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Sustainable production and consumption: analysing barriers and solutions for maintaining green tomorrow by using fuzzy-AHP–fuzzy-TOPSIS hybrid framework

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Abstract
Conventional production and consumption system results in rapid depletion of natural resources. Particularly in developing economies, the key factor behind environmental damage is conventional production and consumption. This problem can be overcome by adopting sustainable production and consumption (SPC) initiatives. But for implementation of SPC, proper knowledge of various challenges and solutions is required as in case of any failure it may lead to heavy losses. So in this research study, efforts have been put to identify various barriers in adopting SPC and various solutions to make these barriers less intense. Keeping Indian manufacturing industry in focus, total twenty-six barriers under six different heads were identified with the help of the literature and experts' input. Fuzzy-AHP MCDM methodology has been adopted to identify the relative importance of all these barriers. As a result, it is found that Government-related barriers, Management-related barriers and Finance-related barriers are the key barriers to be focused for adopting the SPC. Further thirteen solutions either to remove the barriers or to lower the impacts of barriers were identified from the literature and experts' input. These thirteen solutions were ranked using fuzzy-TOPSIS methodology. The final results provided the prioritised list of all twenty-six barriers and thirteen solutions, which will be helpful in understanding the concept of SPC. Further sensitivity analysis has also been done to ensure the correctness of the results obtained. The literature is full of researches focused on identification and analysis of barriers, but very few studies like ours are available, which also analyse various solutions along with barriers. This work will be helpful for government and management in making policies to promote SPC. Finally, this work will be very beneficial for all, who are focused towards SPC.

Keywords Sustainable production and consumption (SPC) · Circular economy (CE) · Barriers in achieving sustainable production and consumption · Fuzzy-analytical hierarchy process (F-AHP) · Fuzzy-the technique for order of preference by similarity to ideal solution (F-TOPSIS)

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1 Introduction

With the slogan of "Make in India", Government of India has created a favourable working environment to the companies around the globe. Global manufacturers are now establishing their production units in India (Luthra et al., 2020). Increased industrialisation resulted in economic growth along with increased usage of natural resources (Bradley, 2019; Esteve-Llorens et al., 2021). With the economic growth, consumers started buying more than their requirement and this resulted in higher consumption of natural resources (Azzurra et al., 2019). This also resulted in wastage of resources and degradation of environment (López-Delgado et al., 2020; Tunn et al., 2019).

Increasing population is also a serious issue as it results in consumption of natural resources at a rate higher than their production rate. So sustainability is greatly affected by growing world population (Govindan, 2018). Though there are many other serious issues related to environment, economy and society which results in unsustainability (Chowdhury et al., 2020; Govindan et al., 2013; Luthra et al., 2016; Neves et al., 2014). Therefore, environmental issues must be given importance to attain the goal of sustainability (Dallas et al., 2020; Tyagi et al., 2015). Sustainability may be defined as to maintain a balance among social, economic and environment by rearranging the various resources (Chowdhury et al., 2020; de Ron, 1998).

All these goals of maintaining a balance among social, economic and environment can be achieved by adopting SPC linked with CE, but it is not an easy task for any organisation as adopting SPC linked with CE may result in heavy losses, if not adopted properly (Orji, 2019; WBCSD, 2008). Many challenges and barriers are there in adopting the SPC, and it is necessary to understand these barriers for successful adoption of SPC (Jayaram & Avittathur, 2015; WBCSD, 2008). Therefore, there is a need of identifying and analyse the various challenges related to adoption of SPC (Caldera et al., 2019).

Sandin and Peters (2018) concluded that repairing, reusing and remanufacturing result in reduced environmental impacts with the reduction in usage of primary resources. Circular economy (CE) is the concept which can be very helpful in ensuring sustainable consumption and production as it ensures repairing and reusing of the product (Diaz et al., 2021; Ghisellini et al., 2016; Tseng et al., 2018). It is very popular among the policymakers, world business leaders, practitioners, academicians and NGOs as it can solve the global environmental and economic challenges (Genovese et al., 2017; Luthra et al., 2019). According to Ellen McArthur foundation, the conventional production and consumption system is based on "take-make-use-dispose", which is unsustainable in nature. In this model, the resources are not used efficiently because in this model, the product is disposed after completion of its first lifespan rather than repair and reuse, even when it is possible, resulting in shorter product life span (MacArthur, 2013; Singhal et al., 2019; Szulecka, 2019). CE was described by The Ellen McArthur foundation as a concept that is regenerative by nature and focused on waste reduction either by repairing and reusing the products or by remanufacturing the products. Repairing, remanufacturing and reusing practices result in lesser use of primary resources and thus reduction in waste generation (Diaz et al., 2021; Hoang et al., 2018). Along with CE, there are certain other solutions to the sustainability issues as strong and clear policy making by government with full financial support from management, encouragement to adopt best efficient technologies, etc. (Luthra et al., 2016).

The present research work recognises the existing barriers and solutions in achieving SPC linked with CE in Indian manufacturing industry and prioritises these barriers

and solutions on the basis of experts input to help producers in decision-making and promoting SPC. The various objectives of this research work are as under:

- To find and analyse the various barriers in adoption of SPC to help managers in making decisions for promoting SPC; and
- To find and analyse the various solutions to remove the barriers or to lower the impact of barriers in achieving SPC.

To find and analyse the barriers in adoption of SPC is the first objective of the present work. Twenty-six barriers from the literature survey and expert's input have been identified. The understanding of these barriers will help managers in decision-making for adopting sustainable production and consumption. In this research work, F-AHP has been used to analyse the data for finding the relative importance of all these twenty-six barriers. F-AHP is widely adopted MCDM technique used for decision-making (Calabrese et al., 2019; Kahraman et al., 2003). In F-AHP, the factors are compared through the linguistic variables. These linguistic variables are represented by triangular numbers. F-AHP is the improved version of AHP as it uses fuzzy logic approach and it is free from vagueness for personal judgments, for which AHP is often criticised (Aouam et al., 2009; Calabrese et al., 2019; Saaty, 1980; Yadav et al., 2018a).

The second objective is to find and analyse the various solutions to remove the barriers or to lower the impact of barriers in achieving SPC. This objective is achieved by identifying thirteen solutions with the help of the literature survey and expert's input. All these identified solutions are ranked with the help of F-TOPSIS methodology. F-TOPSIS is one of the most widely used MCDM techniques for prioritisation of various attributes (Freeman & Chen, 2015; dos et al., 2019). F-TOPSIS gives higher rank to that alternative which is having the minimum distance from the positive ideal solution and the maximum from the negative ideal solution (Mavi et al., 2016). The final result gives the prioritised list of all twenty-six barriers and thirteen solutions, which will be helpful in attaining the goal of SPC. All these results are checked using sensitivity analysis to ensure framework's robustness.

The next section of this paper presents the findings from expert's input and literature based on sustainability, SPC, CE and necessity of adopting SPC. Further, in Sect. 3, research methodology is described. The results are obtained in Sect. 4 and these results along with managerial and practitioners' implications are discussed in Sect. 5. Conclusion along with limitations and scope of work in future of this research study is given in the last section.

2 Findings from the Literature and Experts' Input

This section comprises three subsections. First subsection presents the various barriers identified from the literature and expert's input. Second subsection presents the various solutions to remove the barriers or to lower the impact of the barriers, and in the third subsection, various research gaps have been identified.

2.1 Barriers to achieve SPC linked with circular economy

Adopting SPC linked with CE is not an easy task. It may result in heavy losses, if not adopted correctly (Yadav et al., 2018a). Therefore, for smooth implementation of SPC, it is significant to understand the various barriers in adopting the SPC linked with CE. These barriers to adopt SPC linked with CE can be found from various sources like the literature and expert's inputs. Keeping Indian manufacturing industry in focus, twenty-six barriers have been identified. These barriers were categorised into six categories, i.e. Government-related barriers, Management-related barriers, Technological and Resources barriers, Behaviour-related barriers, Financial barriers and Other barriers. All the twenty-six barriers are given in Table 1.

2.2 Solutions to remove barriers or to lower the impact of barriers

For implementing SPC smoothly and correctly, proper knowledge of various challenges and their solutions is very essential (Mangla et al., 2017). Practitioners and researchers have reported various solutions to overcome the SPC barriers. In this research study, efforts have been made to identify various solutions either to remove the barriers or to lower the impacts of barriers. From the literature and expert's input, thirteen solutions have been identified and ranked by using F-TOPSIS methodology. This will be helpful for managers in making decisions promoting SPC. The list of various solutions is given in Table 2.

2.3 Research gaps

From the exhaustive survey of literature, the various gaps identified are as under:

- It is observed that very limited work, focused on identification of various barriers in the way of SPC and various solutions to attain sustainable development, has been reported (Pathak & Singh, 2019; Zhou et al., 2019). Also, researchers who reported their work focused on various barriers towards SPC, they were limited in finding the barriers in some specific categories as Management related, Government related and based on Finance only (Chams & García-Blandón, 2019; Gherghel et al., 2019; Nishitani & kokubu, 2020). There are some other factors also which affect sustainability as population, education, employment rates, behaviour of producer and consumer, but most of the researchers lack in focusing all these barriers (Bexell et al., 2019; Morris et al., 2021; Thakur & Mangla, 2019).
- Most of the researchers reported their work based on barriers only. Very few researchers have presented the solutions to remove the barriers or to lower the impact of the barriers (Gijo & Antony, 2014; Vinod et al., 2015; Yadav et al., 2018a). There are very few studies that provide any linkage between barriers and solutions by using hybrid methodology to rank both the barriers and solutions.
- Many researchers identified various barriers or solutions and prioritised these barriers or solutions using any MCDM technique, and they ignored the human judgement error-related possibilities in their research work (Yadav et al., 2018a). This problem of some vagueness in human judgement can be ruled out by using fuzzy set theory with the selected methodology (Mathew et al., 2020).

