Chapter 15
The Importance of Software Sustainability in the CSR of Software Companies

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Abstract Organizations around the world, as well as their stakeholders, are becoming increasingly aware of the need for, and the benefits of, socially responsible behavior, and sustainability is a core aspect of this. Given the presence of software systems in most companies and almost every aspect of modern-day life, the promotion of the environmental aspects of software systems is a key factor in sustainable development, and any company aspiring to be considered as a first-class corporate citizen should provide for it in their CSR.

This chapter aims to ascertain how well the policies of companies that develop software are aligned with Software Sustainability, as well as to give recommendations on including specific actions in their CSR to promote Software Sustainability.

The CSR policies of the ten biggest software companies have been studied, identifying a list of actions that the software industry should include in their CSR. In order to do this, different meetings were held among researchers. As a result, a list of actions specific to Software Sustainability that the software industry should be including in their CSR has been proposed. Moreover, we have analyzed the CSR of a Spanish software company, obtaining that the percentage of coverage in respect of the actions defined is 40%. The dimension with more actions is the human dimension, where the percentage of coverage is above 90%. Regarding the economic and environmental dimensions, the company took into consideration 36% and 13% of the actions, respectively. These resulted in a D level of Software Sustainability (possible values: A–E). Based on these results, we have suggested some actions to be implemented in order to improve the industry's Software Sustainability level.

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15.1 Introduction

Organizations around the world, as well as their stakeholders, are becoming increasingly aware of the need for, and the benefits of, socially responsible behavior, and sustainability is a core aspect of it. Indeed, sustainability has increasingly become more important to businesses and must be tackled if we are to successfully develop sustainable societies [1]. By means of sustainable development, the needs of the present are fulfilled without compromising the ability of future generations to meet their own needs [2]. To achieve this aim, sustainable development must satisfy the requirements of three dimensions: society, the economy, and the environment [3]. A business that fails to include sustainable development as one of its top priorities could receive considerable public criticism and subsequently lose market legitimacy [4]. Therefore, sustainable business models (SBMs) are not just a passing fancy but are a field in their own right [5], and commercial organizations have begun to redesign their business models on the basis of sustainability, treating sustainable development as a new source of innovation, a new opportunity to cut costs, and a new mechanism for gaining competitive advantages [4]. All of this can be brought together under the umbrella concept of "strategic sustainability" [6]. When pursuing strategic sustainability, technology is doubly important, as noted by [4]: on one hand, because it helps organizations to tackle environmental issues (using web conferences, repositories, and so on) and, on the other, because technology itself is often responsible for major environmental degradation (e.g., due to the amounts of energy consumed by the engineering processes used to manufacture products). This mixed role that technology plays places organizations under tremendously conflicting types of pressure. Internally, they are under pressure to transform existing engineering processes into ones that are more environmentally friendly, while externally they are expected to design new products that improve the sustainability of society at large.

While sustainability is a standardized practice in several engineering disciplines, there is currently no such awareness within the software engineering community, as stated in [7]. It is of fundamental importance that such awareness be promoted in the software industry by championing "sustainable software"—that is, software whose direct and indirect negative impact resulting from its development, deployment, and usage is either minimal or has a positive effect on sustainable development with respect to the economy, society, humanity, and the environment [8]. But going a step further, the whole software development process could be supported, with sustainable software engineering being defined as "the art of defining and developing software products in such a way that the negative and positive impacts on sustainability that result from and/or are expected to result from the software product over its whole life cycle are continuously assessed, documented, and optimized" [9]. There are several areas in which software sustainability needs to be applied: software systems, software products, web applications, data centers, etc.

We therefore consider it to be of prime importance to find out the impact of software sustainability in (1) the companies that develop software, (2) those who buy

it, and (3) the people who use it. From an organizational perspective, an essential reference document for analyzing how software sustainability is tackled is the corporate social responsibility (CSR) document. The objective of social responsibility is to contribute to sustainable development [2], and organizations are now subject to greater scrutiny by their various stakeholders than ever before. CSR has to "meet the needs of a firm's direct and indirect stakeholders (such as shareholders, employees, clients, pressure groups, communities, etc.) without compromising its ability to meet the needs of future stakeholders as well" [10]. Indeed, this much is stated by Friedman [11]:

> people today expect (and demand) more of business than simply that they maximize their profits without coming to grief by some violation of law. Consumers want and expect attributes from what they buy—quality, safety, value. Employees want more than a paycheck. Communities want the company to be a good corporate citizen and hire from the community, provide employees with a living wage, not pollute and to pay its fair share of taxes and support the community.

