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Prioritizing Drivers for Green Manufacturing: Environmental, Social and Economic Perspectives

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Abstract

The governments are under tremendous pressure to sustain manufacturing growth particularly in emerging and developing economies to improve quality of life of their citizen. Unfortunately, the manufacturing sector consumes lot of energy and other resources and emits large amounts of green house gases which increase environmental problems like climate change and global warming. One possible solution to this problem is green manufacturing (GM) implementation in industry. However, GM implementation faces many challenges. Government and industry should provide motivation to make this change possible. This paper aims at prioritizing these motivating factors based on fuzzy TOPSIS method using environmental, social and economic perspectives. The prioritization is vital for the emerging and developing economies because of the limited financial and other resources. The prioritization of GM drivers is expected to help the government and industry to focus on few vital drivers to facilitate the GM implementation.

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"Keywords: Green Manufacturing (GM); Drivers; Prioritization; Sustainable Manufacturing;"

1. Motivation

Growth of manufacturing sector is vital for the emerging and developing economies to improve the quality of life of their citizen. The decreasing natural resources and increasing energy demand is slowing down the pace of development in technically developed countries, meanwhile, the manufacturing sector of emerging countries is attracting global attention because of untapped potential for growth in terms of natural resources and human resources, in addition to relatively less stringent environmental legislation [1]. At the same time, the growth of manufacturing sector brings in some challenges like fast depleting natural resources; soil, water and air pollution; and severe health hazards to humanity. These challenges are posing threat to sustainable development in general.

The need of achieving higher economic prosperity with least environmental impact has led to new manufacturing paradigm of Green Manufacturing (GM). GM means designing, manufacturing, delivering, and disposing products that produce minimum negative effect on environment and society and are economically viable. However, the implementation of GM in the industry is not an easy task particularly in emerging economies because of many issues – limited financial and human resources, awareness about environmental aspect of manufacturing, governmental policies, immediate impact on GDP, etc. The implementation of GM is possible only with collaborated efforts of government and industry in a strategic way. There is a need to understand the role and potential of various motivations (drivers) facilitating the implementation of GM in industry. Hence, the GM drivers are prioritized using environmental, social and economic perspectives. This will help to focus and leverage few vital drivers to work within limited resources of emerging and developing economies.

The remainder of this paper is organized as follows: next section provides the background of the study followed by methodology in section 3. Section 4 presents the results and

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discussion. Finally, section 5 provides the conclusions and recommendations of the study.

2. Background

Despite economic downturn, the sustainability is not off the corporate agenda. A survey reveals that the businesses are adopting sustainability-driven management, however, the level of adoption varies among companies [2]. Various studies in the past have identified the drivers for green manufacturing [3,4], environmentally conscious manufacturing [5,6,7,8,9], sustainable manufacturing [10,11], environmental management initiatives [12], cleaner production [13,14], environmental behavior in manufacturing [15], cleaner technology adoption [16], environmentally sound technology [17], environmental management system [18,19], environmentally benign manufacturing [20], energy and resource efficient manufacturing [21], and environmental strategies in manufacturing [22], etc. The thirteen drivers for GM implementation identified by Mittal et al. [3] – current legislation (D_1), future legislation (D_2), incentives (D_3), public pressure (D_4), peer pressure (D_5), cost savings (D_6), competitiveness (D_7), customer demand (D_8), supply chain pressure (D_9), top management commitment (D_{10}), public image (D_{11}), technology (D_{12}), organizational resources (D_{13}) – have been adopted for this study.

There are three distinct aspects which should be taken care in order to implement newer manufacturing strategies like green manufacturing – planet, people, and prosperity [23]. This provided the motivation to prioritize the GM drivers using environmental (i.e. planet), social (i.e. people) and economic (i.e. prosperity) perspectives. Moreover, the review of extant literature suggests that there is hardly any paper prioritizing the drivers for GM implementation.