Table 1 Barriers to achieve SPC linked with CE

Category of barriers	Description	Specific barriers		Brief description	References
Government-related barriers	Government plays an important role in every aspect of life, as policy formation and implementation of policy depend on government	GOV 1	Poor policy framing	Government should make the policies which talk about industrial ecology for promoting SPC, but sometimes government fails in strong policy making to promote SPC	Lehtoranta et al. (2011); Nazzal et al. (2013); Brizga et al. (2014); Al-maskari et al. (2019)
		GOV 2	Lack in implementation of policy framed	Government makes the policy but lacks in implementing that policy strictly	Stevens (2010); Luthra et al. (2015); Moktadir et al. (2018)
		GOV 3	Lesser promotional events towards SPC	Government pays less attention to organise events to promote SPC	Sharma and Rani (2014); Luthra et al. (2016)
		GOV 4	Poor support to NGOs to promote SPC	NGOs can play key role in promoting the concept of SPC. But due to poor support of government, NGOs fail in promoting SPC	Jakhar (2015)
		GOV 5	Heavy taxes	Heavy taxes imposed on industries also result in unsustainable production and consumption. Some motivational subsidy packages must be given for the activities like upgradation of technology and skilling the workforce	Wu et al. (2018)
Management-related barriers	Success of any organisation depends on its management. Management is solely responsible for the working environment in any organisation. It is the management who can promote the concept of SPC	MGMT 1	Poor support from management to take decision	Management should support to take decision which ensures sustainability, but mostly management is focused only on economic gain, due to which they do not support to take decisions towards SPC	Clark (2007); Luthra et al. (2015)
		MGMT 2	Lesser determination towards SPC adoption	To adopt SPC, a firm determination is required but for gaining more and more, management tries to escape from these responsibilities and they do not show full determination towards SPC	Jones et al., (2011); Moktadir et al. (2018))
		MGMT 3	One-way communication—top to bottom	In most of the companies, managers are not interested in taking suggestions from their subordinates. This restricts the innovative ideas to come and creates hurdles in adoption of SPC	De Brito et al. (2008); Wong et al. (2009); Dhull and Narwal (2018)

Table 1 (continued)

Category of barriers	Description	Specific barriers		Brief description	References
Technological and Resource-related barriers	Organisational and Resource barriers have their own importance in achieving the target of sustainable development. Sometimes government makes good policies, and management also gives full support, but because of old technology or less skilled workforce, they may fail to achieve the target of sustainable development	T&R 1	No upgradation from old technology to latest technology	Technological innovation is a better tool towards sustainability. Latest technologies are energy efficient and environment friendly, but many organisations still work on old technology	Muduli and Barave (2011); Kaushik et al. (2014); Bhatia et al. (2018)
		T&R 2	Less skilled workforce	To minimise the expenditure, organisations hire employees with lesser skills, which results in unsustainable working. Workforce should be trained to achieve SPC	Gberevbie and Ibietan (2013); Gandhi et al. (2018)
		T&R 3	Lack of a good IT system implementation	A good IT system can help in making the products traceable, so that in case of any theft, it can be recovered easily. It can also be useful in promoting the concept of CE as once the product completes its life; it can be traced for repairing and reuse. A good IT system implementation also results in reduction of paper usage	Almeida et al. (2013); Dubey et al. (2015); Waqas et al. (2018); Bressanelli et al. (2018)
		T&R 4	Technology adoption from other countries rather than technology development	Adopting technology from other countries, costs higher due to heavy taxes. Due to this higher cost, most of the industries especially micro- and small-level industries hesitate to adopt the latest upgraded technology, which results in unsustainable production and consumption	Chan et al. (2018)
		T&R 5	Poor adoption of remanufacturing and reusing	Repairing, remanufacturing and reusing are the concept that are essential to adopt and result in SPC as it saves raw materials and lots of energy. In this concept, a product is not disposed after completion of its first life cycle rather it is repaired or remanufactured for reusing	Sangwan (2017); Manninen et al. (2018); Singhal et al. (2019)

Table 1 (continued)

Category of barriers	Description	Specific barriers		Brief description	References
Behaviour-related barriers	Behaviour defines the possibility of being successful for any nation, organisation or an individual. If the behaviour of producer or consumer is not towards sustainable development, then it is impossible to attain sustainable development even in the presence of all the resources needed for sustainable development	BEH 1	Ignorance of customers towards sustainable products	Mostly customers are focused towards getting cheap products with multiple functions. They are ready to compromise with quality up to certain level, which results in unsustainable consumption and production	Mudgal et al. (2009); Andrews et al. (2016); Morris et al. (2021)
		BEH 2	Poor advertisement of sustainable products	Advertisement helps in promotion of any product. If sustainable products are advertised well, telling customers the benefits of product towards sustainability, then the concept of SPC can be promoted. But due to poor advertisement, sustainable products do not get recognised	Jones et al. (2011); Govindan et al. (2014)
		BEH 3	Producer's behaviour of producing cheap even at the cost of environment	Producers mostly believe in producing cheap to gain more profit even at the risk of environment, which is a big hurdle in the way of SPC. Producers should take responsibility for maintaining quality in their products	Vergragt et al. (2014); Morris et al. (2021)
		BEH 4	Poor involvement of social activist and NGOs	NGOs can help in promoting the concept of SPC. NGOs can compel enterprises to replace potentially hazardous substances, but most of the NGOs are not concerned or having poor knowledge about SPC	Jakhar (2015); Shete et al. (2020)
		BEH 5	Over consumption results in wastage of natural resources	As per the reports of many surveys, people buy more than their requirement, which results in wastage of resources. This also results in higher consumption of natural resources	Jones et al. (2011); Schmidt and Matthies (2018); Shah et al. (2019)

Table 1 (continued)

Category of barriers	Description	Specific barriers		Brief description	References
Financial barriers	For adoption of SPC, standardised machines, tools and processes are required to be implemented, for which finance is a key requirement. But lack of finance acts as a key barrier in adoption of SPC	FIN 1	Funds required for technological upgradation	Technology upgradation is an integral part of any industry. New technologies efficient in terms of working, consuming less energy and producing minimum waste should be adopted, but sometimes industries hesitate for technological upgradation due to lack of funds	Lund et al. (2016); Kar et al. (2016)
		FIN 2	Funds required for developing efficient technology	For developing new efficient technology, a huge amount of money is required, but in the absence of funds, industries lack in developing efficient technology	Kar et al. (2016); Bhandari et al. (2019)
		FIN 3	Funds required to train the workforce	To train workforce is the utmost requirement for SPC. Even to work with the best efficient technology, skilled workforce is required. Sometimes companies lack in providing training to the workforce for saving the money	Bhanot et al. (2017); Luthra et al. (2019)

Table 1 (continued)

Category of barriers	Description	Specific barriers		Brief description	References
Other barriers	There are some barriers such as population, education, the cost of product and the market size for the product, which also have impact on sustainable development	OTH 1	Higher cost of sustainable products	Generally, the costs of sustainable products are more than the cost of general products due to which the demand of sustainable products is less. Though the quality of sustainable products will be better, but due to lack of proper knowledge, the demand is less	Jones et al. (2011)
		OTH 2	Education	Education should teach the person about the environment and society. Education can help in changing the attitude of people who are focused to earn money only, towards sustainability	Welford et al. (1998); Bhanot et al. (2017)
		OTH 3	Poor differentiation of sustainable products from regular products	It is very difficult to differentiate between sustainable products and regular products, due to poor knowledge of sustainable development	Lorek and Spangenberg (2014)
		OTH 4	Employment rates	With the increase in population, unemployment rate also increases. This promotes the micro- and small-level industries. These organizations work for gaining more even at the risk of environment due to shortage of money	Welford et al. (1998); Krajnc and Glavic (2003); Orji (2019)
		OTH 5	Population	Population is increasing very fast, and resources are limited. Resources are being consumed at very high rate. So this increase in population acts as a barrier in the way of SPC	Govindan et al. (2014); Ibrahiem (2018)

Table 2 Solutions to remove barriers or to lower the impact of barriers

S. No	Solution	Brief description	References
1	Strong and clear policy making (S1)	Strong and clear policies will help organisations in adopting SPC	Brizga et al. (2014); Al-maskari et al. (2019)
2	Implementation of the policies formed (S2)	All the policies made for ensuring SPC should be implemented successfully	Moktadir et al. (2018)
3	Full financial support (S3)	For ensuring SPC, efficient technology, processes and machines are required, which is only possible in the presence of full financial support from the management	Kar et al. (2016); Bhandari et al. (2019)
4	Technological upgradation when required (S4)	Upgrading from old technology to new energy efficient technology will result in SPC	Kaushik et al. (2014); Bhatia et al. (2018)
5	Committed top management towards sustainable development (S5)	In any organisation, top management plays the most important role in adopting any practice. So committed top management towards sustainable development is the basic need for adopting SPC practices	Jones et al. (2011); Moktadir et al. (2018); Morris et al. (2021)
6	Promotional events to promote SPC (S6)	Promotional events to promote SPC must be organised, which may help customers in understanding the benefits of sustainable products	Luthra et al. (2016)
7	Training/awareness program for the workers (S7)	Even with the best efficient technology, unskilled workforce will result in unsustainable production and consumption. So some training and awareness programs must be organised for the workers to achieve the goal of sustainability	Welford et al. (1998); Merli et al. (2015); Bhanot et al. (2017); Luthra et al. (2019)
8	Motivating packages to micro and small-level industry (S8)	Some motivating packages must be given especially to micro- and small-level industries to upgrade their technology for sustainable production	Luthra et al. (2014)
9	A good information sharing system (S9)	A good information sharing system will be very helpful in SPC as it will remove the communication gap among various departments. It will also help in promoting the concept of CE by easily tracking the products that have completed their lifespan for repairing or remanufacturing	Dubey et al. (2015); Bressanelli et al. (2018); Waqas et al. (2018)

Table 2 (continued)

S. No	Solution	Brief description	References
10	Educating/Motivating the society for sustainable development (S10)	Education and motivation towards environment and society may result in great change in the attitude of the people. This will be helpful for promoting the concept of sustainability	Liu et al. (2012); Bhanot et al. (2017)
11	Make sustainable products more cost competitive (S11)	Some initiatives must be taken to make sustainable products more cost competitive	Jones et al. (2011)
12	Design for repair and remanufacture (S12)	CE is the concept that promotes repairing and remanufacturing of products after completion of their life. This results in reducing the consumption of natural resources and ensures sustainable development	Xiang and Ming (2011); MacArthur (2013); Aminipour et al. (2021)
13	Skilled workforce (S13)	With the upgradation in technology, there is a requirement of skilled workforce for operating the machines efficiently. This combination of advanced technology and skilled workforce will result in sustainable development	Sarkis et al. (2011); Merli et al. (2015); Gandhi et al. (2018)

- Most of the researchers have reported their work based on manufacturing sector of foreign countries, and less work has been reported especially focusing on the Indian manufacturing industry (Luthra et al., 2016; Nishitani & kokubu, 2020). There is a lot of research work to do, focusing on the various barriers towards SPC and their solutions, especially when it comes to focus on Indian manufacturing industry (Kinnunen & Kaksonen, 2019; Pathak & Singh, 2019).

