

Developing a sustainable manufacturing system based on the Indian FDI manufacturing industry

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Abstract: Sustainable development goals (SDGs) are set from the perspective of the country and industry. There is a gap between the SDGs and the corporate social responsibility (CSR) that has been implemented by industries for years. Activities from the manufacturing industry that meet the SDGs are still missing. This study surveys both academic researchers and senior managers in the manufacturing industry in India. It applies analytical hierarchy process analysis and proposes (1) a sustainable manufacturing system (SMS) that is composed of seven constructs with 55 activities that support SDG 2-12 and 41 sustainable targets, (2) ten activities as the initial stage of the SMS that support SDG 2, 3, 4, 6, 8, 9, and 12, and (3) that SMS needs to be implemented to a company's external environment first, and then within the company, in the sequence of Local community, Enterprise welfare, Enterprise process, Enterprise performance, Enterprise policy, Enterprise human resource, and Enterprise product. By implementing SMS, the gap between the SDGs and CSR can be diminished.

Keywords: Sustainable development, SDGs, sustainable manufacturing, sustainable manufacturing system, CSR

1. INTRODUCTION

Manufacturing generates a significant quantity of greenhouse gases alongside the energy and transport industries [1]. Manufacturing has further a direct social impact as it produces the articles that are used by final consumers. It also has a direct impact on occupational safety and health [2]. Taken together, it is evident that manufacturing requires sustainability as a solution to meet the needs of all parties [3]. Based on the 17 sustainable development goals (SDGs) and 169 sustainable targets issued in 2015 and listed on the United Nations' website, countries around the world have begun to develop the SDGs into activities that suit their own national conditions, and implement these activities one by one. The manufacturing industry consumes a high percentage of natural resources [4] and must therefore align itself with the SDGs by implementing activities to support the sustainable targets [5].

Batterham [6] proposes that sustainable development can be categorized into five levels: global objectives, industry strategies, enterprise sustainable targets, specific projects, and individual actions/measured outcomes. Manufacturing companies often focus on internal processes and operations [7], and except for suppliers and customers, manufacturing companies rarely communicate with society and local communities [8]. Meanwhile, the requirements of the SDGs are clearly developed from the perspective of the country and industry. Activities that manufacturing companies can implement directly within the company are limited. Therefore, manufacturing companies are generally conservative in promoting sustainability. They continue to carry out corporate social responsibility (CSR) activities that were first implemented years ago [9]. Unfortunately, the scope of such CSR activities is not as broad as the triple bottom line (TBL) that SDGs comply with [10]. It shows that there is a gap between the expectation of the SDGs and the practical implementation of manufacturing companies. This study focuses on the enterprise sustainable target level within the manufacturing industry.

Many companies publish CSR reports annually. CSR is important but social responsibility is directed solely to shareholders [11]. Meanwhile, some CSR projects may do little more than promote the agenda of the corporation itself while dispelling attention from deeper economic, political, and social problems that need to be addressed [12]. It shows a gap between sustainable development and CSR. Sustainable manufacturing is expected to diminish the gap in the manufacturing industry [13].

Sustainable manufacturing is defined as the creation of manufactured products that use processes that minimize negative environmental impacts, conserve energy and natural resources, and are economically sound and safe for employees, communities, and consumers [14]. In line with this, Moldavska and Welo [15] propose that product, process, community, employees, and customers are the main domains of sustainable manufacturing. Bhatt, Ghuman, and Dhir [16] state that sustainable manufacturing deals with the conservation of energy and natural resources and ensures the safety and well-being of all stakeholders. Well-being is what

employees feel as related to organizational culture [17] Kulatunga, Jayatilaka, and Jayawickrama [18] state that the supply chain, products, build environment, and processes are the industry focus when implementing sustainable manufacturing in the Sri Lankan manufacturing sector. Ocampo and Clark [19] propose a hierarchical framework for index computation in sustainable manufacturing. The framework shows that employees, customers, and community are categorized under social well-being.

