40
		ST6		0.0420	0.0026	41



**Table 6. Barrier values when changing sustainable outsourcing values**

Barriers Categories	Normal Weights	Increment Changes									
		0.24615	0.2188	0.19145	0.1641	0.13675	0.1094	0.08205	0.0547	0.02735	
SO	0.2735	0.24615	0.2188	0.19145	0.1641	0.13675	0.1094	0.08205	0.0547	0.02735	
SPD	0.2118	0.21759	0.22354	0.22966	0.23594	0.24239	0.24902	0.25583	0.26283	0.27002	
SCI	0.1374	0.14116	0.14502	0.14898	0.15306	0.15725	0.16155	0.16596	0.17050	0.17517	
SBSR	0.1425	0.14640	0.15040	0.15451	0.15874	0.16308	0.16754	0.17212	0.17683	0.18167	
SMOC	0.0871	0.08948	0.09193	0.09444	0.09703	0.09968	0.10241	0.10521	0.10809	0.11104	
SKS	0.0854	0.08774	0.09014	0.09260	0.09513	0.09773	0.10041	0.10315	0.10598	0.10887	
ST	0.0622	0.06390	0.06565	0.06744	0.06929	0.07118	0.07313	0.07513	0.07719	0.07930	

**Table 7. Sensitivity analysis of sub-barriers with “SO” barrier weight changes from (0.2735\*0.9 ... 0.2735\*0.1)**

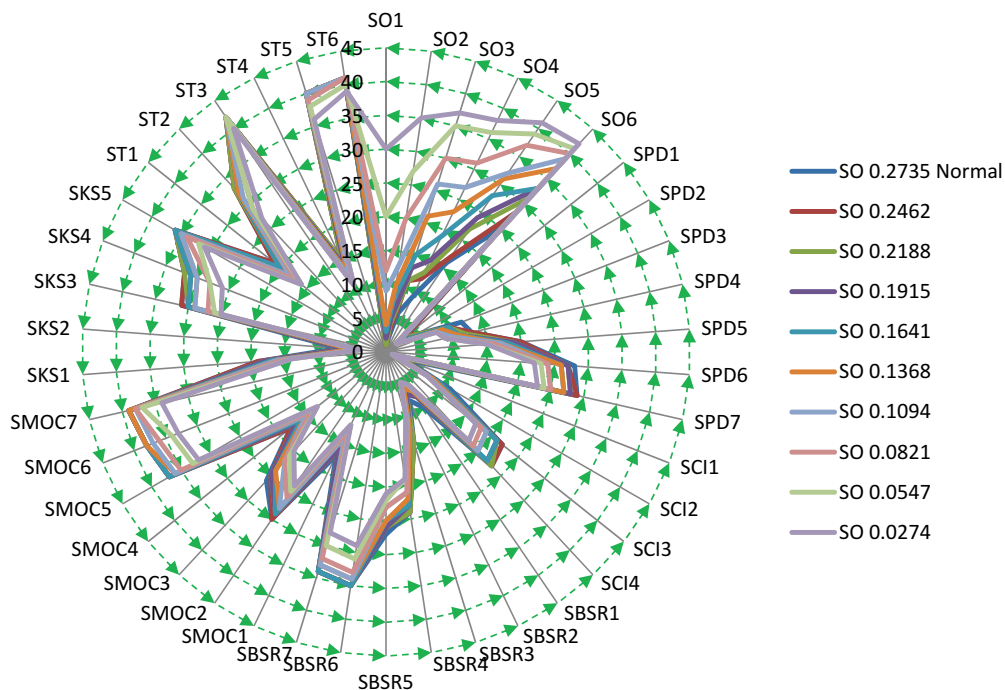
	SO = 0.2735 Normal	SO = 0.246	SO = 0.219	SO = 0.191	SO = 0.164	SO = 0.137	SO = 0.109	SO = 0.082	SO = 0.055	SO = 0.027
SO1	1	1	1	2	3	4	9	12	20	30
SO2	2	3	4	5	8	10	13	20	27	35
SO3	6	11	11	13	15	21	26	30	35	37
SO4	9	12	13	15	19	23	27	31	36	38
SO5	16	17	22	24	28	31	32	37	39	41
SO6	25	28	31	33	33	37	39	40	41	42
SPD1	4	4	3	3	2	2	2	2	2	2
SPD2	5	5	5	4	4	3	3	3	3	3
SPD3	12	10	10	10	10	9	8	8	8	8
SPD4	13	13	12	11	11	11	10	9	9	9
SPD5	20	20	19	19	18	17	17	16	15	15
SPD6	28	27	27	27	26	26	24	24	23	22
SPD7	29	29	28	28	27	27	25	25	24	23
SCI1	3	2	2	1	1	1	1	1	1	1
SCI2	11	9	9	9	9	8	7	7	7	7
SCI3	22	22	21	21	21	19	19	18	17	17
SCI4	23	23	23	22	22	20	20	19	18	18
SBSR1	10	8	8	8	7	7	6	6	6	6
SBSR2	8	7	7	7	6	6	5	5	5	5
SBSR3	14	14	14	12	12	12	11	10	10	10
SBSR4	24	24	24	23	23	22	21	21	19	19
SBSR5	27	26	26	26	25	25	23	23	22	21
SBSR6	35	35	35	35	35	34	34	33	31	29
SBSR7	34	34	34	34	34	33	33	32	30	28