Therefore, the perception and reality of an organization's performance as regards social responsibility can influence, among other things, its competitive advantage, its reputation, and its ability to attract and retain workers or members, customers, clients, or users; it may also have an impact on the maintenance of employees' morale, commitment, and productivity and affect the view of investors, owners, donors, sponsors, and the financial community as well as the organization's relationship with companies, governments, the media, suppliers, peers, customers, and the community in which it operates. According to the results of the study by [12], disseminating companies' CSR results in improved brand value, and publishing complete sustainability reports comes over as a matter of importance for companies. Nave and Ferreira state that sustainability emerges as an increasing concern for those companies which have focused on reducing the impact that their activities have on the environment, while also implementing activities with social and economic dimensions [13]. As a consequence, some related works deal with the management of corporate sustainability in CSR, such as the theoretical model put forward by Butler [14] which deals with integrating Green IS (information systems) into the normal operations of a company, aligning these Green IS with the firm's CSR. Another example is the paper by Baumgartner [1], which proposes a framework for corporate sustainability management that sets out the different tasks and action levels for the transition of a company toward becoming "sustainable."

In summary, given the presence of software systems in most industries and in almost every aspect of current-day life, the promotion of the environmental aspects of software systems is a key factor in sustainable development, and any company aspiring to be regarded as a first-class corporate citizen should provide for it in their CSR. This chapter aims to ascertain how well the policies of companies that develop software are aligned with software sustainability, as well as to give recommendations on including specific actions in their CSR to promote software sustainability. In our quest to fulfill this goal, we will study the CSR policies of the ten biggest software companies, identifying a list of actions that the software industry should

include into their CSR. Finally, we have analyzed the CSR of a specific software company and have suggested some actions to improve it.

The remainder of this chapter is organized as follows: the next section will present the software companies selected for our study, along with an analysis of their respective CSR documents. Section 15.3 will show the specific sustainability actions for the software industry and its companies to take, together with indicators to select the ones most suitable for a given company. Section 15.4 presents the improvements we recommend for the CSR of a Spanish company we investigated, and finally, Sect. 15.5 will set out our conclusions and outline future work.

15.2 Overview of the CSR in Software Industries

15.2.1 Software Companies: A Representative Selection

To find out if, and to what degree, software companies are concerned about the environmental aspects of the sustainability of the software they develop, we analyzed the CSR of several leading software companies. These were chosen based upon the list of the top companies suggested in [6, 15]:

1. Apple
2. Microsoft
3. IBM
4. Oracle
5. SAP
6. Symantec Corp
7. EMC
8. Hewlett-Packard
9. VMware
10. CA Technologies

Next, we studied their CSR statements in depth from the point of view of software sustainability.

15.2.2 Analyzing the CSR Software Sustainability Actions in Software Companies: Work Method

To analyze the degree of awareness on the part of the selected companies as regards the role of software sustainability in their CSR policies, we followed a specifically defined method. The review was carried out by examining the sustainability actions of each respective company, as included in the CSR information available on their corporate websites.

The template we built in order to collect from the companies' CSRs data about their actions on software sustainability includes the following sections:

- Category, which includes the general categories used to group together related actions, such as "People," "Planet," etc.
- Subcategory, to cover specific categories for the actions, for example, "Empowering communities" or "Empowering employees," which fall under the general category "People."
- Action, which covers the specific actions carried out in the context of the CSR, for example, the action "Employee feedback counts," which allows workers to participate in anonymous polls that serve to improve their work conditions. Special care was taken to fill in the specific actions of all the companies and to guarantee that each action included had a similar granularity level to the others, thereby avoiding any validity threats to the comparative study.
- Sustainability dimension, used to classify a given action according to the particular dimension or dimensions in which it is applicable. The dimensions are environmental, human, and economic. It should be noted that the environmental dimension can in turn be divided into Green Software and Green Hardware (this latter subdimension is out of our scope).