In addition, Moldavska [20] states that sustainable assessments should be made not only for sustainability, but also related to competitive advantage, customer satisfaction, and competitiveness of product. Huang and Badurdeen [21] propose a framework that indicates that process and product are two pillars of sustainable manufacturing performance measurements while philosophy is the foundation of the framework and policies are the tool by which to deliver the philosophy. The above studies show how performance, process, product, people, policy, well-being, and community are domains that enterprises should pay attention to while implementing sustainable manufacturing. This study applies these seven domains as constructs to conduct the further research.

2. MATERIALS AND METHODS

India, with its population of 1.4 billion, is expected to be the next major manufacturing country. This is in part due to rising manufacturing costs in China, leading many companies to move their production lines to India. Manufacturing accounts for 14% of India's GDP [22]. The importance of sustainability for India cannot be underestimated. As many foreign direct investment (FDI) manufacturing companies in India have introduced CSR and publish CSR reports to stockholders every year, these companies have a good foundation for implementing sustainable manufacturing. The purpose of this study is to establish a sustainable manufacturing system that manufacturing companies can employ to directly support sustainable targets.

The SDGs are based on a global perspective and have a broad span. To narrow the focus to the manufacturing industry in India, this study employs a two-step questionnaire to collect data. In step one, an SDG and sustainable target questionnaire is sent to Indian academic researchers through email to collect comments about which sustainable targets FDI manufacturing companies should support in India. In step two, based on the collected responses, the seven main constructs and the main activities of sustainable manufacturing are identified, and a second questionnaire is created. This questionnaire collects responses from senior managers who work in FDI manufacturing companies that have implemented CSR for more than five years. Finally, the analytical hierarchy process (AHP) is applied to build a sustainable manufacturing system and to propose the initial stage of sustainable manufacturing.

According to Wikipedia, Chennai is the fourth largest city in India. It is the automobile capital of India, and the main automobile industry base in India. Chennai produces 35% of the car parts and 30% of the vehicles in India. Global automobile companies such as Hyundai, Ford, Mitsubishi, Nissan, etc., have set up factories there. Chennai can be regarded as one of the major foreign manufacturing investment locations in India. This study sets Chennai's foreign manufacturing companies as the research scope.

Further, this study selects companies who have published annual CSR reports the past three years (2018-2020). Because these companies have implemented CSR, they have a better understanding of the terms and meanings on the questionnaire. In order to ensure that respondents have a deep enough understanding of the company's operations, organization, human resources, and local community, the respondents are required to have worked in the company for more than eight years. The collected responses are analyzed by AHP, where the consistency ratio (CR) must be less than 0.1.

3. RESULTS

The SDG and sustainable targets questionnaires with open ended questions were first sent by email to researchers at Indian University's management school. Twelve responses were obtained. Based on the comments from these 12 responses, a list of 11 goals (SDG 2 to 12) that FDI manufacturing companies should support was created. Under these 11 goals, a total of 41 sustainable targets that FDI manufacturing companies can directly execute activities toward to support the achievement of these goals were compiled. This study then broke down the comments of the respondents into the first 49 activities that can be executed and implemented.

Meanwhile, some respondents commented that SDG does not cover competitiveness and performance, which are two major factors companies focus on. Companies must be competitive to provide a stable environment for their employees. It was therefore necessary for this study to add four activities related to business competitiveness: 1. *Ensure the competitiveness of enterprises*, 2. *Improve customer satisfaction*, 3. *Treat suppliers fairly*, and 4. *Develop competitive products*. In addition, some respondents commented that the impact of product life cycles on the environment is important. Companies should produce environmentally friendly products. This study thus added an activity called *Develop products with lower energy consumption and*

longer service life. Some respondents commented that it would be difficult to solve the problem of sustainability with traditional methods. With the rise of new technology, digital transformation should be considered as an approach. This study therefore added *Apply digital technology to improve efficiency of end-to-end processes* [23]. There are thus six activities that do not come from SDG that also need to be addressed, resulting in a total of 55 activities explored in this study.