This work is an attempt to fill all these gaps by identifying the barriers in adoption of SPC linked with CE especially in Indian manufacturing industry and also by finding the solutions to remove these challenges or to lower the impact of these challenges. The above gaps reflect the need of this research work, which provides a linkage between various SPC challenges and their solutions by using F-AHP–F-TOPSIS framework.

3 Methodology

In this research work, all the identified barriers have been ranked by using F-AHP technique based on the ratings given by experts. After getting the prioritised list of barriers, F-TOPSIS technique has been applied to rank the various solutions, found to remove barriers or to lower the impact of barriers. The robustness of all these results has been analysed using sensitivity analysis. All these ranked barriers and solutions will be helpful for government, managers and researchers in decision-making to achieve sustainable production and consumption. All these techniques (F-AHP and F-TOPSIS) are given as under.

3.1 Fuzzy-analytical hierarchy process (F-AHP)

In this research work, F-AHP has been applied to prioritise the barriers in achieving the SPC.

In F-AHP, fuzzy theory is embedded to basic AHP, developed by Thomas L. Saaty in 1970s. AHP is MCDM methodology, used for analysing complex problems and making the decisions (Saaty, 1980). AHP is known as one of the best competent techniques for analysing complex decision-making problems (Freeman & Chen, 2015; Mangla et al., 2017; Yadav et al., 2017; Zhou & Yang, 2020). AHP decomposes the complicated problems and integrates it with opinions of experts and ratings given by experts (Hembram & Saha, 2018; Yadav et al., 2017). The strength of AHP is acknowledged by practitioners and researchers from different domains (Bhosale & Kant, 2014; Luthra et al., 2019). But AHP is often criticised for the biasness of individual in ratings (Yadav et al., 2017). To overcome such situation, Zadeh (1965) introduced fuzzy logic approach, in which linguistic variables have been used for comparing the criteria and alternatives (Kilincci & Onal, 2011; Ocampo, 2019). Buckley (1985) incorporated the fuzzy set theory with AHP (Rostamy et al., 2012). The use of fuzzy set theory with AHP helps in removing the vagueness in decision-making (Patil & Kant, 2014; Singh & Kumar, 2013; Yadav et al., 2018a). The step-by-step procedure is as follows:

Step 1 The alternatives are compared via linguistic terms. The linguistic terms and their corresponding TFNs are defined for rating the alternatives as given in Appendix 1.

In case, if "Barrier 1 (B1) is fairly significant than Barrier 2 (B2)", then on fuzzy triangular scale, it will be written as 2, 3, 4. On the other hand, in pairwise comparison matrix, comparison of B2 to B1 will be written as 1/4, 1/3, 1/2.
The pairwise comparison matrix is shown below, where $d^K_{i,j}$ shows the kth decision maker's preference of ith criterion over jth criterion.

$$A^k = \begin{bmatrix} d^K_{11}\, d^K_{12} \ldots\ldots d^K_{1n} \\ d^K_{21} \ldots\ldots \ldots\ldots d^K_{2n} \\ \ldots\ldots \ldots\ldots \ldots\ldots \\ d^K_{n1}\, d^K_{n2} \ldots\ldots d^K_{nn} \end{bmatrix}$$

Step 2 In case if decision makers are more than one in number, preferences of each decision maker ($d^K_{i,j}$) can be aggregated by using weighted geometric mean of judgements and calculated as (Forman & Peniwati, 1998; Ocampo, 2019):

$$d_{i,j} = \prod_{k=1}^{k} \left(d^k_{ij}\right)^{w_k} where \sum_{k=1}^{K} w_k = 1$$

Step 3 According to aggregated preferences, pairwise comparison matrix is updated as given below (Ocampo, 2019).

$$A = \begin{bmatrix} d_{11}\, d_{12} \ldots\ldots d_{1n} \\ d_{21} \ldots\ldots \ldots\ldots d_{2n} \\ \ldots\ldots \ldots\ldots \ldots\ldots \\ d_{n1}\, d_{n2} \ldots\ldots d_{nn} \end{bmatrix}$$

Step 4 The geometric mean of fuzzy comparison values of each criterion is calculated by given equation. Here, r_1 still represents triangular values (Buckley, 1985; Rostamy et al., 2012).

$$r_1 = (\prod_{j=1}^{n} d_{i,j})^{1/n},\ i = 1, 2, \ldots\ldots\ldots, n$$

Step 5 Find out the fuzzy weights of each criterion by using the given equation (Rostamy et al., 2012).
$W_i = r_i \times (r_1 + r_2 + \ldots + r_n)^{-1}$.
Step 6 The weights (w_i) obtained are fuzzy triangular numbers, so these weights are de-fuzzified by centre of area method proposed by Chou and Chang in 2008 as below.

$$M_i = \frac{lw_i + mw_i + uw_i}{3}$$

Step 7 Though M_i is a non-fuzzy number, it requires to be normalised by using following equation (Rostamy et al., 2012).

$$N_i = \frac{M_i}{\sum_{i=1}^{n} M_i}$$

By following the above steps, the relative weights of all the barriers in each category can be found. Then, to calculate the global weight of barriers, the relative weight of each barrier is multiplied with the weight of head under which barrier comes. On the basis of global weight of barriers, global rank of each barrier can be found.

3.2 F-TOPSIS (Technique for order of preference by similarity to ideal solution)

For analysing the various solutions proposed to remove the barriers or to lower the impacts of barriers, F-TOPSIS has been adopted. F-TOPSIS is a MCDM technique, which is one of the most feasible methods available for prioritisation of various alternatives (dos et al., 2019; Khambhati et al., 2021). Though there are many methods like ANP, AHP, FAHP or FANP for comparison and ranking, but in the situation of pairwise comparison, F-TOPSIS proves to be very useful method for ranking the various alternatives. This technique proves to be superior among other MCDM techniques like AHP, FAHP, ANP, etc., because if new alternatives are added or some are removed, then there is no rank reversal difficulty (Junior et al., 2014).

F-TOPSIS ranks the various alternatives by measuring Euclidean distances. According to F-TOPSIS, that alternative is selected, which is having the shortest distance from the positive ideal solution (PIS) and the farthest from the negative ideal solution (NIS) (Khambhati et al., 2021; Mavi et al., 2016). This method fits human thinking under actual environment. As per Sun (2010), F-TOPSIS method can be applied by using the steps as given below.

Step 1 The alternatives are compared via linguistic terms (Ocampo, 2019). The linguistic variables and their corresponding triangular fuzzy numbers for rating the alternatives are given in Appendix 2.

Step 2 In case if decision makers are more than one in number and the rating of all the experts is described as TFN $\hat{R}_{\mathrm{k}} = (a_{\mathrm{k}}, b_{\mathrm{k}}, c_{\mathrm{k}})$ k = 1,2,…..K, then the aggregate fuzzy ratings for the alternatives with respect to criteria can be calculated as (Patil & Kant, 2014):

$$a = \min\left\{a_{\mathrm{k}}\right\}$$

$$b = \frac{1}{k}\sum_{k=1}^{k} b_{\mathrm{k}}$$

$$c = \max\left\{c_{\mathrm{k}}\right\}$$

Step 3 Construct the normalised fuzzy decision matrix by dividing all the ratings under a criterion with maximum rating value under that criterion, only if that criterion belongs to benefit criteria. In case, the criterion belongs to non-beneficial criteria, the normalised fuzzy decision matrix can be constructed by dividing minimum rating value under that criterion with all the ratings (Patil & Kant, 2014).

Step 4 Construct the weighted fuzzy normalised decision matrix as (Kannan et al., 2013; Ocampo, 2019)

$$V_{\mathrm{i\,j}} = D_{\mathrm{i\,j}} \otimes W_{\mathrm{j}}$$

Step 5 Determine the fuzzy positive ideal solution and fuzzy negative ideal solution (Kannan et al., 2013; Ocampo, 2019).
The elements V_{ij} are normalised positive triangular fuzzy number, and their range belongs to the closed interval [0, 1].
Step 6 The distance (d_i^+ and d_i^-) of each alternative from FPIS and FNIS can be calculated by the area compensation method as follows (Kannan et al., 2013; Ocampo, 2019)

$$d_i^+ = \sum_{j=1}^{n} d\left(V_{ij}, V_j^+\right), \quad i = 1, 2, 3, \ldots\ldots\ldots, m; \quad j = 1, 2, 3, \ldots\ldots\ldots\ldots, n$$

$$d_i^- = \sum_{j=1}^{n} d\left(V_{ij}, V_j^-\right), \quad i = 1, 2, 3, \ldots\ldots\ldots, m; \quad j = 1, 2, 3, \ldots\ldots\ldots\ldots, n$$

$$d(A, B) = \sqrt{\frac{1}{3}[(a_1 - b_1)^2 + (a_2 - b_2)^2 + (a_3 - b_3)^2]}$$

Step 7 Calculate the closeness coefficients and improve alternatives for achieving the required levels in each criterion (Kannan et al., 2013; Ocampo, 2019).

$$CC_i = \frac{d_i^-}{d_i^- + d_i^+}$$

Step 8 Based on the value of CC_i, rank all the solutions (Kannan et al., 2013; Ocampo, 2019).