Having prepared the template and the inclusion and exclusion criteria, the research method was defined and agreed on by all researchers. In the first step, each researcher (the four authors of this chapter) was responsible for filling in the templates of two to three companies. To do so, the weblink to the CSR of each company, the empty template, and the inclusion and exclusion criteria were used. The output of this step was a first set of completed templates (one per company).

Then, in the second step, each researcher reviewed the templates that had been filled in by the other researchers, with the aim of ensuring that all the relevant information was included and classified appropriately into categories, subcategories, actions, and dimensions. The inputs for this step were the links to the CSRs of the companies, the inclusion and exclusion criteria, and the completed templates. The output was four sets of completed and reviewed templates.

The following step consisted of a meeting to discuss the differences identified between the four reviewed templates for each company, and to resolve any discrepancies. There were no actions which did not obtain the full consensus of the participating researchers. The input for this step consisted of the CSR links of each company, the completed and reviewed templates, and the inclusion and exclusion criteria. The output was a list of agreed-on software-related sustainability actions, taken from the verbatim CSR statements of each company.

Finally, and considering those sustainability actions, the researchers met to propose a list of actions that could be valuable for software companies from the point of view of sustainability. In addition, researchers evaluated every action in the final list to provide (1) the *added value* that the inclusion of this action could provide to the company and (2) an approximate *complexity level* that the implementation of the action in the company would require. Section 15.3 presents the outcome of the process described above.

15.2.3 Analyzing the Companies' CSR from the Point of View of Software Sustainability

As previously mentioned, the first step was the classification of the actions, more information of which can be found in [16]. The next step was to analyze the corporate social responsibility document of each selected company, with a view to determining whether software sustainability aspects had been taken into account. In the following subsections, we will present the results obtained from a top-down perspective, as illustrated in Fig. 15.1.

15.2.3.1 Analysis of Software Sustainability Actions

In this analysis a comparison was carried out between the software sustainability actions and other actions of the company. As can be observed in Fig. 15.2, the majority of the actions are intended to address aspects not related to sustainability. We see this as a clear demonstration of the relatively low importance that the companies give to the issue of software sustainability.