The main activities of the manufacturing value chain can be categorized into five dimensions: performance, product, process, people, and policy [24]. Compared with home country manufacturing companies, FDIs also face the aspect of cultural differences. Benefits or welfare are the first factors that employees compare between foreign companies and local companies [25]. To avoid the impression of being a predator, FDI companies need to communicate properly with the local community [26] to achieve the purpose of peaceful, harmonious, and common development. Thus, the issue of welfare and local communities also need to be addressed. This study uses *Enterprise performance*, *Enterprise product*, *Enterprise process*, *Enterprise human resource*, *Enterprise policy*, *Enterprise welfare*, and *Local community* as research constructs and then classify the above 55 activities under the seven constructs as shown in Appendix 1. Appendix 1 presents the seven constructs, 55 activities, and the sustainable targets these activities support. It also presents that the relationship between activity and sustainable target is not one-to-one, but that multiple-to-multiple relationships exist. For example, activity 40, *Expand the scope of medical insurance to reduce the burden of family medical expenses*, supports sustainable targets 3.4 and 3.8. Activity 47, *Improve water quality and sanitation in local community to reduce malaria incidence*, supports sustainable targets 3.3, 3.9, and 6.b. Activity 43 and activity 51 both support sustainable targets 6.2.

3.1. Analysis

This study then conducts the second survey. The questionnaire is sent to senior managers who work in the FDI manufacturing companies in Chennai that have continuously published CSR reports the past three years. Senior managers are defined as those who have worked in the company for more than eight years and hold the titles of manager, senior manager, or directors. A total of 42 responses are collected. Six responses are invalid and therefore removed from the data sample, resulting in a total of 36 valid responses being used for the AHP analysis. The 36 valid responses are provided by 23 managers, eight senior managers, and five directors. These have worked in the company for an average of 9.1 years and have had direct or indirect contact with the company's CSR on an average of 3.7 years. This means that the respondents have a certain degree of understanding of the corporate culture and CSR in the FDI manufacturing companies.

This study analyses the seven constructs of the 36 responses. The CI is equal to 0.1, which means that the seven constructs are consistent. The CR is equal to 0.07, which presents that the results are acceptable. The top three rankings are *Local community*, *Enterprise welfare*, and *Enterprise process*. The rest rankings are *Enterprise performance*, *Enterprise policy*, *Enterprise human resource*, and *Enterprise product*.

The following are the analysis of each construct: (1) *Enterprise Performance*. The CI and CR of this construct are 0.005 and 0.004, respectively. The results are thus considered consistent. The top 3 activities are *Ensure enterprise competitiveness*, *Increase salary year by year alone with productivity*, and *Improve customer satisfaction*. (2) *Enterprise Process*. The CI and CR of this construct are 0.07 and 0.05, respectively. The results are thus considered consistent. The top three activities are *Increase the proportion of renewable energy*, *Improve productivity by diversity, technology, and innovation*, and *Adopt clean and environmental-friendly technologies to improve production processes*. (3) *Enterprise Product*. The CI and CR of this construct are 0.07 and 0.05. The results are thus considered consistent. The top three activities are *Apply circular economy to product design to reduce the impact of product life cycle on environment*, *Examine the products and processes in the value chain for negative impact on ocean and land*, and *Increase number of patents for sustainable product and material*. (4) *Enterprise Human Resource*. The CI and CR of this construct are 0.03 and 0.02. The results are thus considered consistent. The top three activities are *Increase the number of young employees*, *Increase number of technicians and their skills*, and *Corporate with official school for staffs training and education degree*. (5) *Enterprise Policy*. The CI and CR of this construct are 0.03 and 0.02. The results are thus considered consistent. The top three activities are *Put sustainable development into policy*, *Conduct training of sustainability*, and *Promote sustainable development through practical projects by staff*. (6) *Enterprise Welfare*. The CI and CR of this construct are 0.09 and 0.06. The results are thus considered consistent. The top three important activities are *Increase the use of sustainable agricultural products in staff restaurants*, *Provide medical subsidies for pregnant employees*, and *Provide birth registration and medical and nutritional subsidies for employees' new-borns and children under five years old*. (7) *Local Community*. The CI and CR of this construct are 0.09 and 0.06. The results are thus considered consistent. The top three activities are *Improve*