4 Data collection and data analysis

In this research study, data collection has been done through literature survey and inputs from experts of industry and academia. Then, this data is analysed by using F-AHP and F-TOPSIS techniques. The results are given in subsections as below.

4.1 Data collection and proposed framework

With the aim of identifying the various barriers towards SPC and solutions to remove these barriers or to reduce the impact of these barriers, systematic literature survey has been conducted. Opinion of experts from academia and industry has also been included along with literature survey. For collecting data and finding various barriers towards sustainable development, a huge range of the literature based on sustainable developments, sustainability, SPC and CE have been reviewed. The literature based on Indian manufacturing industry has been focused exclusively because this research study is focused on Indian manufacturing industry. The literature based on various decision-making methods was also focused for better understanding the applications and procedures of methodologies selected.

In India, the automotive manufacturing industry is growing very fast. It is expected that by 2026, India will become the world's third-largest automotive market in terms of volume. The Indian automobile industry currently manufactures 25 million vehicles. In tractor manufacturing, India is on top, and in bus manufacturing, India is on second position in the world (Balakrishnan and Suresh, 2018). Therefore, we selected automotive manufacturing case companies for finalisation of variables identified from literature review. We

approached ten automotive components manufacturing companies located in the northern region of India by convenience sampling. Out of these, only four case companies showed their interest. All the selected case companies were ISO 140001 certified companies and suppliers of one of top automobile manufacturer located in India. Similarly, ten experts from academia working in related research domains were approached. Out of these experts, nine academicians showed their interest in providing their valuable feedback and suggestions on the identified variables. The inputs of experts from automotive manufacturing case companies and academia were collected by e-mail or meeting personally after taking appointment. As a cumulative result of systematic literature survey and expert's input, total twenty-six barriers towards SPC and thirteen solutions to remove these barriers or to lower the impact of these barriers have been finalised.

After finalising the barriers and their solutions, a questionnaire was developed (Appendix 4). In second round of data collection, questionnaire was distributed to some additional experts in addition to previously selected experts, i.e. a total of thirty-nine experts from different automotive components manufacturing companies and academicians; but only twenty-one experts responded by answering questionnaire in complete. All the experts were highly skilled professionals in related research domain. Out of selected twenty-one experts, twelve experts were M. Tech. and nine were PhD by education. Most of the experts were having more than five years of experience in medium and large size reputed organisations. Responses received from all these twenty-one experts were analysed with the help of methodologies selected. The proposed framework can be understood from Fig. 1.

4.2 Data analysis

4.2.1 Ranking of barriers by using F-AHP technique

All the barriers are ranked based on their relative weights, which have been calculated by using F-AHP methodology. In this work, there are three different levels of hierarchical structure, i.e. evaluating the barriers towards SPC for their relative importance (Level-1), the six heads under which all barriers lie (Level-2) and twenty-six barriers (Level-3). All the calculations for ranking the various heads of SPC barriers are given in Table 3.

Table 3 shows the comparison matrix (aggregated for all twenty-one experts) for different heads of SPC barriers, i.e. Government-related barriers, Management-related barriers, Technological and Resources barriers, Behaviour-related barriers, Financial barriers and Other barriers.

After applying F-AHP technique, it was found that Government-related barriers, Management-related barriers and Financial barriers are the key barriers in achieving the goal of SPC followed by Technological and Resources barriers, Other barriers and Behaviour-related barriers.

The comparison matrix for barriers under each heads and their relative weights is shown in Appendix 3. After calculating the relative weights of barriers in each category, the global weight of each barrier is calculated so that global rank of each barrier can be found as given in Table 4.

Table 4 shows the global weights and ranks of all twenty-six barriers towards SPC. The ranking shows that "Poor policy framing by government (global weight: 0.1403)", "One-way communication—top to bottom (global weight: 0.1386)", "Funds required for technological upgradation (global weight: 0.1285)", "Lack in implementation of policy framed (global weight: 0.1113)", "Poor support from management to take decision (global weight:

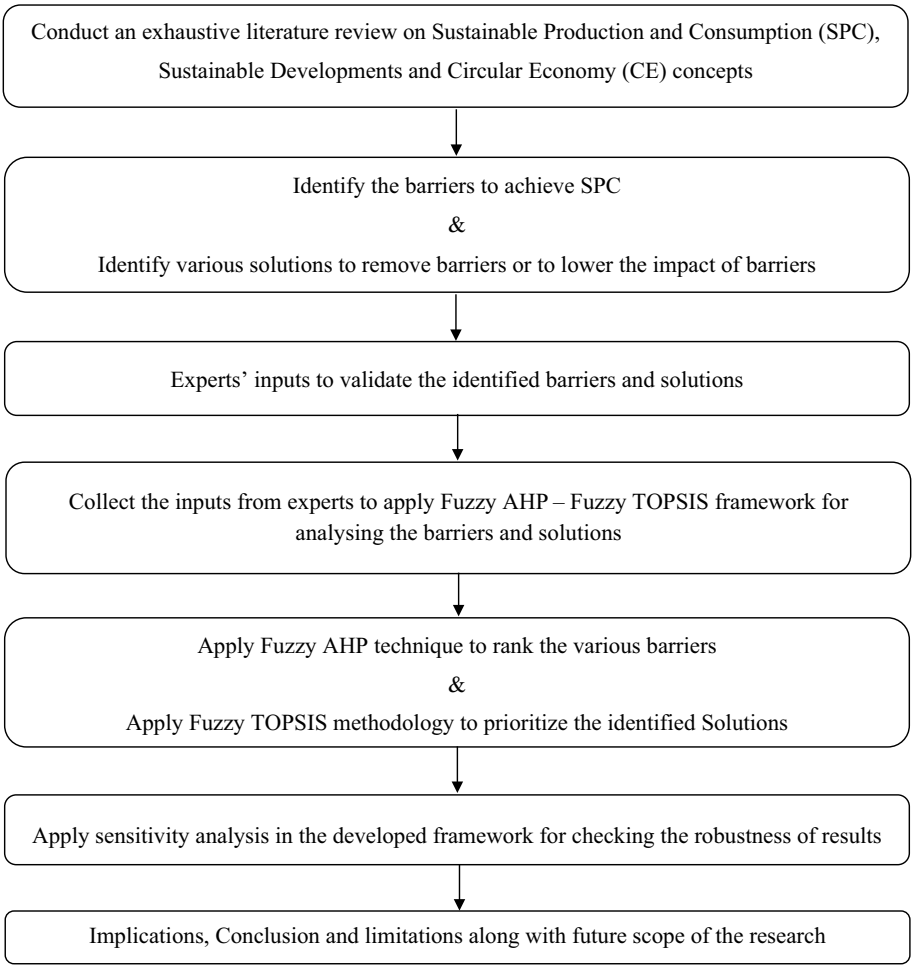

Fig. 1 Proposed framework of this research work

0.0926)", "Lesser determination towards SPC adoption (global weight: 0.0589)" and "Poor adoption of remanufacturing and reusing (global weight: 0.0452)" are top seven main barriers in adoption of SPC. Strong and clear policies should be formed to achieve the aim of sustainable production and consumption, and also these policies should be implemented strongly. Management should be firm focused towards SPC and should show its full support morally as well as financially. Also, the concept of repairing and remanufacturing should be promoted to reduce the consumption of natural resources.

Further, heavy taxes, funds required for developing efficient technology, no technological upgradation and population are also very important for achieving the goal of SPC. Next challenges are lesser promotional events towards SPC, less skilled workforce and funds required to train the workforce followed by producer's behaviour of producing cheap even at the cost of environment and poor support to NGO's. Increased population results in higher consumption rate of natural resources than their production rate and heavy taxes makes the adoption of new technology, very costly. So government should take some

Table 3 Comparison matrix for various heads of SPC barriers

Barrier heads	GOV			MGMT			T&R			BEH			FIN			OTH			Relative Weight	Rank
	P	Q	R	P	Q	R	P	Q	R	P	Q	R	P	Q	R	P	Q	R		
GOV	1.00	1.00	1.00	1.00	1.26	1.44	3.56	4.57	5.58	6.70	7.63	8.55	1.07	1.60	2.03	5.62	6.63	7.63	0.331387	1
MGMT	0.69	0.79	1.00	1.00	1.00	1.00	2.87	3.88	4.89	6.05	7.03	8.00	1.00	1.59	2.08	4.63	5.64	6.64	0.290074	2
T&R	0.18	0.22	0.28	0.20	0.26	0.35	1.00	1.00	1.00	3.13	4.13	5.12	0.32	0.47	0.91	1.94	2.94	3.95	0.104683	4
BEH	0.12	0.13	0.15	0.13	0.14	0.17	0.20	0.24	0.32	1.00	1.00	1.00	0.20	0.26	0.35	0.39	0.53	0.88	0.036954	6
FIN	0.49	0.63	0.94	0.48	0.63	1.00	1.10	2.12	3.13	2.85	3.87	4.89	1.00	1.00	1.00	2.09	3.11	4.12	0.184523	3
OTH	0.13	0.15	0.18	0.15	0.18	0.22	0.25	0.34	0.52	1.14	1.89	2.57	0.24	0.32	0.48	1.00	1.00	1.00	0.052379	5