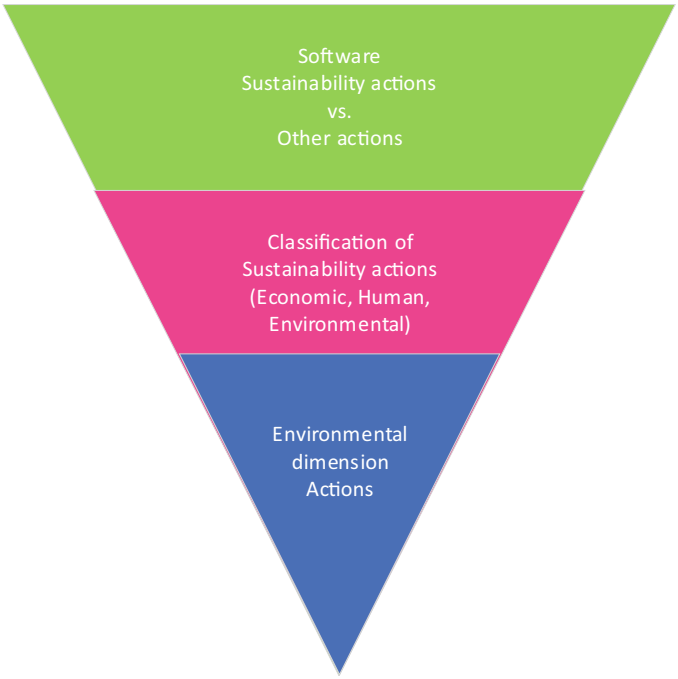


Fig. 15.1 Levels of analysis carried out

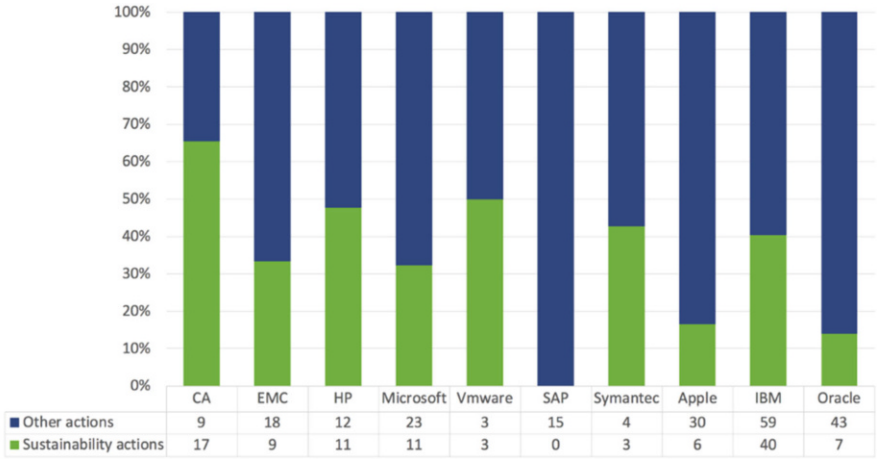


Fig. 15.2 Comparison between sustainability-oriented actions and other kinds of actions

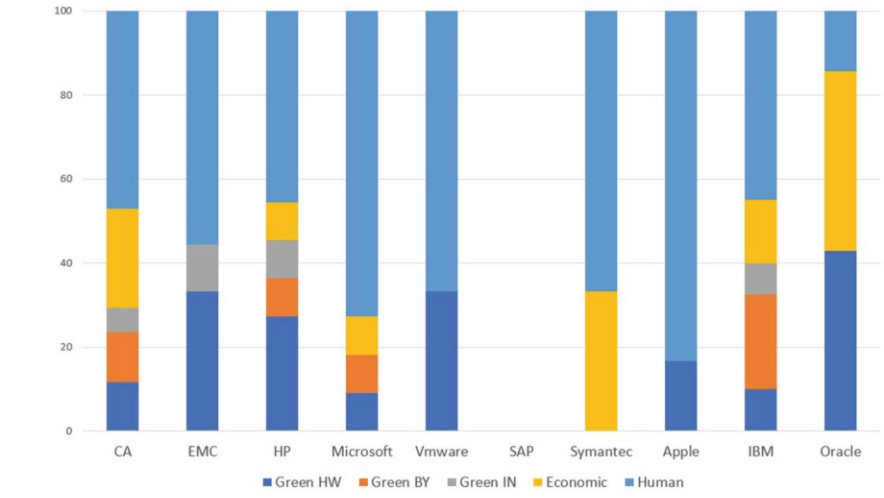
Table 15.1 Percentage of activities devoted to the different dimensions of sustainability per company

Company	Human	Economic	Environmental
CA	14.81%	25.00%	13.51%
EMC	9.26%	0.00%	10.81%
HP	9.26%	6.25%	13.51%
Microsoft	14.81%	6.25%	5.41%
VMware	3.70%	0.00%	2.70%
Symantec Corp	3.70%	6.25%	0.00%
Apple	9.26%	0.00%	2.70%
IBM	33.33%	37.50%	43.24%
Oracle	1.85%	18.75%	8.11%

15.2.3.2 Analysis of Software Sustainability Actions

Software sustainability actions can be related variously to the human, economic, and environmental dimensions of the company's actions.

To give a more detailed breakdown of each of those activities listed in the CSR documents of the different companies that are oriented toward software sustainability, we classified them into three dimensions: human, economic, and environmental. Table 15.1 presents a view of the relative effort each company makes, with respect to the others, as regards these software sustainability dimensions. For each dimension, the percentage figure of each company has been calculated as a mean between the number of actions of the company and the total number of actions proposed by all companies in that dimension. Table 15.1 thereby attempts to represent the relative importance given by each company to each software sustainability dimension, according to the number of actions proposed by them. It should be noted that, although the CSR documents of all ten companies were analyzed, Table 15.1 shows only those companies with software sustainability actions.