water quality and sanitation in local community, Employ a certain proportion of residents, and Provide awards for innovation and scientific research and development in higher education.

3.2. Initial Stage

According to the analysis results of the questionnaire responses collected from senior managers, the activities under the seven constructs are calculated by the Eigenvector method, and the weights of the activities at each level are calculated and ranked. The top five activities are shown in Table 1.

Table 1. Top five activities of initial stage

Construct	S.N.	Activity	Rank	Sustainable target supported
7. Local Community	47	Improve water quality and sanitation in local community to reduce malaria incidence	1	3.3, 3.9, 6.b
7. Local Community	48	Employ a certain proportion of residents	2	4.5
7. Local Community	50	Provide awards for innovation and scientific research and development in higher education	3	4.b, 9.5
6. Enterprise Welfare	37	Increase the use of sustainable agricultural products in staff restaurants	4	2.4
3. Enterprise Product	14	Apply circular economy to product design to reduce the impact of product life cycle on environment	5	8.4, 12.2

Among the top five activities, three belong to Local community. This indicates that companies can start by improving their community relationships and the local environment. Related to Enterprise welfare, Increase the use of sustainable agricultural products in staff restaurants also directly expresses the company's actions of sustainability to employees. Many Indian FDI companies serve meals. Food fees are cheap, and the food is cleaner than roadside stands around the company where the employees usually buy their meals. At the same time, Indian vegetarians account for the majority of the population. Therefore, the simple and most direct way to educate employees regarding what sustainability is and let employees personally feel the practice of sustainability is by serving sustainable food directly to employees through company meals.

The fifth activity related to *Enterprise product* shows that company products need to also directly add sustainability. This is a further statement to employees and shareholders that the company is going to move towards sustainable manufacturing. The top four activities are related to the external environment and employee living. These activities do not yet involve the actual production process and policies that are of the major functions of manufacturing. This means that for FDI manufacturing companies, the first stage of sustainable manufacturing can be to start with communication to the community, improve employee living, and then focus on the company's products. In this way the concept of sustainable manufacturing can be introduced to all stakeholders.

To further explore the activities linked to the initial stage, the top 6-10 activities are analyzed. To officially announce a company is pursuing sustainability, it must *Put sustainable development into policy*, as this helps communicate out to all the employees how sincere the company is. Because of India's caste system, some children may not be able to complete their education. Access to clean and safe water supplies may also be an issue in certain communities. *Subsidize education for vulnerable children in local community* and *Establish public toilets in the community and supply free water and soap* are thus easy ways to enhance a company's relationship with the local community. Furthermore, the power supply in India is not as convenient or easy to access as it is in other developed countries. To reduce the impression that foreign companies plunder Indian resources, companies can *Increase the proportion of renewable energy*, which is highly supported by the government.

The medical expense of pregnant women in India is costly. It would be very helpful in the implementation of the concept of sustainability if companies help pregnant employees by providing them with company welfare plans. Welfare is not only financial support. Companies can (1) make contracts with high quality hospitals to provide periodic health checks during pregnancy, (2) organize and pay for doctors to visit the company during working hours, (3) provide postpartum leave, and (4) relocate employees to low-labor workstations.