Here, P, Q and R represent the three values of a triangular fuzzy number

Table 4 Global ranking matrix of SPC barriers

Category of barriers	Relative weight	Specific barriers		Relative weight	Relative rank	Global weight	Global rank
Government-related barriers	0.331387198	GOV 1	Poor policy framing	0.4233325	1	0.1403	1
		GOV 2	Lack in implementation of policy framed	0.3359639	2	0.1113	4
		GOV 3	Lesser promotional events towards SPC	0.0630457	4	0.0209	12
		GOV 4	Poor support to NGOs to promote SPC	0.0438739	5	0.0145	16
		GOV 5	Heavy taxes	0.1337838	3	0.0443	8
Management-related barriers	0.290073701	MGMT 1	Poor support from management to take decision	0.3191503	2	0.0926	5
		MGMT 2	Lesser determination towards SPC adoption	0.2029182	3	0.0589	6
		MGMT 3	One-way communication—top to bottom	0.4779313	1	0.1386	2
Technological and Resources-related barriers	0.104682614	T&R 1	No upgradation from old technology to latest technology	0.2513626	2	0.0263	10
		T&R 2	Less skilled workforce	0.1807356	3	0.0189	14
		T&R 3	Lack of a good IT system implementation	0.0896898	4	0.0094	19
		T&R 4	Technology adoption from other countries rather than technology development	0.0464890	5	0.0049	23
		T&R 5	Poor adoption of remanufacturing and reusing	0.4317228	1	0.0452	7
Behaviour-related barriers	0.036954277	BEH 1	Ignorance of customers towards sustainable products	0.1877246	3	0.0069	21
		BEH 2	Poor advertisement of sustainable products	0.08588235	4	0.0032	24
		BEH 3	Producer's behaviour of producing cheap even at the cost of environment	0.4084768	1	0.0151	15
		BEH 4	Poor involvement of social activist and NGOs	0.05581903	5	0.0021	26
		BEH 5	Over consumption results in wastage of natural resources	0.2620971	2	0.0097	18
Financial barriers	0.184522807	FIN 1	Funds required for technological upgradation	0.6963442	1	0.1285	3
		FIN 2	Funds required for developing efficient technology	0.1932702	2	0.0357	9
		FIN 3	Funds required to train the workforce	0.1103855	3	0.0204	13

Table 4 (continued)

Category of barriers	Relative weight	Specific barriers		Relative weight	Relative rank	Global weight	Global rank
Other barriers	0.0523794	OTH 1	Higher cost of sustainable products	0.0938710	4	0.0049	22
		OTH 2	Education	0.2499841	2	0.0131	17
		OTH 3	Poor differentiation of sustainable products from regular products	0.05697946	5	0.0030	25
		OTH 4	Employment rates	0.1596260	3	0.0084	20
		OTH 5	Population	0.4395392	1	0.0230	11

initiatives for controlling the population and reduce some taxes, and also, government should organise some training events for workforce.

Education, over consumption, lack of a good IT system and employment rates are also important barriers in the way of SPC. Though technology adoption from other countries rather than technology development and higher cost of sustainable products, ignorance of customers towards SPC, poor differentiation of sustainable products, poor advertisement of sustainable products and poor involvement of social activist and NGOs are the barriers having very low global weights and ranks, but they can help greatly in achieving the goal of sustainable production and consumption.

4.2.2 Ranking of solutions by using F-TOPSIS technique

After finding the global rank of all twenty-six barriers, fuzzy decision matrix (aggregated for all twenty-one experts) for ranking the various solutions was formulated as given in Table 5.

Finally, the solutions are prioritised with the help of F-TOPSIS technique and ranking of solutions is shown in Table 6.

Table 6 shows the ranking of the solutions relative to all twenty-six barriers. When the solutions are ranked over the above said criteria, it is found that the "Strong and clear policy making along with its implementation (S1 & S2)", "Full financial support (S3)", "Design for repair and remanufacture (S12)", "Committed top management towards sustainable development and technological upgradation (S5)" are the top rated solutions for ensuring SPC followed by skilled workforce, motivating packages to micro- and small-level industry, training/awareness program for the workers and making sustainable products more cost competitive. Some motivating packages must be given especially to micro- and small-level industry to upgrade their technology for sustainable production. Also, some training programs must be organised for enhancing the skills of workforce. Next solutions are good information sharing system, promotional events and motivating the society for sustainable development. Some initiatives must be taken to motivate the society for sustainable development.

4.3 Sensitivity analysis

The sensitivity analysis has been performed to check the robustness of the results obtained through the fuzzy-AHP–fuzzy-TOPSIS hybrid approach. It represents the results of MCDM methods in dynamic circumstances (Yadav et al., 2018b). Rezaei et al. (2016) suggested that sensitivity analysis for MCDM methods may be conducted in three ways, i.e. (i) observing the variation in final ranking by varying all the alternatives with respect to a specific criterion, (ii) observing the variation in final ranking by varying one or more criteria of an alternative and (iii) observing the variation in final ranking by varying the initial criteria weights of the problem. Among above these three choices, most of the researchers adopt the third option for performing sensitivity analysis of the developed framework in which hybrid research methods are used (Prakash & Barua, 2015). This may help in checking the results obtained for any variation with the change in weights of any criteria (Yadav et al., 2018b). To conduct the sensitivity analysis, thirteen experiments have been carried out by varying the weights of criteria (barriers). The details of the experiments performed are shown in Table 7.

Table 5 Fuzzy decision matrix for various solutions

Weights	0.140286994			0.111334148			0.020892564			–	0.002984552			0.008361117			0.023022803		
Criteria→solutions↓	GOV 1			GOV 2			GOV 3			–	OTH 3			OTH 4			OTH 5		
S1	0.9	1	1	0.7	.985	1	0.1	.604	0.9	–	0.3	0.7	1	0.3	.747	1	0.5	.966	1
S2	0.7	.995	1	0.7	.990	1	0.1	.585	0.9	–	0.3	.709	1	0.3	.738	1	0.5	.961	1
S3	0.7	.971	1	0.3	.747	1	0.1	.661	1	–	0.1	.661	1	0.3	.747	1	0.5	.966	1
S4	0.3	.766	1	0.7	.985	1	0.1	.614	1	–	00	.309	0.7	00	.319	0.7	0.1	.452	0.9
S5	0.3	.652	1	0.9	1	1	0.3	.823	1	–	0.3	0.7	1	0.3	.747	1	0.5	.928	1
S6	0.1	.452	0.9	1	.576	1	0.9	1	1	–	00	0.3	0.7	00	.319	0.7	0.1	.423	0.9
S7	0.3	.614	1	0.5	.861	1	0.3	.614	1	–	00	0.3	0.7	00	.328	0.7	0.1	.452	0.9
S8	0.7	.990	1	0.1	.347	0.7	0.3	.633	1	–	00	.328	0.7	00	.338	0.7	0.1	.471	0.9
S9	00	0.3	0.7	0.5	.885	1	00	.280	0.7	–	00	.319	0.7	00	.328	0.7	0.1	.452	0.9
S10	0.10	.480	0.9	0.1	.471	0.9	0.1	.357	0.7	–	00	.271	0.7	00	.290	0.7	0.1	.538	1
S11	0.3	.814	1	0.3	.804	1	0.1	.509	0.9	–	00	.290	0.7	00	.319	0.7	0.1	.452	0.9
S12	0.5	.866	1	0.5	.880	1	0.3	.785	1	–	0.3	.690	1	0.3	.738	1	0.5	.914	1
S13	0.5	.780	1	0.5	.747	1	0.3	.576	0.9	–	00	0.3	0.7	00	.309	0.7	0.1	.442	0.9

Table 6 Ranking of solutions

Solutions	d_i+	d_i-	CC_i	Rank
S1 Strong and clear policy making	0.078775	0.296263	0.789956	1
S2 Implementation of the policies formed	0.109736	0.272366	0.712810	2
S3 Full financial support	0.120467	0.263579	0.686322	3
S4 Technological upgradation when required	0.149226	0.254236	0.630136	6
S5 Committed top management towards sustainable development	0.124197	0.254754	0.672262	5
S6 Promotional events to promote SPC	0.277509	0.109791	0.283478	12
S7 Training/awareness program for the workers	0.196793	0.208287	0.514187	9
S8 Motivating packages to micro- and small-level industry	0.186553	0.212751	0.532804	8
S9 A good information sharing system	0.235654	0.164872	0.411639	11
S10 Educating/Motivating the society for sustainable development	0.336153	0.043465	0.114496	13
S11 Make sustainable products more cost competitive	0.204589	0.185908	0.476081	10
S12 Design for repair and remanufacture	0.119636	0.261143	0.685812	4
S13 Skilled workforce	0.158659	0.237366	0.599372	7

While conducting all thirteen experiments, weights of barriers have been changed from 0 to 15%. The results of sensitivity analysis show that with the variation in weights of criteria, the results obtained through the fuzzy-AHP–fuzzy-TOPSIS hybrid approach remain unchanged. This can be depicted in Fig. 2, which shows the very less difference in the ranking of solutions while conducting sensitivity analysis.

This depicts that the results obtained through the fuzzy-AHP–fuzzy-TOPSIS hybrid approach are correct and validated by sensitivity analysis test.

5 Discussion of findings

Industrial development is a factor that shows the economic growth of any country, but if this development is concentrated to economic gain only, then this may result in unsustainable development. Industrial development may result in economic growth, but it may also increase the environmental pollution and consumption of natural resources. This is a very challenging condition for industries to ensure economic growth without damaging the environment and ultimately quality of life. This situation can be avoided by adopting SPC linked with CE, which keep environment in focus and society along with economy comes under its boundary. But there are various barriers in adoption of SPC that must be understood. As a result of efforts made to identify the various barriers in the adoption of SPC, total twenty-six barriers have been identified. All these barriers were categorised under six different heads and prioritised using F-AHP. As a result, it was found that Government-related barriers (GOV), Management-related barriers (MGMT) and Finance-related barriers (FIN) are the most important barriers to be focused for adopting the SPC followed by Technological and Resources barriers (T&R), Other barriers (OTH) and Behaviour-related barriers (BEH).