	CA	EMC	HP	Microsoft	Vmware	SAP	Symantec	Apple	IBM	Oracle
Green HW	2	3	3	1	1	0	0	1	4	3
Green BY	2	0	1	1	0	0	0	0	9	0
Green IN	1	1	1	0	0	0	0	0	3	0
Economic	4	0	1	1	0	0	1	0	6	3
Human	8	5	5	8	2	0	2	5	18	1

Fig. 15.3 Distribution of the activities of the CSR per company

As already mentioned, we have classified the environmental dimension actions as Green Hardware (GH) and Green Software—divided further between Green-IN Software (GI) and Green-BY Software (GB). The distribution of the software sustainability actions is depicted in graph form in Fig. 15.3.

From the previous analysis of each of the software sustainability dimensions, we can conclude that two companies are more aware of software sustainability than the others: IBM and CA.

We can thus conclude that, from the perspective of software sustainability actions, IBM and CA are the most balanced and are the companies that propose the most actions. The rest of the firms display different behavior but, in general, have most of their actions classified into only one of the dimensions, with a few actions in the other two.

15.2.3.3 Environmental Dimension Actions

Focusing our analysis on the environmental dimension, Tables 15.2, 15.3, and 15.4 present a more detailed view of the actions for both categories in this dimension, particularly as regards Green Software and Green Hardware.

Table 15.2 shows the percentage of activities based on Green Software, demonstrating the percentage of actions in each company as compared to the number of actions proposed by all companies. At first sight the table reveals something that is

Table 15.2 Percentage of environmental (software-related) activities in each company's CSR

Company	Green software
CA	15.79%
EMC	5.26%
HP	10.53%
Microsoft	5.26%
VMware	0.00%
SAP	0.00%
Symantec Corp	0.00%
Apple	0.00%
IBM	63.16%
Oracle	0.00%

Table 15.3 Percentage of environmental (Green-IN and Green-BY) activities in each company's CSR

Company	Green-IN	Green-BY
CA	16.67%	15.38%
EMC	16.67%	0.00%
HP	16.67%	7.69%
Microsoft	0.00%	7.69%
VMware	0.00%	0.00%
SAP	0.00%	0.00%
Symantec Corp	0.00%	0.00%
Apple	0.00%	0.00%
IBM	50.00%	69.23%
Oracle	0.00%	0.00%

Table 15.4 Percentage of environmental (hardware) activities in each company's CSR

Company	Green hardware
CA	11.11%
EMC	16.67%
HP	16.67%
Microsoft	5.56%
VMware	5.56%
SAP	0.00%
Symantec Corp	0.00%
Apple	5.56%
IBM	22.22%
Oracle	16.67%

highly significant: while only five companies implement actions that are categorized as Green Software, the same number of companies is unaware of the importance of providing such type of actions. A more detailed view of the results of this table may be observed in Table 15.3: this presents a fine-grained view of Green Software, which is made up of Green-IN and Green-BY actions.

These results are in sharp contrast to the actions belonging to the category of Green Hardware (Table 15.4), where eight companies propose actions. It is also

Table 15.5 Percentage of software (Green-IN and Green-BY) and hardware efforts for each company

	Green-IN	Green-BY	GREEN HW
CA	20.00%	40.00%	40.00%
EMC	25.00%	0.00%	75.00%
HP	20.00%	20.00%	60.00%
Microsoft	0.00%	50.00%	50.00%
VMware	0.00%	0.00%	100.00%
Apple	0.00%	0.00%	100.00%
IBM	18.75%	56.25%	25.00%
Oracle	0.00%	0.00%	100.00%

striking that with respect to the Green Hardware category, all the percentages are somewhat more balanced than those in the Green Software category. This remarkable finding stems from the fact that in current IT infrastructures, hardware resources have been the focus of continuous optimizations, in a quest to save energy and reduce their carbon footprint.

From both analyses we can determine that the conclusion reached by Calero and Piattini [17] from their research on software sustainability can be applied also to the software industry in general: i.e., that there is more awareness of the need for Green Hardware than for Green Software.

To conclude our analysis, Table 15.5 presents a comparison between the percentages of actions (categorized into Green-IN, Green-BY, and Green Hardware) for the eight companies whose CSR documents include actions in the environmental dimension. These data are especially useful to show the extent and distribution of the efforts of the different companies in these three categories.

