Performance Evaluation of Sustainable Innovation Practices in Food Supply Chain Using Best Worst Method

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Abstract

The growing demand for sustainable Food Supply Chains (FSCs) is steering adoption of sustainable practices. Adoption alone cannot reap the desired benefits, lest it is followed by evaluation and re-examination of the practices. This study proposes an analytical policy framework for the adoption of sustainable innovation practices (SIPs) in the Flour Milling sector with the help of an illustration of an Indian flour mill. In the pursuit for sustainability, the company implemented few SIPs and embracing of these practices has influenced the decisions within the strategic, operational and tactical domains of the company. Hence, investigation and identification of SIPs that have had an insightful impact on the sustainable performance of the company is needed. Best-Worst method, a multi-criteria technique, ideally suited in decision making environment involving multiple decision makers with conflicting judgments, is adopted in the present study for evaluation of SIPs. The final inference is that 'Increasing sustainability awareness' is the most important SIP, having the maximum social and environmental impact with minimum economic input. The outcomes of this case-based study can be utilized as reference for other industry managers to make key strategic decisions regarding practical implementation of SIPs, with an objective to enhance sustainability of their FSC.

Keywords

Sustainable Innovation Practices, Food Supply Chain, Multi-dimensional attributes and Best-Worst Method.

1. Introduction

The rapid pace of growth of global population is a contributing factor to foresee the voluminous increase in food production in the coming years. With the resultant increase in resource demand, comes the responsibility of using a highly pragmatic and appropriate approach which embraces the correct trade-off between economic growth and environment protection (McKenzie et al. 2014). The emergent need for this embrace is that more than half of the food manufacturing sectors are not efficient in terms of sustainability performance. Also, due to agro-industrialisation, consumer consciousness (Faerne et al. 2001; Manning et al. 2006), emergence of modern retailer forms, government intervention, strict requirement of maintenance of food quality and safety (Hassini et al. 2012), etcetera, they are under fierce pressure to integrate sustainable practices in their supply chain (SC) (Wang and Hue, 2017; Keeble et al. 2003; Kolk 2004). Thus, sustainability plans for any food supply chain (FSC) need to be multi-dimensional with constructive inputs from all the SC actors. Their well-coordinated and strategic response to implementation of sustainable practices can be vital to ensure sustainability of the whole FSC (Dania et al. 2018). This, in turn, will not only yield enhanced economic and sustainable outcomes but will also lay a foundation to earn competitive advantage for all the stakeholders involved in the SC (Carter and Rogers 2008).

Earlier apprehension on the efficacy and sanctity of implementing the sustainable practises is no longer debatable. Further, the need is to regularly evaluate and monitor the impact of sustainable practices which cannot be done without completely understanding the exact context and circumstances in which the SC operates (Kolk 2004). This is mainly because SC sustainability issues are industry specific as well as country specific (Maloni & Brown 2006). In fact, companies within the same sector also face varied sustainability issues due to difference in the SC specifications, targets and objectives (Gerbens-Leenes et al. 2003). For instance, cocoa farmers in Columbia and Mexico are under consumer and industry pressure to keep price of their produces rational enough to knock down the competitors (Fluck 2014). In Indonesia, there is insufficient sugar supply in market due to absence of integration between policy and goals of stakeholders (Jati and Premaratne 2015). The meat supply chain in Italy has serious issues related to waste management, small gross profit, imports reliance, public image, food safety, security and traceability, employee training and welfare, etc (Golini et al. 2017). The examples stated above clearly legitimize the importance of timely assessment of sustainable practices being followed in order to substantiate and concentrate all the synergies and interactions towards the right direction.