Fuzzy TOPSIS multi-criteria decision making (MCDM) technique is used to prioritize the drivers because it better equipped to deal with two major kinds of uncertainties, i.e. ambiguity and vagueness, which exist in the real life. Also, fuzzy TOPSIS methodology possess advantages – easy to compute and easily understood [24]. MCDM is widely used in prioritizing one or more alternatives from a set of available alternatives with respect to multiple criteria.

3. Methodology

Fuzzy TOPSIS (Technique for Order Preference by Similarity to Ideal Situation) developed by Chen, is a practical method and fits human thinking under actual environment [25]. Fuzzy theory is applied to model parameters for decision making to prioritize GM drivers. In fuzzy set theory, a triangular fuzzy number can be defined by a triplet (a_1,a_2,a_3) and the conversion scales are applied to transform the linguistic terms into fuzzy numbers. Table 1 provide the selection and assessment criteria and alternatives for prioritizing GM drivers.

The steps of fuzzy TOPSIS algorithm can be expressed as follows [26,27]:

Table 1: Linguistic variables and fuzzy ratings for the criteria and alternatives

LT for criteria ratings		LT for alternative ratings	
LT	MF	LT	MF
Very Low (VL)	(1,1,3)	Not Important (NI)	(1,1,3)
Low (L)	(1,3,5)	Less Important (LI)	(1,3,5)
Medium (M)	(3,5,7)	Fairly Important (FI)	(3,5,7)
High (H)	(5,7,9)	Important (I)	(5,7,9)
Very High (VH)	(7,9,9)	Very Important (VI)	(7,9,9)

LT – Linguistic Term ; MF – Membership Function

Step 1: Assignment of ratings

The linguistic ratings are assigned to various criteria and alternatives with the help of three decision maker groups named as DM1, DM2, and DM3 from people of environmental, social and economic expertise respectively (Table 2 and 3). Each decision maker group comprises of three experts with atleast 5 years of experience in the field of green manufacturing/sustainable manufacturing. The three experts of each group agreed on single assessment, which is used as input for the study.

Table 2: Linguistic assessment of criteria

Criteria	DM1	DM2	DM3
Environmental perspective (C1)	VH	H	H
Social perspective (C2)	H	H	L
Economic perspective (C3)	M	H	VH

Table 3: Linguistic assessment of alternatives

Drivers	Environmental	Social	Economic
D_1	I	I	FI
D_2	VI	I	FI
D_3	I	I	VI
D_4	VI	VI	FI
D_5	VI	I	LI
D_6	FI	LI	I
D_7	LI	LI	I
D_8	FI	LI	I
D_9	LI	NI	FI
D_{10}	VI	VI	LI
D_{11}	I	I	FI
D_{12}	FI	LI	I
D_{13}	LI	LI	I

Step 2: Compute aggregate fuzzy ratings for the criteria

The linguistic ratings of the criteria are transformed into aggregate fuzzy ratings using table 1 as shown in table 4.

If the fuzzy ratings of all decision makers are described as triangular fuzzy numbers $\widetilde{R}_k = (a_k, b_k, c_k)$, k = 1, 2. . . K, then the aggregated fuzzy rating is given by

$$\widetilde{R}_k = (a, b, c), k = 1, 2... K,$$

where

$$a = \min_k \{a_k\}, \quad b = \frac{1}{K}\sum_{k=1}^{K} b_k \quad \text{and}$$

$$c = \max_k \{c_k\}$$

Table 4: Aggregate fuzzy weights for the criteria

Criteria	DM1	DM2	DM3	Aggregate Fuzzy Weight
C1	(7,9,9)	(5,7,9)	(5,7,9)	(5,7.66,9)
C2	(5,7,9)	(5,7,9)	(1,3,5)	(1,5.66,9)
C3	(3,5,7)	(5,7,9)	(7,9,9)	(3,7,9)

Step 3: Compute the fuzzy decision matrix

The linguistic ratings of the alternatives are transformed into fuzzy ratings, using table 1, as shown in table 5.