As far as the companies listed in Table 15.5 are concerned, only four of them propose actions for Green-BY Software and another four propose actions for Green-IN Software; the percentage is very low. All the companies shown present actions for Green Hardware, allowing us to confirm our prior observation that the element to which companies give more importance is Green Hardware, rather than Green Software.

Finally, the actions of Green-IN represent the lowest percentages. This may be due to a lack of knowledge about the impact of software on the environment, but it may also be due to a lack of actions to reduce this impact.

15.3 Specific Actions for Software Industries

Based upon our analysis of the actions of these leading software companies' CSRs, a set of actions has been chosen that we believe are particularly interesting for software companies, from the point of view of sustainability.

In Tables 15.6, 15.7, and 15.8, these actions are shown, grouped together according to the sustainability dimension to which they belong. In each table the following information is included:

Table 15.6 Actions proposed to improve the human dimension

ID	Action	Added value (1–3)	Complexity (1–3)
	Employees must be encouraged to be successful in their jobs and to be innovative. To this end:		
H1	Employees must be supported to improve their skills and acquire the ability to work in a different, innovative, and open-minded way	1	1
H2	Employees must be encouraged to propose and implement solutions that are innovative	2	1
H3	At the organizational level, a culture will be fostered that facilitates employees and partners providing the necessary feedback for the transformation of both the processes and the business itself	3	2
	Ethics and rights:		
H4	(a) Create a work environment that respects the personal circumstances of each employee and allows them to manage their work responsibilities, reconciling these with their personal lives. (b) Provide our employees with principles, guidelines, directives, and tools that enable them to effectively manage their work	2	2
H5	Nondiscriminatory policies will be included to make the company a safe place to work	2	2
H6	An open work environment characterized by trust, mutual respect, and empathy is created, promoting leadership guided by ethics and integrity	2	2
H7	Human rights, including the right to privacy and freedom of expression, must be respected and upheld	3	2
H8	A good relationship between all company personnel should be encouraged and good communication between organizational levels should be promoted	2	1
	Women and technology:		
H9	The company must be committed to the professional advancement of its employees and encourage their access to leadership positions within the company	3	2
	Development of training programs for the acquisition of knowledge and skills:		
H10	The company must offer training programs to improve the skills and abilities of its employees, fostering a positive culture for both the employee and the organization	2	2
	Protecting people by:		
H11	Setting standards that are rigorous to protect employees and the planet during the software development process	3	3
H12	Rigorous standards should be established to make the organization's facilities safe	3	3
H13	Occupational risk review, assessment, and awareness programs, covering both the physical and mental health of employees, should be implemented to ensure the health and well-being of employees	3	3

Table 15.7 Actions proposed to improve the economic dimension

ID	Action	Added value (1–3)	Complexity (1–3)
E1	Sustainability must be part of the organization's business model	3	3
E2	Employees should preferably use video conferencing or similar technologies in their communications, travelling only when essential	1	1
E3	Policies that support software business continuity should be encouraged	3	3
E4	The use of energy-efficient technologies should be considered within the business model	3	3
E5	The security and privacy of business and customer data must be ensured to avoid excessive costs due to threats to data	2	1
E6	Customers must be provided with secure solutions with full connectivity and availability	3	2
E7	GDPR (or current country-specific legislation) must be implemented in all the organization's contracts to ensure compliance	3	3
E8	A policy must be defined to manage potential operational, legislative, and financial risks affecting business continuity, and technological support must be provided to carry out this management	3	2
E9	Customers must be provided with IT solutions that optimize resources, minimizing both unnecessary expenses and energy	3	3
E10	It is necessary to analyze and monitor compliance with the economic forecasts of software projects, identifying the reasons for deviations and applying actions to correct them, where necessary	2	2
E11	It is necessary to carry out the digital transformation of the company, using software solutions that support the business model by providing the necessary levels of security	3	3

- Action: Short description of the action.
- Added Value: Effort required to be implemented in the company and the value provided. To facilitate understanding of what is meant by "value" and "effort," a scale has been adopted where "1" is the lowest (easiest and least valuable, respectively) and "3" is the highest (more complex and more valuable, respectively).
- Complexity: Indicates how difficult it is to implement the action.