(Continued)

**Table 7. (Continued)**

	<b>SO = 0.2735 Normal</b>	<b>SO = 0.246</b>	<b>SO = 0.219</b>	<b>SO = 0.191</b>	<b>SO = 0.164</b>	<b>SO = 0.137</b>	<b>SO = 0.109</b>	<b>SO = 0.082</b>	<b>SO = 0.055</b>	<b>SO = 0.027</b>
SMOC1	17	16	16	16	14	14	14	13	12	12
SMOC2	30	30	29	29	29	28	28	26	25	24
SMOC3	26	25	25	25	24	24	22	22	21	20
SMOC4	18	18	17	17	16	15	15	14	13	13
SMOC5	37	37	37	37	37	36	36	35	33	32
SMOC6	38	38	38	38	38	38	37	36	34	33
SMOC7	39	39	39	39	39	39	38	38	37	34
SKS1	19	19	18	18	17	16	16	15	14	14
SKS2	7	6	6	6	5	5	4	4	4	4
SKS3	31	31	30	30	30	29	29	27	26	25
SKS4	32	32	32	31	31	30	30	28	28	26
SKS5	36	36	36	36	36	35	35	34	32	31
ST1	21	21	20	20	20	18	18	17	16	16
ST2	33	33	33	32	32	32	31	29	29	27
ST3	42	42	42	42	42	42	42	42	42	40
ST4	15	15	15	14	13	13	12	11	11	11
ST5	40	40	40	40	40	40	40	39	38	36
ST6	41	41	41	41	41	41	41	41	40	39

**Figure 3. Results of sensitivity analysis for sustainable outsourcing barriers (SO).**



Next is the involvement of the potential customers in design process (SPD<sub>2</sub>) barrier. Adequacy for the disposal of the waste (SPD<sub>3</sub>), ranked on third priority level. Availability of green stock for the sustainable operations (SPD<sub>4</sub>) barrier, ranked at 4<sup>th</sup> level. Waste reduction through production Phase (SPD<sub>5</sub>) acts next to (SPD<sub>4</sub>), based on its weight. In this category, the second last barrier (SPD<sub>6</sub>) is the problem in requesting compliance statements. Lack of flexibility in manufacturing process (SPD<sub>7</sub>) is the last barrier.

#### 4.2.3. Sustainable competitiveness and innovation

The importance of this barrier can be seen by its ranking at third number among the entire categorized barriers list. In order to sustain the competitive edge, the first priority is given to (SCI<sub>1</sub>) in the competitive markets. In prioritizing the formulation of a sustainable database for maintenance of products (SCI<sub>2</sub>), it is kept at the second level of priority. Due to less-advanced equipment and innovative knowledge cannot disseminate smoothly. Analyzing (SSCI) initiatives of competitors within supply chain (SCI<sub>3</sub>) ranked next after (SCI<sub>2</sub>). Establishment of R&D cell for innovation of products (SCI<sub>4</sub>) ranked the last barrier.