The fuzzy decision matrix for the alternatives ($\widetilde{D}$) is constructed using the following relation:

$$\widetilde{D} = \begin{matrix} & c_1 & c_2 & \dots & c_n \\ D_1 & \widetilde{x}_{11} & \widetilde{x}_{12} & \dots & \widetilde{x}_{1n} \\ D_2 & \widetilde{x}_{21} & \widetilde{x}_{22} & \dots & \widetilde{x}_{2n} \\ \dots & \dots & \dots & \dots & \dots \\ D_m & \widetilde{x}_{m1} & \widetilde{x}_{m2} & \dots & \widetilde{x}_{mn} \end{matrix}$$

Table 5: Aggregate fuzzy weights for alternatives

S. No.	Environmental	Social	Economic
D_1	(5,7,9)	(5,7,9)	(3,5,7)
D_2	(7,9,9)	(5,7,9)	(3,5,7)
D_3	(5,7,9)	(5,7,9)	(7,9,9)
D_4	(7,9,9)	(7,9,9)	(3,5,7)
D_5	(7,9,9)	(5,7,9)	(1,3,5)
D_6	(3,5,7)	(1,3,5)	(5,7,9)
D_7	(1,3,5)	(1,3,5)	(5,7,9)
D_8	(3,5,7)	(1,3,5)	(5,7,9)
D_9	(1,3,5)	(1,1,3)	(3,5,7)
D_{10}	(7,9,9)	(7,9,9)	(1,3,5)
D_{11}	(5,7,9)	(5,7,9)	(3,5,7)
D_{12}	(3,5,7)	(1,3,5)	(5,7,9)
D_{13}	(1,3,5)	(1,3,5)	(5,7,9)

Step 4: Normalize the fuzzy decision matrix

The raw fuzzy weights presented in table 5 are normalised using a linear scale transformation to bring the various criteria scales onto a comparable scale.

The normalized fuzzy decision matrix $\widetilde{R}$ shown in table 6 is computed as:

$$\widetilde{R} = [\widetilde{r}_{ij}]_{m\times n}, \quad i = 1, 2, \dots, m; \quad j = 1, 2, \dots, n$$

Table 6: Normalised alternatives

S. No.	Environmental	Social	Economic
c_j^*	9	9	9
D_1	(0.55,0.77,1)	(0.55,0.77,1)	(0.33,0.55,0.77)
D_2	(0.77,1,1)	(0.55,0.77,1)	(0.33,0.55,0.77)
D_3	(0.55,0.77,1)	(0.55,0.77,1)	(0.77,1,1)
D_4	(0.77,1,1)	(0.77,1,1)	(0.33,0.55,0.77)
D_5	(0.77,1,1)	(0.55,0.77,1)	(0.11,0.33,0.55)
D_6	(0.33,0.55,0.77)	(0.11,0.33,0.55)	(0.55,0.77,1)
D_7	(0.11,0.33,0.55)	(0.11,0.33,0.55)	(0.55,0.77,1)
D_8	(0.33,0.55,0.77)	(0.11,0.33,0.55)	(0.55,0.77,1)
D_9	(0.11,0.33,0.55)	(0.11,0.11,0.33)	(0.33,0.55,0.77)
D_{10}	(0.77,1,1)	(0.77,1,1)	(0.11,0.33,0.55)
D_{11}	(0.55,0.77,1)	(0.55,0.77,1)	(0.33,0.55,0.77)
D_{12}	(0.33,0.55,0.77)	(0.11,0.33,0.55)	(0.55,0.77,1)
D_{13}	(0.11,0.33,0.55)	(0.11,0.33,0.55)	(0.55,0.77,1)