Among the top ten activities, five activities are related to *Local community*, two are related to *Enterprise welfare*, one is related to *Enterprise product*, and the final one is related to *Enterprise process*. This indicates that sustainable manufacturing activities should be implemented by companies first related to outside factors

then to inside factors. Companies can start with activities related to the local community so that employees are introduced to the concept of sustainable manufacturing and see that this is something the company prioritizes. It can then implement activities related to enterprise welfare. In this way employees can trust that the purpose of sustainable manufacturing is not just another public relationship activity employed by the company, but a true priority. Companies can directly put sustainable manufacturing into its product design and perform official employee training. This study considers the top ten activities to be the initial stage of sustainable manufacturing that a company can start implementing, after which the company can implement the rest of the constructs in the sequence of *Enterprise performance*, *Enterprise policy*, and *Enterprise human resource*.

Linking the first ten activities to SDG, if companies implement sustainable manufacturing according to the initial stage described above, SDG 2, 3, 4, 6, 7, 8, 9, and 12 will be supported. That is to say that four SDG 4 (*Quality education*) and three SDG 3 (*Good health and well-being*) sustainable targets will be supported. Companies can publish these activities in their CSR reports to disclose them to the public and shareholders. The CSR reports can be used to explain the relationship between SDG and the sustainable manufacturing activities the companies implement. This strengthens the link of the companies' SDG support as well as makes it more transparent.

3.3. Sustainable Manufacturing System

Based on the above analysis, this study proposes a sustainable manufacturing system that is composed of seven constructs and the implementation sequence as shown in the following figure. The sequence is *Local community*, *Enterprise welfare*, *Enterprise process*, *Enterprise performance*, *Enterprise policy*, *Enterprise human resource*, and finally *Enterprise product*.

In Fig. 1, one can see there is a house surrounded by Local Community. The house represents the manufacturing company itself and is composed of the six manufacturing constructs. Sustainable manufacturing can thus be seen as not only being an internal activity within companies, but also needs to be communicated out to the external environment. The most direct external environment of the company is the local community, so the sustainable manufacturing house is surrounded by the local community. Because policies are the principles and guidelines of company activities, *Enterprise policy* is placed at the bottom as a cornerstone. *Enterprise welfare* and *Enterprise process* are two of four pillars that directly communicate with the local community. These two constructs are placed on the left and right sides of the sustainable manufacturing house. *Enterprise human resource* and *Enterprise product* are placed in the middle and are thus considered the core constructs inside the enterprise. These four pillars directly influence *Enterprise performance*.