#### 4.2.4. Sustainable buyer-supplier relationship

The importance of this barrier can be seen by its ranking at fourth number among the entire categorized barriers list. The selection of suppliers on the basis of sustainability criteria (SBSR<sub>2</sub>) holds the highest priority. The (SBSR<sub>1</sub>) are the second barrier. Providing awareness to (SC) partners for (SSCM) (SBSR<sub>3</sub>) ranked next after (SBSR<sub>1</sub>), (SBSR<sub>4</sub>) is ranked fourth in the priority levels, (SBSR<sub>5</sub>) is ranked the fifth priority, (SBSR<sub>7</sub>) it is seventh in priority and finally (SBSR<sub>6</sub>) is ranked at sixth number.

#### 4.2.5. Sustainable marketing and organizational culture

In this particular dimension, providing awareness about the sustainable products (SMOC<sub>1</sub>) holds the highest priority. Establishing culture for producing green products (SMOC<sub>4</sub>) comes next in the priority level. The customer profitability on the green products (SMOC<sub>5</sub>) comes after (SMOC<sub>4</sub>) in the priority level. Finding markets for the sustainable customers (SMOC<sub>3</sub>) ranked next after (SMOC<sub>4</sub>). Acquiring the sustainable customer satisfaction and loyalty of supply chain (SMOC<sub>2</sub>), lack of

customer awareness (SMOC<sub>6</sub>) towards (SSCM) is ranked after (SMOC<sub>2</sub>) and (SMOC<sub>7</sub>) is ranked at seven number.

#### 4.2.6. Sustainable knowledge sharing

The barrier category comprises five selected barriers. Sharing business knowledge with trading partners to avoid disruptions (SKS<sub>2</sub>) barrier comes first in this category. The succeeding barrier is providing awareness about forward/revers logistics adoption (SKS<sub>1</sub>). Maximizing the information sharing process (SKS<sub>3</sub>) barrier is placed in third. Another important barrier is sharing the sustainable supply chain concepts SKS<sub>4</sub>. At last, less weight priority is gained for discouraging disbeliefs regarding the environmental benefits (SKS<sub>5</sub>) barrier.

#### 4.2.7. Sustainable technology

Due to globalization, the manufacturing as well as service industries need to focus on updating the emerging trends and advanced technologies while taking the initiative in supply chain. In the sustainable technology barrier category, complexity of design is to reuse the used products (ST<sub>4</sub>) barrier ranks first, (ST<sub>1</sub>) barrier at two, (ST<sub>4</sub>) at three, (ST<sub>2</sub>), (ST<sub>5</sub>), (ST<sub>2</sub>), (ST<sub>6</sub>) and (ST<sub>3</sub>), respectively.

In the light of above results, this study demonstrated that (SSCI) initiatives are not constrained for dealing the technical aspects, but also focus on the non-technical aspects. From the findings of these results, the managers and decision-makers would be in a condition to understand and grasp a complete phenomenon of (SSCI) adoption.

### 5. Sensitivity analysis

The sensitivity analysis is an essential technique to check the fluctuations among the ratings/leveling of the variables by changing the value of weight vectors. This study categorized seven key barriers and out of these seven the highly prioritize barrier is the 'sustainable outsourcing barrier' (SO). It shows that a slight fluctuation in weightage of highly ranked barrier can influence the rest of barriers (see Table 5). For addressing the fluctuations among variables this research applied sensitivity analysis. Therefore, highly prioritize barrier weightage can be changed from 0.2735 (SO) to ( $0.2735 \times 0.9 = 0.2461$ ,  $0.2735 \times 0.8 = 0.2188$ ,  $0.2735 \times 0.7 = 0.1914$ ,  $0.2735 \times 0.6 = 0.1641$ ,  $0.2735 \times 0.5 = 0.1367$ ,  $0.2735 \times 0.4 = 0.1094$ ,  $0.2735 \times 0.3 = 0.0820$ ,  $0.2735 \times 0.2 = 0.0547$  and  $0.2735 \times 0.1 = 0.02735$ , values are taken to four decimal places) (see Table 7 and Figure 4).