Where $\widetilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*} \right)$ and

$$c_j^* = \max_i \{c_{ij}\} \text{ …. (Benefit or Importance Criteria)}$$

Step 5: Compute the weighted normalized matrix

The weighted normalized matrix $\widetilde{V}$ for criteria is computed by multiplying the weights $(\widetilde{w}_j)$ of evaluation criteria with the normalized fuzzy decision matrix $\widetilde{r}_{ij}$ (Table 7) as:

$$\widetilde{V} = [\widetilde{v}_{ij}]_{m\times n}, \quad i = 1, 2\dots m; \quad j = 1, 2\dots n$$

where $\widetilde{v}_{ij} = \widetilde{r}_{ij}(.)\widetilde{w}_j$

Table 7: Weighted normalised alternatives

S. No.	Environmental	Social	Economic
D_1	(2.75,5.8982,9)	(0.55,4.3582,9)	(0.99,3.85,6.93)
D_2	(3.85,7.66,9)	(0.55,4.3582,9)	(0.99,3.85,6.93)
D_3	(2.75,5.8982,9)	(0.55,4.3582,9)	(2.31,7,9)
D_4	(3.85,7.66,9)	(0.77,5.66,9)	(0.99,3.85,6.93)
D_5	(3.85,7.66,9)	(0.55,4.3582,9)	(0.33,2.31,4.95)
D_6	(1.65,4.213,6.93)	(0.11,1.8678,4.95)	(1.65,5.39,9)
D_7	(0.55,2.5278,4.95)	(0.11,1.8678,4.95)	(1.65,5.39,9)
D_8	(1.65,4.213,6.93)	(0.11,1.8678,4.95)	(1.65,5.39,9)
D_9	(0.55,2.5278,4.95)	(0.11,0.6226,2.97)	(0.99,3.85,6.93)
D_{10}	(3.85,7.66,9)	(0.77,5.66,9)	(0.33,2.31,4.95)
D_{11}	(2.75,5.8982,9)	(0.55,4.3582,9)	(0.99,3.85,6.93)
D_{12}	(1.65,4.213,6.93)	(0.11,1.8678,4.95)	(1.65,5.39,9)
D_{13}	(0.55,2.5278,4.95)	(0.11,1.8678,4.95)	(1.65,5.39,9)
FPIS(B+)	(9,9,9)	(9,9,9)	(9,9,9)
FNIS(B-)	(0.55,0.55,0.55)	(0.11,0.11,0.11)	(0.33,0.33,0.33)

Step 6: Compute the fuzzy positive ideal solution (FPIS) and the fuzzy negative ideal solution (FNIS)

FPIS and FNIS of alternatives are computed in the last two rows of the table 7 as follow:

$$A^* = (\widetilde{v}_1^*, \widetilde{v}_2^*, \dots\dots \widetilde{v}_n^*) \quad , \quad A^- = (\widetilde{v}_1^-, \widetilde{v}_2^-, \dots\dots \widetilde{v}_n^-)$$

where $\widetilde{v}_j^* = \max_i \{v_{ij3}\}$, $\widetilde{v}_j^- = \min_i \{v_{ij3}\}$,

$i = 1, 2\dots m; \quad j = 1, 2, \dots, n$

Step 7: Compute the distance of each alternative from FPIS and FNIS

The distance of each weighted alternative from the FPIS and the FNIS is computed as shown in tables 8 and table 9 respectively.

The distance between them is given by following relation using vertex method

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

$$d_i^* = \sum_{j=1}^{n} d_v(\widetilde{v}_{ij}, \widetilde{v}_j^*) \quad i = 1, 2\dots m$$

$$d_i^- = \sum_{j=1}^{n} d_v(\widetilde{v}_{ij}, \widetilde{v}_j^-) \quad i = 1, 2\dots m$$

Table 8: Distance for GM drivers (from FPIS)

Distance	C1	C2	C3
d(D1,D+)	4.028385	5.566232	5.626352
d(D2,D+)	3.072355	5.566232	5.626352
d(D3,D+)	4.028385	5.566232	4.031381
d(D4,D+)	3.072355	5.127979	5.626352
d(D5,D+)	3.072355	5.566232	6.741105
d(D6,D+)	5.203293	6.983382	4.727741
d(D7,D+)	6.575063	6.983382	4.727741
d(D8,D+)	5.203293	6.983382	4.727741
d(D9,D+)	6.575063	7.864982	5.626352
d(D10,D+)	3.072355	5.127979	6.741105
d(D11,D+)	4.028385	5.566232	5.626352
d(D12,D+)	5.203293	6.983382	4.727741
d(D13,D+)	6.575063	6.983382	4.727741