In Indian context, food manufacturing companies find it particularly complex and challenging to deal with sustainability requirements. Core reason for the same is lack of empowerment of the upstream suppliers. Farmers form the foundation of any FSC and even though government has introduced policies and measures for their upliftment but they have limited exposure to technology and have little awareness about the far reaching impacts of the practices that they follow (Haque 2006). As a result, their focus is narrowed down only to their own operations rather than aligning it with the overall sustainability of the FSC. Therefore, companies need to focus on their sustainability in order to ensure sustainability of the entire SC. Further, there is absence of extensive literature for research on sustainability initiatives in FSC planning, particularly in the Indian context. Wang et al. (2018) has discussed the impact of sustainable SC practices on food safety assurance and sustainable performance in food firms in China, Kirwan et al. (2017) identified and analysed various attributes contributing to complexities in sustainable performance evaluation of FSCs and Mani et al. (2018) has explored measures related to supplier social sustainability in emerging economies. Other than the above mentioned contributions to the research, concrete work related to the inclusion of sustainability in FSC for Indian agro industry is still missing in the literature, which is the focus of the present work. In this study, an attempt has been made to delve upon the present sustainability practices that are or can be adopted by the Indian wheat millers and their impact on the FSC and the associated stakeholders. Wheat is staple food of north India and sustainability practices such as flour fortification can eliminate the roots of mal nutrition from the country, appropriate resource conservation measures can help in reducing the environmental degradation and effective social initiatives can lead to better working environment for the wheat producers, suppliers and employees. With this motivational background, the present research work explores to analyse the impact of sustainable practices adopted by Indian flour millers. This has been done with the help of a case study of an Indian flour mill-Delhi Flour Mills Company. The company strives to develop and grow on sustainable basis through implementation of different Sustainable Innovation Practices (SIPs). Actual performance of any SIP may differ from the targeted performance because of variation in risks, threats or economic condition faced by the company during the period between SIP setting and SIP evaluation. This triggers the need to evaluate performance of each SIP and compare it with that of the previous fiscal year, in order to map its correct contribution in the growth of the company. For this, we need to verify that a practice categorized as 'best' from economic point of view is equally productive or 'best' from environmental and social point of view (Chardine & Botta 2014). Only after this coherence of all the three dimensions, can any SIP qualify as a successful SIP. In this study, SIPs adopted by the company to strike a balance between complying with the sustainability regulations enforced by the government and the pressure exerted by the stakeholders, are taken into consideration. Need of the hour is to conduct an in-depth analysis of the impact of each of these initiatives with respect to attributes at the strategic, tactical and operational levels to understand the maximum benefits attained from these sustainable initiatives.

Therefore, the objective behind the present study is as follows:

- To quantifiably measure the sustainable impact of each SIP in comparison with each other, using an appropriate mathematical technique.
- Based on the analysis of the result findings of the mathematical model, to develop an analytical policy framework for the decision makers (DMs) of the company, using which the company can strategize its future course of action for achieving a sustainable FSC.

A detailed evaluation of the aggregate sustainable impact of the current policy framework is done in order to construct a prioritization model. A thorough analysis using a multi-criteria decision making (MCDM) method called Best-Worst (BWM) method is done in order to determine the most crucial SIP which reaps maximum long-term social, environmental and economic benefits. BWM has been effectively applied in various real-life application problems. The past studies utilizing BWM include Rezaei (2016a), Guo and Zhao (2017) for transportation problems, Gupta and Barua (2017), Rezaei et al. (2016b) for supplier selection problems, Torabi et al. (2016) for risk assessment, etc. The key idea behind BWM is the identification of 'best' alternative and 'worst' alternative for each DM and comparisons of each alternative with the best and worst. This is the reason behind using BWM in this study as it has the advantage in terms of reduction of the number of pair-wise comparisons required for relative evaluation of alternatives, as compared to other multi-criteria techniques.

The rest of the paper is structured as follows: Section 2 describes the SC of the firm on which the case study is based, along with the list of identified sustainable practices followed by it. Subsequent section discusses the methodology adopted and section 4 elaborates upon the findings and draws useful inferences emanating from the study. The conclusion emerging out of the study is summarized in the final section of the paper.