Government-related barriers are the top rated barriers. Government plays the key role in policy making and implementation. Government of India has included SPC in their goals of sustainable development (Nishitani & Kokubu, 2020; http://niti.gov.in). In the category

Table 7 Experiments conducted for sensitivity analysis

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
Exp. 1	0.8295	0.7585	0.7206	0.6616	0.7059	0.2977	0.5399	0.5594	0.4322	0.1202	0.4999	0.7201	0.6293
Exp. 2	0.8444	0.7563	0.7337	0.6717	0.7126	0.3005	0.5450	0.5648	0.4363	0.1214	0.5046	0.7270	0.6353
Exp. 3	0.8453	0.7627	0.7344	0.6742	0.7193	0.3033	0.5502	0.5701	0.4405	0.1225	0.5094	0.7338	0.6413
Exp. 4	0.8532	0.7698	0.7412	0.6805	0.7260	0.3062	0.5553	0.5754	0.4446	0.1237	0.5142	0.7407	0.6473
Exp. 5	0.8690	0.7841	0.7550	0.6931	0.7395	0.3118	0.5656	0.5861	0.4528	0.1259	0.5237	0.7544	0.6593
Exp. 6	0.8769	0.7912	0.7618	0.6995	0.7462	0.3147	0.5707	0.5914	0.4569	0.1271	0.5284	0.7613	0.6653
Exp. 7	0.8848	0.7983	0.7687	0.7058	0.7529	0.3175	0.5759	0.5967	0.4610	0.1282	0.5332	0.7681	0.6713
Exp. 8	0.8926	0.8055	0.7755	0.7121	0.7597	0.3203	0.5810	0.6021	0.4652	0.1294	0.5380	0.7750	0.6773
Exp. 9	0.9005	0.8126	0.7824	0.7184	0.7664	0.3232	0.5862	0.6074	0.4693	0.1305	0.5427	0.7818	0.6833
Exp. 10	0.9084	0.8197	0.7893	0.7247	0.7731	0.3260	0.5913	0.6127	0.4734	0.1317	0.5475	0.7887	0.6893
Exp. 11	0.9321	0.8411	0.8099	0.7436	0.7933	0.3345	0.6067	0.6287	0.4857	0.1351	0.5618	0.8093	0.7073
Exp. 12	0.9558	0.8625	0.8304	0.7625	0.8134	0.3430	0.6222	0.6447	0.4981	0.1385	0.5761	0.8298	0.7252
Exp. 13	0.9795	0.8839	0.8510	0.7814	0.8336	0.3515	0.6376	0.6607	0.5104	0.1420	0.5903	0.8504	0.7432

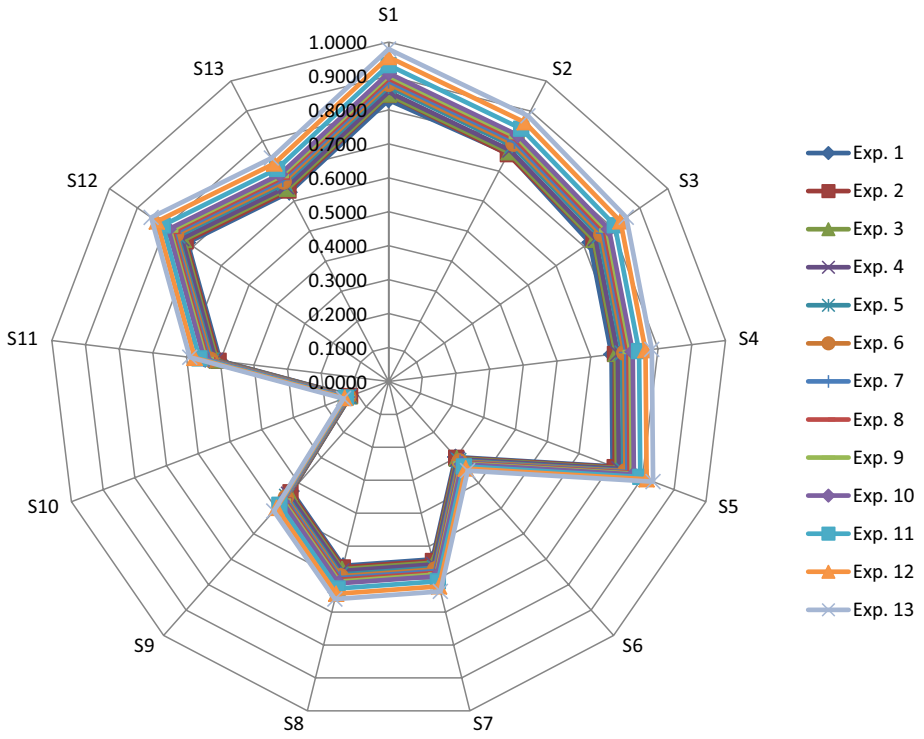

Fig. 2 Outcome of sensitivity analysis

of Government-related barriers, "Poor policy framing (GOV 1)" is ranked first. To ensure sustainable production and consumption, government should make strong policies as promotion of electrical vehicles by launching National Electric Mobility Mission Plan 2020. It will help in reducing the pollution level (https://dhi.nic.in/). "Lack in implementation of policy framed (GOV 2)" is ranked after GOV 1. Policy making is one task, but implementation is another, which is also very important. So government must ensure the implementation of all the policies framed, very strictly without deviation. "Heavy taxes (GOV 5)" is ranked after GOV 2. Heavy taxes are also important barriers in the way of SPC. Wu et al. (2018) suggested that government should offer some motivational subsidy packages to the industries for promoting the concept of SPC towards CE. "Lesser promotional events towards SPC (GOV 3)" is ranked after GOV 5. Sharma and Rani (2014) suggested that government should organise some promotional events to promote SPC. "Poor support to NGOs to promote SPC (GOV 4)" is ranked after GOV 3. NGOs can help in promoting the concept of SPC. So NGOs should get full support from government to promote SPC linked with CE (Jakhar, 2015).

Management-related barriers are on second place among all other barrier heads. Management paves the way for success in any organisation. Working culture in any organisation solely depends on its management. So promoting the concept of SPC in an organisation is also dependent on management. But there are certain Management-related barriers in the way of SPC. "One-way communication—top to bottom (MGMT 3)" is ranked first. Dhull and Narwal (2018) suggested that innovative idea can come from any level in an

organisation. But, generally the boss or the head hesitates in taking suggestions from their subordinates. This practice acts as a big barrier while identifying the techniques ensuring sustainable development (Dhull & Narwal, 2018; Wong et al., 2009). "Poor support from management to take decision (MGMT 1)" is ranked after MGMT 3. Sometimes, for making more economic growth, management did not support decisions which ensure sustainability (Zhu & Geng, 2013). "Less determination towards SPC adoption (MGMT 2)" is ranked after MGMT 1. This is an important barrier in adoption of SPC. If management of any organisation is determined towards achieving the goal of SPC, then that organisation will pass all the hurdles like government issues, legal issues and social issues. But generally management gives more priority to economic growth over environment and society, which results in unsustainable development (Jones et al., 2011; Moktadir et al., 2018).

Financial barriers are on third place among all other barrier heads. Finance is required for upgrading to efficient machines, tools and processes, because use of efficient technology will help in ensuring SPC (de Haen & Requillart, 2014). In the category of financial barriers, "Funds required for technological upgradation (FIN 1)" is ranked first. Kar et al. (2016) suggested that finance plays an important role in upgrading from old technology to new energy efficient technology, which produces minimum waste. Sometimes in lack of funds, industries hesitate for technological upgradation. "Funds required for developing efficient technology (FIN 2)" is ranked after FIN 1. Technology development is an activity which involves a huge amount of money and time (Bhandari et al., 2019). Due to shortage of funds, industries lack in developing efficient technology, which results in unsustainable production and consumption (Bhandari et al., 2019; Kar et al., 2016). "Funds required for training the workforce (FIN 3)" is ranked after FIN 2. Skilled workforce is the basic requirement for SPC. Luthra et al. (2019) suggested that training programs for skilling the workforce must be organised. But sometimes companies lack in providing training to the workforce either due to shortage of funds or due to unwillingness, but both the conditions result in unsustainable production and consumption (Bhanot et al., 2017; Luthra et al., 2019).

Technological and Resource barriers come after Finance-related barriers in the priority list. To ensure SPC, there is a need of development of efficient technologies which consumes less energy and produces more with minimum wastage (Petrolo et al., 2017). Without using efficient technologies, the goal of SPC cannot be achieved even if government makes the best policies and management is full determined towards SPC (Kaushik et al., 2014). "Poor adoption of remanufacturing and reusing (T&R 5)" is ranked first. This is the key barrier in ensuring the SPC especially in developing countries like India. Remanufacturing and reusing help in saving the resources like raw materials, power consumption, etc., because the product is recycled or repaired to reuse rather disposing after completion of its life cycle (Sangwan K. S., 2017; Singhal et al., 2019). Repairing or remanufacturing activities result in SPC (Manninen et al., 2018). "No upgradation from old technology to latest technology (T&R 1)" is ranked after T&R 5. Technology is changing very rapidly all over the world. Previously manual lathe machines were used, but now CNC lathe has taken place in the market. New machines are full of automation and having artificial intelligence, which results in higher production with minimum wastage of raw material and energy. But sometimes organisations lack in upgrading from old technology to latest technology, which results in unsustainable production and consumption. This is the case especially with micro- and small-level enterprises (Bhatia et al., 2018; Kaushik et al., 2014; Muduli & Barave, 2011). "Less skilled workforce (T&R 2)" is ranked after T&R 1. Skilled workforce is the utmost requirement for SPC because an unskilled worker may not produce a better product even with the best technology available. So for handling the latest technology

and getting the best from it, the workforce should be skilled enough (Gberevbie & Ibietan, 2013). For enhancing the skills of workforce, companies should organise the training programs. These training programs help in better understanding the technology, enhancing the skills, getting the expertise and ultimately achieving the goal of SPC (Gandhi et al., 2018). "Lack of a good IT system implementation (T&R 3)" is ranked after T&R 2. A good IT system implementation may be very useful in achieving the goal of SPC as it may help in tracing the products which complete their life cycle, for remanufacture and reuse (Dubey et al., 2015; Waqas et al., 2018). Also, a good IT system may result in better communication among various departments in an organisation, which will result in better product development with minimum rework requirement (Bressanelli et al., 2018). "Technology adoption from other countries rather than technology development (T&R 4)" is ranked after T&R 3. This is a very important barrier especially in developing countries like India. Generally, developing countries lack in technology development, rather they purchase the technology from other countries. Purchasing a new technology from other countries is very costly. So industries, especially micro- and small-level industries, in lack of funds hesitate to adopt the latest technology, which results in unsustainable production and consumption (Chan, 2018; Reynaert, 2019).