Table 9: Distance for GM drivers (from FNIS)

Distance	C1	C2	C3
d(D1,D-)	5.911732	5.694234	4.335359
d(D2,D-)	6.654437	5.694234	4.335359
d(D3,D-)	5.911732	5.694234	6.418157
d(D4,D-)	6.654437	6.062733	4.335359
d(D5,D-)	6.654437	5.694234	2.901999
d(D6,D-)	4.294647	2.972959	5.845651
d(D7,D-)	2.785181	2.972959	5.845651
d(D8,D-)	4.294647	2.972959	5.845651
d(D9,D-)	2.785181	1.677534	4.335359
d(D10,D-)	6.654437	6.062733	2.901999
d(D11,D-)	5.911732	5.694234	4.335359
d(D12,D-)	4.294647	2.972959	5.845651
d(D13,D-)	2.785181	2.972959	5.845651

Step 8: Compute the closeness coefficient (CC_i) of each alternative

The closeness coefficient (CC_i) represents the distances to the FPIS and the FNIS simultaneously. The aggregate closeness coefficient of each alternative is shown in table 10. Also, the individual perspective closeness coefficients are shown in table 11.

The closeness coefficient of each alternative is calculated as:

$$CC_i = d_i^- \big/ (d_i^- + d_i^*), \qquad i = 1, 2\ldots m$$

Table 10: Closeness coefficient for alternatives (aggregate)

Driver	d_i^*	d_i^-	CC_i
D_1	15.22097	15.94133	0.511558
D_2	14.26494	16.68403	0.539082
D_3	13.626	18.02412	0.56948
D_4	13.82669	17.05253	0.552233
D_5	15.37969	15.25067	0.497894
D_6	16.91442	13.11326	0.436706
D_7	18.28619	11.60379	0.388217
D_8	16.91442	13.11326	0.436706
D_9	20.0664	8.798073	0.304806
D_{10}	14.94144	15.61917	0.511088
D_{11}	15.22097	15.94133	0.511558
D_{12}	16.91442	13.11326	0.436706
D_{13}	18.28619	11.60379	0.388217

Table 11: Closeness coefficient for alternatives (individual perspective)

Code	CC_i (Environmental Perspective)	CC_i (Social Perspective)	CC_i (Economic perspective)
D_1	0.5947346	0.5056837	0.4352022
D_2	0.6841348	0.5056837	0.4352022
D_3	0.5947346	0.5056837	0.6142049
D_4	0.6841348	0.5417647	0.4352022
D_5	0.6841348	0.5056837	0.3009403
D_6	0.4521662	0.2985996	0.5528643
D_7	0.2975543	0.2985996	0.5528643
D_8	0.4521662	0.2985996	0.5528643
D_9	0.2975543	0.1757958	0.4352022
D_{10}	0.6841348	0.5417647	0.3009403
D_{11}	0.5947346	0.5056837	0.4352022
D_{12}	0.4521662	0.2985996	0.5528643
D_{13}	0.2975543	0.2985996	0.5528643

Step 9: Rank the alternatives (i.e. drivers)

Prioritization of GM drivers according to the CC_i in decreasing order and the alternative with the highest closeness coefficient for final implementation is presented in table 12. The best alternative is closest to the FPIS and farthest from the FNIS.