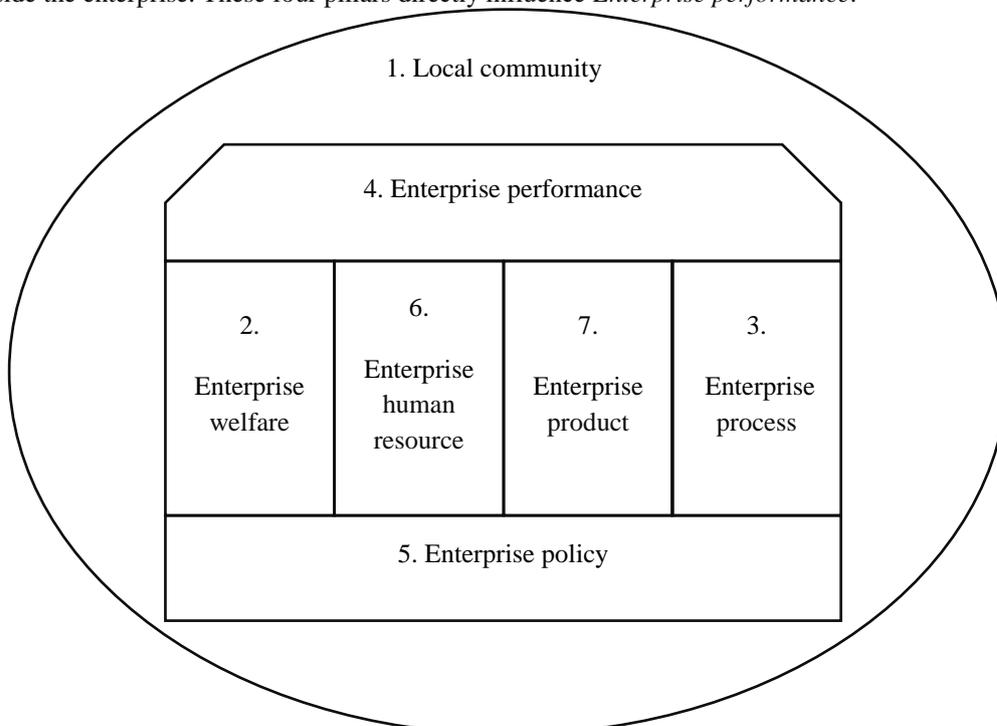


Fig. 1 Sustainable manufacturing system.

4. CONCLUSION

SDGs and sustainable targets are proposed from the perspective of the country and industry. There is a gap between the SDGs and CSR that has been carried out by the manufacturing industry for many years. This study proposes (1) a sustainable manufacturing system that is composed of seven constructs and 55 activities that support SDG 2-12 and 41 sustainable targets, (2) ten activities to be implemented in the initial stage of a sustainable manufacturing system that supports SDG 2, 3, 4, 6, 7, 8, 9, and 12, and (3) the sustainable manufacturing system needs to be implemented related to the external environment first and then internally within the company. To sum up, by implementing the sustainable manufacturing system in the sequence of *Local community*, *Enterprise welfare*, *Enterprise process*, *Enterprise performance*, *Enterprise policy*, *Enterprise human resource*, and *Enterprise product*, SDG 2-12 will be supported and the gap between the SDGs and CSR can be diminished.

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APPENDIX 1: AHP RESULTS AND SUSTAINABLE TARGETS SUPPORTED

No	S.N.	Activities	Weight within construct	Weight among all constructs	Rank	Sustainable target supported
1. Enterprise Performance (Weight: 0.120)						
1	1	Increase the recycling and utilization efficiency of both industrial and domestic water	0.14	0.02	25	6.4
2	2	Increase energy efficiency	0.16	0.02	21	7.3
3	3	Increase salary year by year along with productivity and GDP improvement	0.19	0.02	14	8.1
4	4	Ensure enterprise competitiveness	0.20	0.02	11	NA
5	5	Improve customer satisfaction	0.17	0.02	18	NA
6	6	Treat suppliers fairly	0.14	0.02	26	NA
2. Enterprise Process (Weight: 0.128)						
1	7	Increase the proportion of renewable energy	0.23	0.03	8	7.2
2	8	Improve productivity through diversity, technology, and innovation	0.18	0.02	12	8.2
3	9	Adopt clean and environmentally friendly technologies to improve production processes	0.15	0.02	20	9.4
4	10	Reduce production and emission of carbon dioxide and other gases that have a negative impact on the environment	0.14	0.02	23	11.6
5	11	Promote environmentally sound management of chemicals and wastes to reduce the negative impact on human health and the environment	0.12	0.02	31	12.4
6	12	Reduce production waste through prevention, emission reduction, and recycling	0.10	0.01	40	12.5
7	13	Apply digital technology to improve the efficiency of end-to-end processes	0.08	0.01	48	NA
3. Enterprise Product (Weight: 0.117)						
1	14	Apply circular economy to product design to reduce the impact of product life cycles on the environment	0.258	0.03	5	8.4, 12.2
2	15	Increase number of sustainable product and material patents	0.186	0.02	17	9.5
3	16	Examine products and processes in the value chain for negative impacts on ocean and land	0.190	0.02	15	11.4