Other barriers come after Technological and Resources barriers in the priority list. There are some other barriers such as education, population, employment rate and cost of sustainable products, etc., which also have impact on sustainable development. "Population (OTH 5)" is the top rated Other barriers. Govindan (2017) suggested that consumption of natural resources is directly proportional to the population. As the population increases, the usage of natural resources is also increased to a very high level, which leads to unsustainable production and consumption. "Education (OTH 2)" is ranked after OTH 5. Education plays an important role in everyone's life. Education can help in making people aware about the environment and society along with the economic growth (Bhanot et al., 2017). "Employment rate (OTH 4)" is ranked after OTH 2. Employment rate also affects the concept of SPC. With the increase in unemployment, the number of micro-level industries also increases, which results in unsustainable production and consumption (Orji, 2019). "Higher cost of sustainable products (OTH 1)" is ranked after OTH 4. Sustainable products ensure better quality and environment sustainability, but this better quality also results in increased cost of sustainable products (Jones et al., 2011). "Poor differentiation of sustainable products from regular products (OTH 3)" is ranked last in this category. Due to poor knowledge or less promotion of sustainable products, it becomes difficult to identify the various advantages of sustainable products over regular products (Lorek & Spangenberg, 2014).

Behaviour-related barriers occupy the last place in the priority list. Success or failure depends on behaviour. Even if all the resources are available, then also the behaviour of producer or consumer defines the success or failure of the target of sustainable development. "Producer's behaviour of producing cheap even at the cost of environment (BEH 3)" is ranked first in this category. Vergragt et al., (2014) suggested that most of the producers are focused only on economic growth even at the risk of environment and society. They should change their behaviour of producing cheap products by understanding their responsibility towards environment and society. "Over consumption results in wastage of resources (BEH5)" is ranked after BEH 3. Schmidt and Matthies (2018) suggested that buying more than requirement may result in higher consumption of resources. This situation of over consumption will lead to wastage of resources, which will result in unsustainable consumption and production (Shah et al., 2019). "Ignorance of customers towards sustainable products (BEH 1)"

is ranked after BEH 5. Andrews et al. (2016) suggested that it is the behaviour of customers that defines the success or failure of sustainable products. If customer is ready to compromise with quality for getting cheap products, then this situation will lead to unsustainable development (Mudgal et al., 2009). "Poor advertisement of sustainable products (BEH 2)" is ranked after BEH 1. Jones et al. (2011) suggested that due to poor advertisement, people are not aware about sustainable products. Govindan et al. (2017) suggested that advertisement may help people in understanding the importance of sustainable products.. "Poor involvement of social activist and NGOs (BEH 4)" is ranked after BEH 2. Jakhar (2015) suggested that NGOs and social activist can play important role in promoting the concept of SPC through awareness programs, but it is unfortunate that most of the NGOs and social activist are not much involved in this either due to lesser knowledge about sustainable development or lesser interest towards environment and society.

Further global ranking of all these twenty-six barriers was found. According to global ranking of barriers, poor policy framing is the top rated barrier in adoption of SPC followed by one-way communication—top to bottom, funds required for technological upgradation, lack in implementation of policy framed, poor support from management to take decisions, lesser determination towards SPC adoption and poor adoption of remanufacturing and reusing. These are the top seven barriers in the way of SPC.

Further to remove or to reduce the effects of these barriers, thirteen solutions have been identified from the literature and expert's input. All these solutions were ranked using F-TOPSIS technique. The result shows that strong and clear policy must be made and implemented along with full financial support and technological upgradation. Technology should be designed to promote the repair and remanufacture of the products. This will save the resources, raw materials and energy. The top management should be committed towards sustainable development. Workforce is very important part of SPC, so skilled workforce should be available and also some training programs must be organised on regular intervals to enhance the skills of workforce. There must be existence of a good information sharing system in the organisation, and some motivation especially for micro- and small-level industry must be there to upgrade their technology for sustainable production. Along with all these steps, society must also be motivated for sustainable development.

The sensitivity analysis shows that results obtained after applying fuzzy-AHP–fuzzy-TOPSIS are robust in nature.

5.1 Managerial and practitioners' implications

This research work will be very helpful to every actor, who is focused to SPC. It will help them in understanding the concept of green production and consumption for sustainable development, various barriers in adoption of SPC and the solutions to lower the impact of these barriers. The understanding of various barriers and their solutions will help managers in making decision, ensuring SPC linked with CE. This work will also help researchers and academicians in their research work.

This work will act as torch bearer for government and management as these are the key actors for ensuring SPC. This work offers the following implications for government, management, policymakers and practitioners.

5.1.1 Role of good governance and strong policy making

Governance plays the most important role in achieving the target of SPC. Good governance helps in strong policy making. It also helps in ensuring the implementation of policies framed. Good governance is also responsible for better coordination among central government, state government and the concerned organisations. Good governance always tries to enhance the transparency in decisions.

5.1.2 Financial and other support from management

Management is the key factor in assuring SPC. If management is fully determined towards SPC, then surely it will give full support in making decisions, which ensure sustainable development. In such situation, there will be no issues related to funds. Management is also responsible for technological upgradation as the decision will be taken by management. This work will be helpful in removing Management-related, Finance-related and technology-related barriers.

5.1.3 Educating the society

Education can change the thought process of anyone. It can help in developing the understanding of environment and society. Once the sense of responsibility towards environment and society is developed in someone, many issues like increased population and over consumption will be solved automatically. This work may result in solving the various issues like increased population, over consumption, wastage of natural resources and poor understanding of sustainable development.

5.1.4 Motivation for behavioural change

Everyone acts differently according to their behaviour. Behaviour of both producer and consumer defines the success of the concept of SPC. Producers should be motivated to produce the sustainable products, and consumers should be motivated to buy sustainable products. Consumers should also be motivated to buy in the required quantity, as over consumption results in wastage. This work will help in removing various Behaviour-related barriers.

5.1.5 Focus on environment and society

SPC puts more focus on environment and society along with economic, while unsustainable production and consumption focus mainly on economic growth. SPC focuses on making policies which ensures environmental stability, societal development along with economic growth. So this research work is very helpful in ensuring sustainable development.

6 Conclusion

Nature has given all the things free of cost to the human. But, with the increase in industrialisation, human has spoiled all the resources blessed by nature in the name of economic growth. In the name of productivity and competitiveness, various organisations

are exploiting the natural resources (Tilwankar et al., 2019). The stage of development, in which the usage of resources, development of technology and the direction of investments all are in harmony and ensure the fulfilment of present and future needs of human, may be known as sustainable development (Hummels & Argyrou, 2021). These goals of sustainable development can be achieved by adopting the SPC (Ülkü & Hsuan, 2017). But successful adoption of SPC requires full understanding of various challenges and their solutions; otherwise, it may result in heavy losses to the organization if not adopted properly.

So in this research work, efforts have been put to find the various barriers in adopting SPC. From literature survey, it was found that very limited work has been published. So the experts from industry and academia have been contacted for their response. Based on the literature and inputs from experts, total twenty-six barriers have been identified and prioritised using fuzzy-analytical hierarchy process (F-AHP). In this research work along with challenges, some solutions have also been identified to remove all these challenges or to lower the impact of these challenges. All these solutions are ranked by using F-TOPSIS technique. Further, sensitivity analysis has been performed for checking the robustness of obtained results. Sensitivity analysis shows that the results obtained in this research work are correct.

The final output of this research work depicts that "Government-related barriers", "Management-related barriers" and "Financial barriers" are the key barriers that must be focused for adopting the SPC. Strong and clear policies should be formed and implemented strictly. Management should be firm determinant towards SPC, and it should provide full financial support especially for developing efficient technology, technological upgradation, for providing training to the workforce and for promoting the concept of circular economy. Circular economy can also play an important role in sustainable development as it focuses on reducing the wastage by repairing and reusing the product after its first life cycle is completed.

This research work may help in developing better understanding about the various barriers and their solutions in adoption of SPC and hence may be very helpful for government, policymakers and producers in attaining the goal of SPC successfully.

There are always some limitations associated with every research work. As in this research work, the data collection includes the expert's input, but there may be some biasness in expert's input. In future, some other barriers in adoption of SPC may be identified. Also, the importance or priority of any barrier may change in future with the upgradation in technology (Diabat et al., 2013). Further in future research, different techniques (like ELECTERAL, DEMETAL, VIKOR, etc.) can be used for prioritising the various barriers or solutions.

Appendix 1

See Table 8

Table 8 Linguistic terms with their corresponding triangular fuzzy numbers used in F-AHP

Likert scale	Verbal scale	Fuzzy triangular scale
1	Equally significant	1,1,1
3	Fairly significant	2,3,4
5	Medium significant	4,5,6
7	Strongly significant	6,7,8
9	Extremely significant	9,9,9
2	In between values	1,2,3
4		3,4,5
6		5,6,7
8		7,8,9

Source Kannan et al., 2013

Appendix 2

See Table 9

Table 9 Linguistic variables with corresponding triangular fuzzy numbers used in F-TOPSIS.

Likert scale	Linguistic variables	Triangular fuzzy number
1	Least significant	0.0, 0.0, 0.1
2	Less significant	0.0, 0.1, 0.3
3	Equally significant	0.1, 0.3, 0.5
4	Fairly significant	0.3, 0.5, 0.7
5	Medium significant	0.5, 0.7, 0.9
6	Strongly significant	0.7, 0.9, 1.0
7	Absolutely significant	0.9, 1.0, 1.0

Source: Chen, 2000; Mavi et al., 2016

Appendix 3

Comparison matrix for barriers by decision makers.
See Tables 10, 11, 12, 13, 14 and 15.