Table 12: Closeness coefficient for alternatives (aggregate)

Code	Driver	CC_i	Priority
D_3	Incentives	0.56948	1
D_4	Public Pressure	0.552233	2
D_2	Future Legislation	0.539082	3
D_1	Current Legislation	0.511558	4
D_{11}	Public Image	0.511558	5
D_{10}	Top Management Commitment	0.511088	6
D_5	Peer Pressure	0.497894	7
D_6	Cost Savings	0.436706	8
D_8	Customer Demand	0.436706	9
D_{12}	Technology	0.436706	10
D_7	Competitiveness	0.388217	11
D_{13}	Organizational Resources	0.388217	12
D_9	Supply Chain Pressure	0.304806	13

4. Results and Discussion

Figure 1 shows the graphical presentation of the importance of GM drivers obtained from fuzzy TOPSIS.

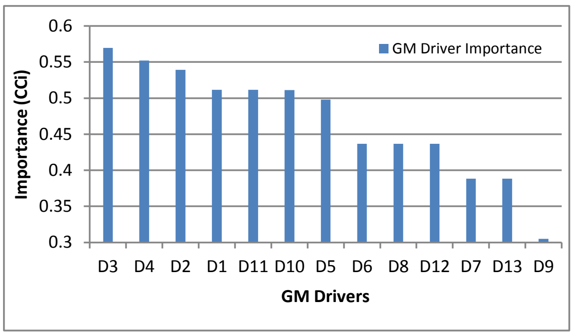

Figure 1: Importance of GM drivers (aggregate)

The results of MCDM of GM drivers using inputs from Indian experts reveals that 'incentives' is top ranked (1/13) drivers which can facilitate the easy implementation of GM in manufacturing industry. The study further reveals that 'public pressure' in terms of pressure from media, banks, insurance companies, NGOs, etc. is ranked second (2/13) driver followed by 'future legislation' (3/13). 'Current legislation' has been ranked at four (4/13) followed by 'public image' at fifth (5/13). It seems that legislation is not fully enforced, public image of the company to use green processes, and commitment of the management are not strong drivers as in technically advanced countries having lesser population, higher literacy rate, better enforcement of legislation, and higher commitment of the management to invest in green manufacturing systems.

Among the least important drivers are – 'competitiveness', 'organizational resources', and 'supply chain pressure'. The 'competitiveness' as a driver can impact the implementation process only after the cost saving and benefits of newer technologies are fully understood, which is not fully realized in manufacturing industry in developing countries. Companies particularly micro, small and medium enterprises (MSMEs) which comprises a major industrial sector in most of the emerging countries always have tight financial and human resources and hence do not implement newer manufacturing systems.

Figure 2 shows the comparison of importance of GM drivers from environmental, social and economical perspectives.

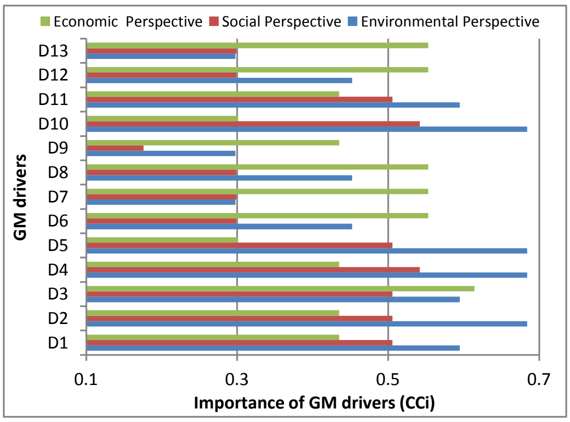

Figure 2: Importance of GM drivers (individual perspectives)

The prioritization of the GM drivers based on aggregate criteria and individual perspectives are largely different. The drivers namely 'future legislation', 'public pressure', 'peer pressure', and 'top management commitment' are most important drivers from the environmental perspective. 'Public pressure' and 'top management commitment' are most important drivers from social perspective. Similarly, the drivers namely 'incentives' is the most important driver from economic perspective. 'Cost savings', 'competitiveness', 'customer demand', 'technology', and 'organizational resources' are also important drivers from economic perspective. The results revealed that the 'incentives' is the most important driver from aggregate perspectives as well as from economic perspective, which means that companies particularly in emerging and developing economies may not implement green manufacturing if does not yield benefits in terms of economic incentives.