2. Case Study

2.1 Overview of the Supply Chain of Delhi Flour Mills

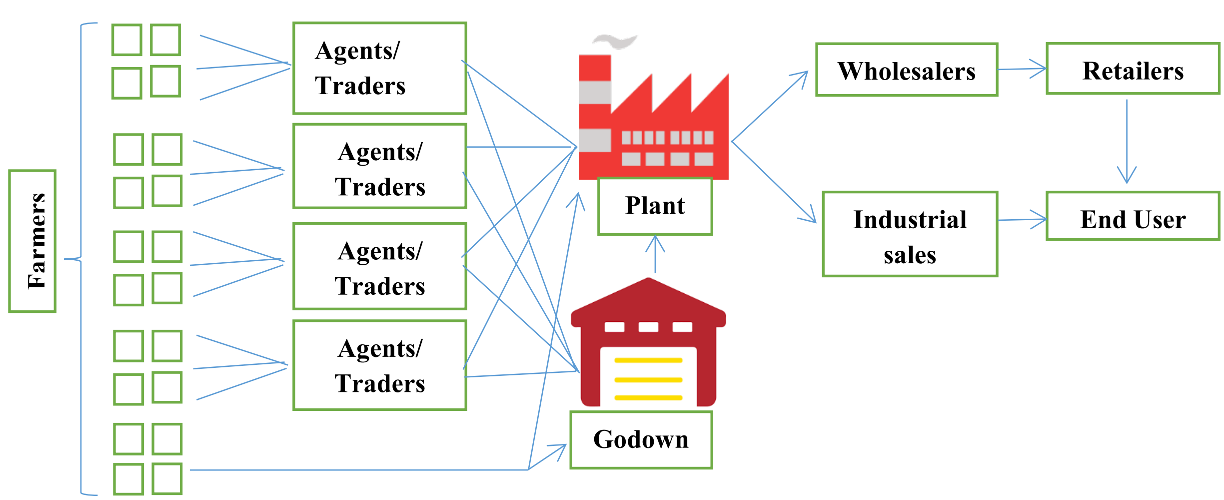

Figure 1: Supply Chain of DFM

The company in focus is Delhi Flour Mills (DFM) which is involved in the production of aata, maida, sooji from wheat and bran is it's by-product. It is one of the oldest and biggest flour mills in India having an installed capacity of more than 7 thousand quintals per day. The brief overview of its SC is as follows: The basic SC of DFM is multi-tier involving farmers, traders/agents, manufacturing plant, godown, Finished Product Depots (distribution agents/centres), retailers and consumers. DFM procures its raw materials directly from farmers or from its own network of dedicated traders or raw material agents. It may also procure wheat, directly or through agents, from Food Corporation of India when wheat is not easily available in the open market during the lean season. Depending upon the commercial viability, it is not averse to importing wheat as well. As per the requirement of the company, the agents transport the raw material (wheat) either to the warehouse/godown or to the production plant/mill. Once the finished product is ready, it is sent to Finished Product Depots or for direct bulk institutional sales. Figure 1 provides the pictorial representation of the SC of DFM.

2.2 Sustainable Innovation Practices of DFM

DFM already has a strategic plan of action and operational measures in place to work for more sustainable food production, but many challenges exist. Table 1 provides a detailed description of the SIPs currently followed by the company. Some of the SIPs such as *Introduction of sustainable food safety measures* and *Agents' work ethics and past record* have long been taken up by the company, whereas some of the SIPs such as *Alliance with social groups, project or institutes* have been recently introduced by the company. It also provides the future scope of each SIP which the company wishes to incorporate as part of its ongoing efforts towards sustainability. The problem addressed in this study is to analyse the annual impact of the ongoing SIPs to understand if the sustainable productivity of each SIP in the last year is as per the company's targets and objectives. The point to be noted here is that productivity and output is measured in comparison with previous year's performance of the SIP. Such monitoring and measurement can give us valuable inputs for correcting the underperforming SIPs and further developing the performing SIPs for the next fiscal year. Further, a framework needs to be developed which can aid the company is maintaining a balance between the economic input and sustainable output of each SIP for optimal utilization of resources, time energy and efforts for maximum sustainable impact. It is also required to understand the relative impact of each SIP so that strategic decisions can be made regarding the SIPs which must be continued in and the SIPs which have negligible impact and must be improved. Given below are the SIPs implemented in DFM:

1. Use of energy efficient equipment
2. Recyclable packaging
3. Increasing sustainability awareness
4. Sustainable employment practices
5. Adoption of pollution reduction measures
6. Rewards for sustainable supply
7. Introduction of sustainable food safety measures
8. Alliance with social groups, project or institutes
9. Agents' work ethics and past record

2.3 Research Problem

The main focus of the company at present is to understand the environmental and social impact of implementation of each SIP mentioned above, so that a concrete future course of action can be devised for achieving sustainability within the practical limitations of the company. This takes us to the following multi fold objective of the study:

- To investigate and identify the SIPs that had an insightful sustainable impact on the SC performance of the company.
- To evaluate performance of the SIPs in terms of whether there has been significant impact as compared to the last assessment report such as reduction of the total energy use and greenhouse emissions and enhancement of social wellbeing of its upstream suppliers, within the budgetary constraints of the company.