#### 5.1. Implications of the research

In the light of above-mentioned research findings and personal discussions with the experts, the industrial officers and stakeholders the following implications are made:

##### 5.1.1. Managerial implications

- *Designing sustainability policies to overcome on the barriers*

The results of the study suggest that the prioritization of key barriers is very helpful for the stakeholders to design sustainability policies and also to develop a pollution-free, socially responsible and economic friendly policies.

- *Facilitating industries to convert traditional supply chain into sustainable supply chain*

The implications of this research would be helpful for the industries to adopt (SSCI) in the Pakistani context. The findings of this study would be extremely beneficial to stakeholders that are interested to convert their classical supply chain management to sustainable supply chain.

- *Developing strategies to reduce the import bill*

As import bill of Pakistan is increasing day by day which resultantly decreasing the export volumes marked as "Made in Pakistan" products from many years. In order to tackle this crucial position of

Pakistan economy, adopting the supply chain initiatives in producing the hygienic products is one of key strategies that need to be focused in order to position in the international marketplace.

#### 5.1.2. Policy implications

- *Implementing ISO14001:2004, ISO:9001:2015 and ISO 26000:2010 standards*

The Government should take steps towards sustainable business practices and compliance of ISO14001:2004 (*Environment Management System*) ISO:9001:2015 (*Quality Management System*) and ISO 26000:2010 (*Guidance on Social Responsibility*) standards and needs to promote these standards.

- *Introducing the electronic data interchange systems*

Introducing the electronic data interchange system in terms of sustainable technology is also one of the significant challenges, faced by the industries nowadays in Pakistan.

- *Designing recyclability and cleaner production strategies*

Recyclability and cleaner production are the major issues which are facing by the Pakistani industries. Industries in Pakistan should focus on the use of end of life product management which disposes off the product safely after being consumed. Cleaner production can be achieved through cleaner procurement and evaluation of the suppliers during purchasing process.

## 6. Conclusions

Adoption of sustainable supply chain management practices to eradicate or overcome the barriers is very difficult tasks for the industries. In order to improve business operations, this study applied sustainable concept along supply chain to categorize the barriers under uncertain environment. The objectives of this research were to identify the seven major barrier categories and forty-two sub-criteria related to (SSCI) adoption through the help of literature and experts inputs. The basic aim of this research was to develop the sustainability-roadmap for the barriers which may affect the productivity of the industries. This section includes four components: (i) application of the proposed model, (ii) conducting survey for identification of barriers relevant to implementation of sustainable supply chain initiatives, (iii) identification of key barriers for (SSCI) implementations using fuzzy AHP, (iv) analysis of results of key barriers category. Initially, the proposed fuzzy AHP approach is used to compute criterion weights and provide ranking to these forty-two barriers. From the results of Table 4, it is clear that lack of sustainable outsourcing is the top priority barrier category due to highest weight. Lack of outsourcing found as highly significant hurdle in implementing (SSCI). The rest of the barrier categories sorted in this order, SPD > SCI > SBSR > SMOC > ST barrier categories. The findings of this research study also provide valuable guidelines' to the management of the companies by providing direction in terms of green, social, and economic prospects. This suggests the industries to develop the strategies for accurate policy decisions for improving the supply chain sustainability of the industries.

Despite the contributions of this research, it also has few shortcomings as: the barriers identified are only forty-two in sub-domains and seven as main criteria domains and secondly respondents were selected only from Pakistani agro-industries. This research involves pairwise comparison to experts inputs which may be biased sometimes and difficult to understand. The subjective inputs of experts may be varied from country to country and industry to industry. Therefore, based on these limitations, the results cannot be generalized for all type of agro-based industries located in surrounding countries. In the future research studies, the researcher can add more attributes and sub-attributes which previously did not treat in this study. Similarly, other multi-attribute techniques can also be used to check the robustness of the proposed results.



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