Table 10 Comparison matrix for Government-related barriers

Barriers	GOV 1			GOV 2			GOV 3			GOV 4			GOV 5			Relative weight	Rank
	P	Q	R	P	Q	R	P	Q	R	P	Q	R	P	Q	R		
GOV 1	1.00	1.00	1.00	1.00	1.54	1.97	5.02	5.90	6.78	6.40	7.13	7.84	3.59	4.51	5.41	0.4233	1
GOV 2	0.51	0.65	1.00	1.00	1.00	1.00	3.78	4.68	5.56	5.41	6.29	7.16	3.28	4.19	5.09	0.33596	2
GOV 3	0.15	0.17	0.20	0.18	0.21	0.26	1.00	1.00	1.00	1.00	1.94	2.85	0.22	0.27	0.36	0.06305	4
GOV 4	0.13	0.14	0.16	0.14	0.16	0.18	0.35	0.52	1.00	1.00	1.00	1.00	0.19	0.24	0.30	0.04387	5
GOV 5	0.18	0.22	0.28	0.20	0.24	0.31	2.78	3.68	4.57	3.36	4.25	5.14	1.00	1.00	1.00	0.13378	3

Table 11 Comparison matrix for Management-related barriers

Barriers	MGMT 1			MGMT 2			MGMT 3			Relative weight	Rank
	P	Q	R	P	Q	R	P	Q	R		
MGMT 1	1	1	1	1	1.69	2.30	0.49	0.63	0.96	0.31915	2
MGMT 2	0.43	0.58	1	1	1	1	0.27	0.38	0.65	0.20292	3
MGMT 3	1.03	1.56	2.00	1.52	2.57	3.60	1	1	1	0.47793	1

Table 12 Comparison matrix for Technological and Resources barriers

Barriers	T&R 1			T&R 2			T&R 3			T&R 4			T&R 5			Relative weight	Rank
	P	Q	R	P	Q	R	P	Q	R	P	Q	R	P	Q	R		
T&R 1	1.00	1.00	1.00	1.03	1.79	2.47	2.13	3.15	4.16	3.84	4.86	5.87	0.30	0.44	0.82	0.25136	2
T&R 2	0.41	0.56	0.97	1.00	1.00	1.00	1.75	2.78	3.79	3.11	4.12	5.12	0.25	0.33	0.51	0.18074	3
T&R 3	0.24	0.32	0.47	0.26	0.36	0.57	1.00	1.00	1.00	1.81	2.83	3.84	0.17	0.21	0.26	0.08969	4
T&R 4	0.17	0.21	0.26	0.20	0.24	0.32	0.26	0.35	0.55	1.00	1.00	1.00	0.13	0.15	0.18	0.04649	5
T&R 5	1.23	2.26	3.28	1.96	3.01	4.03	3.86	4.87	5.87	5.71	6.64	7.54	1.00	1.00	1.00	0.43172	1

Table 13 Comparison matrix for Behaviour-related barriers

Barriers	BEH 1			BEH 2			BEH 3			BEH 4			BEH 5			Relative weight	Rank
	P	Q	R	P	Q	R	P	Q	R	P	Q	R	P	Q	R		
BEH 1	1.00	1.00	1.00	1.88	2.91	3.92	0.25	0.34	0.54	3.03	4.05	5.06	0.37	0.52	0.97	0.18772	3
BEH 2	0.26	0.34	0.53	1.00	1.00	1.00	0.18	0.23	0.29	1.07	1.95	2.78	0.23	0.31	0.45	0.08588	4
BEH 3	1.84	2.90	3.93	3.41	4.43	5.44	1.00	1.00	1.00	4.21	5.23	6.23	1.38	2.13	2.80	0.40848	1
BEH 4	0.20	0.25	0.33	0.36	0.51	0.94	0.16	0.19	0.24	1.00	1.00	1.00	0.18	0.21	0.27	0.05582	5
BEH 5	1.03	1.91	2.74	2.25	3.26	4.26	0.36	0.47	0.72	3.68	4.69	5.70	1.00	1.00	1.00	0.2621	2

Table 14 Comparison matrix for Financial barriers

Barriers	FIN 1			FIN 2			FIN 3			Relative weight	Rank
	P	Q	R	P	Q	R	P	Q	R		
FIN 1	1.00	1.00	1.00	3.28	4.30	5.30	4.63	5.64	6.64	0.69634	1
FIN 2	0.19	0.23	0.30	1.00	1.00	1.00	1.26	2.14	2.97	0.19327	2
FIN 3	0.15	0.18	0.22	0.34	0.47	0.79	1.00	1.00	1.00	0.11039	3

Table 15 Comparison matrix for Other barriers

Barriers	OTH 1			OTH 2			OTH 3			OTH 4			OTH 5			Relative weight	Rank
	P	Q	R	P	Q	R	P	Q	R	P	Q	R	P	Q	R		
OTH 1	1.00	1.00	1.00	0.24	0.31	0.46	1.18	2.20	3.21	0.32	0.47	0.91	0.17	0.21	0.27	0.09387	4
OTH 2	2.17	3.19	4.21	1.00	1.00	1.00	3.39	4.40	5.41	1.22	2.17	3.09	0.28	0.37	0.58	0.24998	2
OTH 3	0.31	0.45	0.85	0.18	0.23	0.29	1.00	1.00	1.00	0.24	0.32	0.47	0.15	0.18	0.22	0.05698	5
OTH 4	1.10	2.12	3.13	0.32	0.46	0.82	2.15	3.16	4.17	1.00	1.00	1.00	0.26	0.33	0.48	0.15963	3
OTH 5	3.72	4.74	5.75	1.74	2.69	3.61	4.65	5.67	6.68	2.06	3.01	3.92	1.00	1.00	1.00	0.43954	1

Appendix 4

Survey questionnaire

The questionnaire comprises three sections. Section 1 consists of the general details of the expert and the details about the organisation in which the expert works. Section 2 consists of the various barriers in the way of sustainable production and consumption towards circular economy (CE). Section 3 consists of the various solutions proposed to remove the barriers or to lower the impacts of the barriers

Section [1]: General information

Please mark the option that is best suited to you:

1. Professional qualification?

(a) Graduate
(b) Post Graduate
(c) Doctorate
(d) If other than above, please specify_____

2. Work experience?

(a) Less than 5 Years
(b) 5 to 10 Years
(c) 10 to 15 Years
(d) 15 to 20 Years
(e) Greater than 20 Years

3. What is the size of your organisation?

(a) Less than 50 Employees
(b) 51 to 250 Employees
(c) 251–500 Employees
(d) 501–1000 employees
(e) 1001–5000 employees
(f) Greater than 5001 employees

4. Whether the work organisation belongs to:

(a) Private Sector
(b) Public Sector
(c) Multinational Corporation
(d) Regulatory Bodies
(e) Mixed public and private ownership
(f) If any other, please specify_____

Section [2]: Barriers to achieve SPC linked with circular economy

Please rate the barriers in the given one-to-one comparison matrices on Likert scale ("1"-Equally important, "3"-Fairly important, "5"-Medium important, "7"-Strongly important, "9"-Extremely important, "2,4,6,8"-In between values). Further, you are requested to add any specific barrier within any main category, which you think, should be included into the list

Head barriers	Expert's rating					
	GOV	MGMT	T & R	BEH	FIN	OTH
Government-related barriers (GOV)						
Management-related barriers(MGMT)						
Technological and Resources barriers (T & R)						
Behaviour-related barriers (BEH)						
Financial barriers (FIN)						
Other barriers (OTH)						

Specific barriers	Expert's rating				
	GOV 1	GOV 2	GOV 3	GOV 4	GOV 5
GOV 1-Poor policy framing					
GOV 2-Lack in implementation of policy framed					
GOV 3-Lesser promotional events towards SPC					
GOV 4-Poor support to NGOs to promote SPC					
GOV 5-Heavy taxes					

Specific barriers	Expert's rating		
	MGMT 1	MGMT 2	MGMT 3
MGMT 1-Poor support from management to take decision			
MGMT 2-Lesser determination towards SPC adoption			
MGMT 3-One-way communication—top to bottom			

Specific barriers	Expert's rating				
	T&R 1	T&R 2	T&R 3	T&R 4	T&R 5
T&R 1-No upgradation from old technology to latest technology					
T&R 2-Less skilled workforce					
T&R 3-Lack of a good IT system implementation					

Specific barriers	Expert's rating				
	T&R 1	T&R 2	T&R 3	T&R 4	T&R 5
T&R 4-Technology adoption from other countries rather than technology development					
T&R 5-Poor adoption of remanufacturing and reusing					

Specific barriers	Expert's rating				
	BEH 1	BEH 2	BEH 3	BEH 4	BEH 5
BEH 1-Ignorance of customers towards sustainable products					
BEH 2-Poor advertisement of sustainable products					
BEH 3-Producer's behaviour of producing cheap even at the cost of environment					
BEH 4-Poor involvement of social activist and NGOs					
BEH 5-Over consumption results in wastage of natural resources					

Specific barriers	Expert's rating		
	FIN 1	FIN 2	FIN 3
FIN 1-Funds required for technological upgradation			
FIN 2-Funds required for developing efficient technology			
FIN 3-Funds required to train the workforce			

Specific barriers	Expert's rating				
	OTH 1	OTH 2	OTH 3	OTH 4	OTH 5
OTH 1-Higher cost of sustainable products					
OTH 2-Education					
OTH 3-Poor differentiation of sustainable products from regular products					
OTH 4-Employment rates					
OTH 5-Population					

Section [3]: Solutions to remove barriers or to lower the impact of barriers

Please rate the following solutions, proposed to remove the barriers or to lower the impact of barriers on Likert scale ("1"-Least important, "2"-Less important, "3"-Equally important, "4"-Fairly important, "5"-Medium important, "6"-Strongly important, "7"-Absolutely important). Further, you are requested to add any specific solution, which you think, should be included into the list.

S. No	Solutions	Rating by expert's relative to various barriers				
		GOV 1	GOV 2	– – – –	OTH 4	OTH 5
1	Strong and clear policy making (S1)			– – – –		
2	Implementation of the policies formed (S2)			– – – –		

S. No	Solutions	Rating by expert's relative to various barriers				
		GOV 1	GOV 2	– – – –	OTH 4	OTH 5
3	Full financial support (S3)			– – – –		
4	Technological upgradation when required (S4)			– – – –		
5	Committed top management towards sustainable development (S5)			– – – –		
6	Promotional events to promote SPC (S6)			– – – –		
7	Training/awareness program for the workers (S7)			– – – –		
8	Motivating packages to micro- and small-level industry (S8)			– – – –		
9	A good information sharing system (S9)			– – – –		
10	Educating/Motivating the society for sustainable development (S10)			– – – –		
11	Make sustainable products more cost competitive (S11)			– – – –		
12	Design for repair and remanufacture (S12)			– – – –		
13	Skilled workforce (S13)			– – – –		

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