In order to accomplish the above objectives, the following research methodology is adopted:

3. Research Methodology

To judge the need of modification of existing policies subject to the constraints of cost-efficiency of the ongoing SIPs and their sustainable productivity, BWM has been applied. BWM compares the set of SIPs using pairwise comparison with respect to the best SIP and the worst SIP. The two major advantages of using BWM are: i) the number of pairwise comparisons are less compared to full pairwise matrix as used in AHP (analytical hierarchy process), resulting in less time and effort and (ii) it results in better consistency of the judgment matrix compared to that of a full comparison matrix used in other MCDM methods. In this study, the performance of the nine SIPs $S_1, S_2, \ldots, S_9$ is assessed for their economic, environmental and social impact on the SC.

The steps of the BWM for evaluation of economic performance of SIPs are briefly described in steps 1-4 described below: (Rezaei 2015, Rezaei 2016):

Step 1: Selection of best (most desirable) and the worst (least desirable) SIP as per their economic impact by the DM.

Step 2**:** Calculate the preference of the best identified SIP over the other SIPs using a numerical scale of 1-9 where value of 1 represents equal preference between the best SIP and other SIP and a value of 9 represents the extreme preference of the best SIP over the other SIP for the economic impact. This results in the Best-to-Others (BO) vector given by:

$$\{a_{B1}, a_{B2}, \ldots, a_{B9}\}^{EC}$$

Where a_{Bj} indicates the preference of the best SIP over *j^th^* SIP for economic performance. It is deduced that $a_{BB} = 1$.

Step 3**:** Calculate the preference of each SIP over the economic worst identified SIP using the numerical scale of 1-9. This results in the Worst-to-Others (WO) vector given by:

$$\{a_{1W}, a_{2W}, \ldots, a_{9W}\}^{EC}$$

Where a_{jW} indicates the preference of the j^{th} SIP over the worst identified SIP for economic performance. It is deduced that $a_{ww} = 1$.

Step 4**:** Calculate the optimal weighting vector $w^{EC} = \{w_1^{EC}, w_2^{EC}, \ldots, w_9^{EC}\}$ of the SIPs for economic impact.

The optimal weight $\mathrm{w_j^{EC}}$of jth SIP is to be calculated such that $\frac{\mathrm{w_B^{EC}}}{\mathrm{w_j^{EC}}} = \mathrm{a_{Bj}^{EC}}$ and that $\frac{\mathrm{w_j^{EC}}}{\mathrm{w_w^{EC}}} = \mathrm{a_{jw}^{EC}}$, for which the maximum of their absolute differences need to be minimized. This results in formulation of the following min-max problem:

$$\min_j \max \left\{ \left| \frac{w_B^{EC}}{w_j^{EC}} - \right|, \left| \frac{w_j^{EC}}{w_w^{EC}} - a_{jw}^{EC} \right| \right\}$$

Subject to

$$\sum_{i=1}^{9} w_j = 1$$

$$w_j \geq 0 \quad \forall j$$

The min-max model is equivalent to the following linear model:

$$\min \alpha^l$$

Subject to

$$|w_B - a_{Bj} w_j| \leq \alpha^l \quad \forall j$$

$$|w_j - a_{jW} w_W| \leq \alpha^l \quad \forall j$$

$$\sum_{i=1}^{9} w_j = 1$$
$$w_j \geq 0 \quad \forall j$$

It results in a unique weighting vector given by $w^{EC} = \{w_1^{EC}, w_2^{EC}, \ldots, w_9^{EC}\}$ and α^{l^*} which is the measure of consistency of the comparisons. Value of α^{l^*} closer to '0' indicates higher consistency.

Further, *Step*s 1-4 are repeated for finding the optimal weights $w^{EN} = \{w_1^{EN}, w_2^{EN}, \ldots, w_9^{EN}\}$ and $w^{SO} = \{w_1^{SO}, w_2^{SO}, \ldots, w_9^{SO}\}$ of SIPs for their environmental and social performance respectively. The final weights are obtained by taking average of the economic weights, environmental weights and social weights.

4. Result Discussion

The team of DMs chosen for the assessment includes Works Manager (with 5-7 years of experience, Quality Material Manager (with 7 years of experience), General Manager Business Operations (with 10-12 years of experience), Company secretary (with 12-15 years of experience) Chief Financial Officer (with 12-15 years of experience), Executive Director (with 25 years of experience). Each member of this team had a separate role to play in the decision making process. The Works Manger focused on selecting those SIP's which works towards training and welfare of employees. The Quality Material Manager focused on SIPs which aimed at providing the best quality product to the end customer. General Manager Business Operations was more inclined towards SIP's which are holistic in nature, i.e. the ones which empower the employees, are profitable to company as well as does not cause irreparable damage to the environment. The Chief Financial Officer as well as Company Secretariat preferred SIPs which are economically reasonable for the company.