No	S.N.	Activities	Weight within construct	Weight among all constructs	Rank	Sustainable target supported
4	17	Increase proportion of sustainable materials in product development	0.155	0.02	22	12.2
5	18	Develop competitive products	0.119	0.01	36	NA
6	19	Develop products with lower energy consumption and longer service life	0.092	0.01	46	NA
4. Enterprise Human Resource (Weight: 0.118)						
1	20	Cooperate with official schools for staff training and education degrees	0.067	0.01	53	4.3
2	21	Help staff receive technical training and certificates	0.078	0.01	51	4.4
3	22	Provide same education to men and women	0.080	0.01	49	4.5
4	23	Improve literacy and calculating ability of employees	0.076	0.01	52	4.6
5	24	Increase proportion of females in management	0.093	0.01	44	5.5
6	25	Increase application of information and communications technology and the technical skills of female employees	0.101	0.01	42	5.b
7	26	Offer equal pay for equal work	0.113	0.01	39	8.5
8	27	Increase hiring proportion of those with disabilities	0.123	0.01	34	8.5
9	28	Increase number of young employees	0.140	0.02	29	8.b
10	29	Increase number of technicians and their skills	0.128	0.02	32	9.5
5. Enterprise Policy (Weight: 0.119)						
1	30	Put sustainable development into policy	0.248	0.03	6	4.7
2	31	Conduct sustainability training	0.191	0.02	13	4.7
3	32	Promote sustainable development through practical projects by staff	0.142	0.02	27	4.7
4	33	Employ incentives to encourage employees to carry out sustainable development activities	0.115	0.01	38	4.7
5	34	Treat different religious beliefs fairly	0.124	0.01	33	10.2
6	35	Publish sustainable development reports periodically	0.094	0.01	43	12.6
7	36	Communicate enterprise sustainability practices to the local community and society so that the public can understand the sustainability contribution of the enterprise	0.087	0.01	47	12.6
6. Enterprise Welfare (Weight: 0.150)						
1	37	Increase use of sustainable agricultural products in staff restaurants	0.205	0.03	4	2.4
2	38	Provide medical subsidies to pregnant employees	0.161	0.02	10	3.1
3	39	Provide birth registration and medical and nutritional subsidies to employees with newborns and children under five years old	0.119	0.02	24	3.2, 16.9
4	40	Expand scope of medical insurance to reduce the burden of family medical expenses	0.111	0.02	28	3.4, 3.8
5	41	Provided transportation as a commuting option	0.093	0.01	37	3.6
6	42	Subsidize employees so their children can complete preschool, primary, and secondary education	0.083	0.01	41	4.1, 4.2

No	S.N.	Activities	Weight within construct	Weight among all constructs	Rank	Sustainable target supported
7	43	Provide indoor toilets with free soap and water for all employees	0.073	0.01	45	6.2
8	44	Create a safe working environment	0.062	0.01	50	8.8
9	45	Offer sustainable tourism to employees to promote local culture	0.053	0.01	54	8.9
10	46	Deposit salaries into bank accounts, not cash-in-hand	0.041	0.01	55	8.10
7. Local Community (Weight: 0.247)						
1	47	Improve water quality and sanitation in the local community to reduce malaria incidences	0.197	0.05	1	3.3, 3.9, 6.b
2	48	Employ a certain proportion of residents	0.166	0.04	2	4.5
3	49	Subsidize education for vulnerable children in the local community	0.118	0.03	7	4.5
4	50	Provide awards for innovation and scientific research and development in higher education	0.127	0.03	3	4.b, 9.5
5	51	Establish public toilets in the community and supply free water and soap	0.101	0.02	9	6.2
6	52	Prioritize water safety, not only meet the local government standards but require zero environment pollution	0.089	0.02	16	6.3
7	53	Adjust working days to match religious activities	0.079	0.02	19	10.2
8	54	Increase proportion of local research and development and technical personnel	0.066	0.02	30	12.a
9	55	Connect enterprises regularly to share knowledge and technology for mutual growth	0.057	0.01	35	12.a