As suggested by Awasthi et al. (2011), the sensitivity analysis is conducted to investigate the impact of criteria weights on the prioritization of drivers for green manufacturing. The details of eight experiments conducted for sensitivity analysis are listed in table 13.

Table 13: Sensitivity analysis for criteria weights

E. No.	Description	Prioritization
1	$W_{C1, C2, C3} = (1,1,3)$	$D_3 > D_4 > D_2 > D_1 > D_{11} > D_{10} > D_5 > D_6 > D_8 > D_{12} > D_7 > D_{13} > D_9$
2	$W_{C1, C2, C3} = (1,3,5)$	$D_3 > D_4 > D_2 > D_1 > D_{11} > D_{10} > D_5 > D_6 > D_8 > D_{12} > D_7 > D_{13} > D_9$
3	$W_{C1, C2, C3} = (3,5,7)$	$D_3 > D_4 > D_2 > D_{10} > D_1 > D_{11} > D_5 > D_6 > D_8 > D_{12} > D_7 > D_{13} > D_9$
4	$W_{C1, C2, C3} = (5,7,9)$	$D_3 > D_4 > D_2 > D_{10} > D_1 > D_{11} > D_5 > D_6 > D_8 > D_{12} > D_7 > D_{13} > D_9$
5	$W_{C1, C2, C3} = (7,9,9)$	$D_3 > D_4 > D_2 > D_{10} > D_1 > D_{11} > D_5 > D_6 > D_8 > D_{12} > D_7 > D_{13} > D_9$
6	$W_{C1} = (7,9,9)$, $W_{C2, C3} = (1,1,3)$	$D_4 > D_2 > D_{10} > D_5 > D_3 > D_1 > D_{11} > D_6 > D_8 > D_{12} > D_7 > D_{13} > D_9$
7	$W_{C2} = (7,9,9)$, $W_{C1, C3} = (1,1,3)$	$D_4 > D_{10} > D_3 > D_2 > D_1 > D_{11} > D_5 > D_6 > D_8 > D_{12} > D_7 > D_{13} > D_9$
8	$W_{C3} = (7,9,9)$, $W_{C1, C2} = (1,1,3)$	$D_3 > D_6 > D_8 > D_{12} > D_7 > D_{13} > D_4 > D_2 > D_1 > D_{11} > D_{10} > D_5 > D_9$

Table 13 shows that that, in the first five experiments, weights of all criteria are set equal to (1, 1, 3), (1, 3, 5), (3, 5, 7), (5, 7,9) and (7, 9,9) respectively. In experiments 6–8, the weight of each criteria is set as highest (7, 9,9) one by one and the remaining criteria are set to the lowest value (1, 1, 3). The sensitivity analysis is done to find the most important criteria influencing decision making process [28].

The sensitivity analysis can be conducted to investigate the impact of variation in the weights of the drivers. The small variation in the decisions made by experts are already addressed by the methodology itself, which is the distinct feature of fuzzy TOPSIS to handle uncertainties. So, In this paper, the sensitivity analysis is conducted on criteria weights only.

5. Conclusions and Recommendations

The investigation of GM drivers and their prioritization based on triple bottom line dimensions namely environmental, social and economic perspectives suggest very useful and interesting results. Some of the recommendations based on the outcome for the policy and decision makers both in government and industry in emerging and developing economies are:

- The government should provide incentives to the industry to encourage them for investment in green technologies in terms of tax rebates, environmental performance awards, etc.
- The federal government should develop policies, wherein the private and public sector banks should encourage the

subsisted loans to MSMEs for investments in green technologies and environmental practices.

- The governments should provide long term roadmap of future legislations with milestones of achievable targets.
- The government should also include the awareness campaigns as a mandatory activity for government funded NGOs, to educate the community as a whole about the importance of environmental products and processes, which can further generate more customer demand for environment friendly products.

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