First, best and worst SIPs are identified, as explained in step 1. Table 1 provides the best and worst SIP as per their economic, environmental and social performance respectively. '*Use of energy efficient equipment*' has been regarded as the Best SIP under the 'Economic' and 'Environmental' dimension. Reason behind the same is evident from the fact that energy efficient equipments not only consume less energy and price but also generate smaller amount of greenhouse gases making them cost efficient and environment friendly at the same time. SIP S7-'*Alliance with social groups, project or institutes*' is best SIP from the social point of view. Involvement of social groups, projects or institutes can turn out to be a vital link between farmer and the company. They can play a very crucial role in upliftment of farmers by providing them adequate and timely support in farm extension services, easy and quick facilitation of farm loans, cover against weather risk, price protection, etc.

Table 1: Best and worst SIP for each sustainable dimension

	ECONOMIC	ENVIRONMENTAL	SOCIAL
BEST SIP	S1:Use of energy efficient equipment	S1:Use of energy efficient equipment	S8: Alliance with social groups, project or institutes
WORST SIP	S3:Increasing sustainability awareness	S9:Agents' work ethics and past record	S7: Introduction of sustainable food safety measures

On the other hand, glancing at the worst SIPs from the point of view of all the three dimensions, it is quite evident that their respective economic, environmental and social output is not reasonable enough. For instance, SIP S3-'*Increasing sustainability awareness'* might not immediately increase gross profit for the company but according to the social aspect of sustainability (as shown in Table 2), it is second most crucial SIP. It is at such logger heads where striking a balance between economic input and sustainable output becomes challenging that we resort to decision making methodology like BWM which handles all the criteria of importance simultaneously and steer the entangled problem towards an optimal solution. SIP S9-'*Agents' work ethics and past record*' may seem to bring negligible benefits for the environment and hence, has been chosen as the worst SIP in terms of environmental performance in this study, but economically it can yield greater benefits, as an old association with ethical agents can help the company to save many resources including time. As a result, it ranks 3 in economic dimension as shown in Table 2. For the DMs, environmental performance of SIP-'*Introduction of sustainable food safety measures*' has been estimated to be less productive. The reason can be attributed to the fact that food safety, in general, is already well engraved in the production process ensuring a high quality end product as well as safeguarding consumers from any kind of food borne illness caused due to inappropriate storage, production or handling method. Clubbing food safety with sustainability can surely be helpful to enhance the sustainability quotient but its contribution towards environment protection is almost trivial.

Hence, the result shown in Table 2 clearly indicates that a trade-off is needed between the economic, environmental and social benefits while selecting best performing SIPs. The economic reimbursements derived from a particular SIP may not result in good social output and vice versa. Thus, a MCDM technique is needed to understand which SIPs rank the best and must be chosen, for maintaining a good compromised SC performance. The BWM method is ideally used in such a situation whereby all SIP's are compared with the 'best' and the 'worst' according to their operational and sustainable performance and then the optimal weights are obtained through a linear programming optimization model as done below.After identification of best and worst SIP, the DMs are asked to use a score of 1-9 for the pairwise comparisons as explained in steps 2 and 3, results of which are shown in Table 2. Therefore, the BO and WO vectors obtained for economic performance are as follows:
$\{a_{B1}, a_{B2}, \dots, a_{B9}\}^{EC} = \{1,6,9,7,5,4,4,6,3\}$ and $\{a_{1W}, a_{2W}, \dots, a_{9W}\}^{EC} = \{9,2,1,4,4,5,6,2,5\}$

Table 2: Pairwise comparisons of SIPs with best and worst SIP (for economic impact)

Pairwise comparison with Best SIP	a_{Bj}	**Pairwise comparison over Worst SIP**	a_{jW}
Use of energy efficient equipment	1	Use of energy efficient equipment	9
Recyclable packaging	6	Recyclable packaging	2
Increasing sustainability awareness	9	Increasing sustainability awareness	1
Sustainable employment practices	7	Sustainable employment practices	4
Adoption of pollution reduction measures	5	Adoption of pollution reduction measures	4
Rewards for sustainable supply	4	Rewards for sustainable supply	5
Introduction of sustainable food safety measures	4	Introduction of sustainable food safety measures	6
Alliance with social groups, project or institutes	6	Alliance with social groups, project or institutes	2
Agents' work ethics and past record	3	Agents' work ethics and past record	5

Similarly, Table 3 and 4 give the pairwise comparison values for environmental and social performances of SIPs with best and worst SIPs. Therefore, the BO and WO vectors obtained for environmental performance and social performance respectively are as follows:
$\{a_{B1}, a_{B2}, \dots, a_{B9}\}^{EN} = \{1,3,4,6,2,5,6,7,9\}$, $\{a_{1W}, a_{2W}, \dots, a_{9W}\}^{EN} = \{9,5,3,2,6,4,3,2,1\}$ and

$\{a_{B1}, a_{B2}, \dots, a_{B9}\}^{SO} = \{5,2,2,3,5,3,9,1,4\}$, $\{a_{1W}, a_{2W}, \dots, a_{9W}\}^{SO} = \{3,5,6,6,3,4,1,7,4\}$

Next, the linear programming problem given in step 4 is solved utilizing the BO and WO economic vectors obtained above, resulting in the following weighting vector for the economic performance of the 9 SIP's:

$$w^{EC} = \{w_1^{EC}, w_2^{EC}, \dots, w_9^{EC}\} = \{0.341, 0.069, 0.029, 0.059, 0.083, 0.104, 0.069, 0.138\}.$$

Similarly the weighting vectors $w^{EN} = \{w_1^{EN}, w_2^{EN}, \dots, w_9^{EN}\}$ and $w^{SO} = \{w_1^{SO}, w_2^{SO}, \dots, w_9^{SO}\}$ of the SIPs are obtained for the environmental and social performance respectively. The respective resulting values along with the consistency value obtained are tabulated in Table 5. After obtaining the values, the average optimal weights and the normalized weights are calculated respectively as follows:

$$w^{O} = \{w_1^*, w_2^*, \dots, w_9^*\}^{O} = \frac{1}{3}[w^{EC} + w^{EN} + w^{SO}]$$

and

$$w^{N} = \{w_1^{\wedge}, w_2^{\wedge}, \dots, w_9^{\wedge}\}^{N} = \frac{1}{\max\{w_1^*, w_2^*, \dots, w_9^*\}^{O}}[\{w_1^*, w_2^*, \dots, w_9^*\}^{O}]$$

Table 3: Pairwise comparisons of SIPs with best and worst SIP (for environmental impact)

Pairwise comparison with Best SIP	a_{Bj}	**Pairwise comparison over Worst SIP**	a_{jW}
Use of energy efficient equipment	1	Use of energy efficient equipment	9
Recyclable packaging	3	Recyclable packaging	5
Increasing sustainability awareness	4	Increasing sustainability awareness	3
Sustainable employment practices	6	Sustainable employment practices	2
Adoption of pollution reduction measures	2	Adoption of pollution reduction measures	6
Rewards for sustainable supply	5	Rewards for sustainable supply	4
Introduction of sustainable food safety measures	6	Introduction of sustainable food safety measures	3
Alliance with social groups, project or institutes	7	Alliance with social groups, project or institutes	2
Agents' work ethics and past record	9	Agents' work ethics and past record	1

Table 4: Pairwise comparisons of SIPs with best and worst SIP (for social impact)

Pairwise comparison with Best SIP	a_{Bj}	**Pairwise comparison over Worst SIP**	a_{jW}
Use of energy efficient equipment	5	Use of energy efficient equipment	3
Recyclable packaging	2	Recyclable packaging	5
Increasing sustainability awareness	2	Increasing sustainability awareness	6
Sustainable employment practices	2	Sustainable employment practices	6
Adoption of pollution reduction measures	5	Adoption of pollution reduction measures	3
Rewards for sustainable supply	3	Rewards for sustainable supply	4
Introduction of sustainable food safety measures	9	Introduction of sustainable food safety measures	1
Alliance with social groups, project or institutes	1	Alliance with social groups, project or institutes	7
Agents' work ethics and past record	4	Agents' work ethics and past record	4

Table 5: Optimal weights of SIPs for each sustainable dimension

	Optimal Weights		
SIP	Economic w^{EC}	Environmental w^{EN}	Social w^{SO}
S1	0.341	0.320	0.058
S2	0.069	0.122	0.145
S3	0.029	0.092	0.145
S4	0.059	0.061	0.145
S5	0.083	0.184	0.058
S6	0.104	0.073	0.097
S7	0.104	0.061	0.029
S8	0.069	0.052	0.247
S9	0.138	0.030	0.072
Consistency Value	0.07433	0.0477	0.0436

The average weights, normalized weights and the final rankings are obtained as shown in Table 6. Inference derived from Table 6 is that the SIP S1-*Use of energy efficient equipment* which ranked 1 in the economic as well as environmental performance and fifth in the social performance has been ranked first in the overall performance. SIP S2-*Recyclable packaging* with rank 6, 3 and 2 respectively for the three sustainability dimensions has emerged as second most important SIP in the final rankings. The SIP with overall third rank is S8-*Alliance with social groups, project or institutes* which ranked poorly with respect to the economic impact (rank 6) and environmental impact (rank 7). Clearly, these three are the most important SIPs which can lead to a substantial improvement in the overall sustainable performance of the company and must be continued for long-term benefits. On the other hand, SIP S7-*Introduction of sustainable food safety measures* ranks 9th. This in no way implies that this SIP is not be continued. It only gives an indication that this SIP has led to only a marginal improvement in the sustainable output of the SC as compared to the last assessment report.

Table 6: Final rankings of each SIP

	SIP	**Average weights w^O**	**Normalized weights w^N**	**TBL rank**
S1	Use of energy efficient equipment	0.240	0.240	1
S2	Recyclable packaging	0.112	0.112	3
S3	Increasing sustainability awareness	0.088	0.089	6
S4	Sustainable employment practices	0.088	0.088	7
S5	Adoption of pollution reduction measures	0.108	0.108	4
S6	Rewards for sustainable supply	0.091	0.0915	5
S7	Introduction of sustainable food safety measures	0.064	0.064	9
S8	Alliance with social groups, project or institutes	0.123	0.123	2
S9	Agents' work ethics and past record	0.080	0.080	8

BWM method has proved to be an effective MCDM too for finding a compromised ranking for the SIP's based on their economic, environmental and social performance. It gives a clear idea to the DMs about which SIPs should be carried on and which need more improvement. If they are adopted effectively by the DMs, then it can be instrumental for the company in the overall sustainable performance of the FSC.

5. Conclusion

The study has attempted to present a MCDM model for performance evaluation of Sustainability Innovation Practices implemented in the wheat milling sector with specific fact findings of Delhi flour Mills Company. The company faces a tough task of attaining a productive FSC while striking a balance between complying with the sustainability regulations enforced by the government and the pressure exerted by the stakeholders. As a consequence, the challenge which lies further ahead for the company is to investigate and identify the SIPs that have had an insightful impact in the last assessment year on the sustainable performance of the company so that key decisions can be made for the next year. Nine key ongoing SIPs are identified and analyzed for their impact on the overall sustainability performance of the SC. The motivation behind the study was to provide an analytical framework to DMs so that existing policies can be modified subject to the constraints of cost-efficiency and sustainable productivity of the ongoing SIPs, keeping in mind the stakeholders' interest and arriving on key decisions for broadening the spectrum of sustainability. Therefore, performance evaluation of the SIPs are done based on significant reduction of the total energy use and the greenhouse emissions of the SC along-with enhancement of social wellbeing, within the budgetary constraints of the company. Since sustainability is a multi-criteria concept, therefore, to assess the relevance of each SIP as compared to each other and within the context of overall sustainability, a recently developed multi-criteria method called the Best-Worst method is used. To evaluate and improve the current practices and processes, the DMs are asked to identify the best (most desirable), and the worst (least desirable) SIPs, followed by a pairwise vector comparison of best SIP and worst SIP with others. The weights of the SIPs are generated by solving a max-min model. Then, the weights of the economic, environmental and social performance are obtained using the same procedure. Finally, significance of the SIPs is obtained in the aggregation phase in terms of their importance to the organizational sustainability of the supply chain. The consistency ratio is also checked for the reliability of the comparisons made. The final inference obtained is that '*Use of Energy Efficient Equipment*' is the most important sustainability initiative which has maximum long-term social, environmental and economic benefits. The outcomes of this study will help industry managers, decision-makers and practitioners decide where to channelize their resources during the next stage of implementation of SIPs, with an objective to enhance sustainability in their supply chain and move towards sustainable development

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