15.4 Analyzing and Improving the CSR of a Specific Company

Having defined the actions specific to software sustainability that the software industry should be including in their CSR, we now turn to analyze the CSR of a specific medium-sized company in Spain. It is a consulting company which is

Table 15.8 Actions proposed to improve the environmental dimension

ID	Action	Added value (1–3)	Complexity (1–3)
M1	Wherever possible, the resources needed for software development will be reduced and reused	2	2
M2	It is necessary to reduce the KW/h required by each software functionality	3	3
M3	Mechanisms should be defined to qualify software products with respect to energy-saving criteria	3	1
M4	Energy efficiency of software products must be defined and implemented as a corporate objective	3	3
M5	Regular monitoring is needed, through a process of accurate and rigorous collection of software energy consumption in all facilities	2	1
M6	Unnecessary energy expenditure should be avoided by using shared infrastructures for software development and execution	1	1
M7	The environmental footprint of software companies' DPCs must be reduced by using the state-of-the-art energy efficiency and cooling technologies	2	1
M8	Operations associated with software development must be persuaded to use efficient technologies (cloud computing, service virtualization, parallelization, SaaS, infrastructure, etc.)	2	2
M9	Software solutions for energy saving should be used in all company facilities	1	1
M10	Any software features that promote sustainability throughout its life cycle should be evaluated and improved	3	2
M11	The use of reporting systems for the sustainability management of software products is recommended	1	1
M12	Environmental aspects (energy efficiency, sustainability, etc.) should be incorporated into all stages of the life cycle prior to the operation of the software	3	2
	Regarding the process:		
M13	It is necessary to develop and keep the process assets needed for software development updated	2	2
	Regarding the requirements:		
M14	The environmental sustainability requirements (green requirements) of the software must be selected, analyzed, specified, validated, and managed throughout its life cycle	2	1
	Regarding design:		
M15	Green software requirements must be analyzed to obtain an internal description of the software structure that serves as a basis for its construction	3	2
M16	Solutions that promote green software must be provided when defining its architecture (organization into components and their relationships)	3	2

(continued)

Table 15.8 (continued)

ID	Action	Added value (1–3)	Complexity (1–3)
M17	Design decisions must be analyzed and any consequent corrective actions that impact on the green requirements must be carried out	3	2
M18	Design constraints related to green software must be managed and supported	2	1
	Regarding construction of the software:		
M19	Functional software must be created to meet green requirements through a combination of coding, verification, unit testing, integration testing, and debugging	2	1
M20	Construction approaches and technologies that support green requirements must be selected	3	2
	Regarding testing:		
M21	The software must be dynamically verified to meet green requirements through a finite set of test cases, appropriately selected	2	1
M22	Problems with any green requirements identified during testing should be verified as being satisfactorily resolved	2	1
	Regarding maintenance:		
M23	Software maintenance must be performed to ensure compliance with green requirements	1	2

specialized in Oracle technology and which carries out different types of projects ranging from digital transformation to business analytics, data management to security. Although the company has several locations throughout Spain, it is not normal practice for its developers to relocate among these various locations. One of the hallmarks of this company is a concern for the quality of life of its workers (from the perspective of the work environment).

The company's CSR is based on three basic foundations: the company, the people, and the planet. Integrated in their CSR, they have a specific program which addresses four fundamental topics, seen as being complementary to the day-to-day work of their employees: personal well-being, solidarity, teamwork, and ecological focus. This program is derived from the philosophy and the way of living of the people who are part of the company. With regard to their ideal of solidarity, it should be noted that the company collaborates with different associations and holds events to support them. As regards well-being they propose, for example, that employees have at least one healthy breakfast per month (fruit) or that they engage in a "wellness month." This activity consists in adopting healthy lifestyle habits, in four areas (physical, mental, spiritual, and emotional). To foster teamwork, they organize different recreational activities outside of the working day. In this way the employees get to know each other better and can connect on a personal level and not only professionally. Regarding their ecological focus, the company's objective is to contribute to the improvement of our environment. As part of their campaigns to

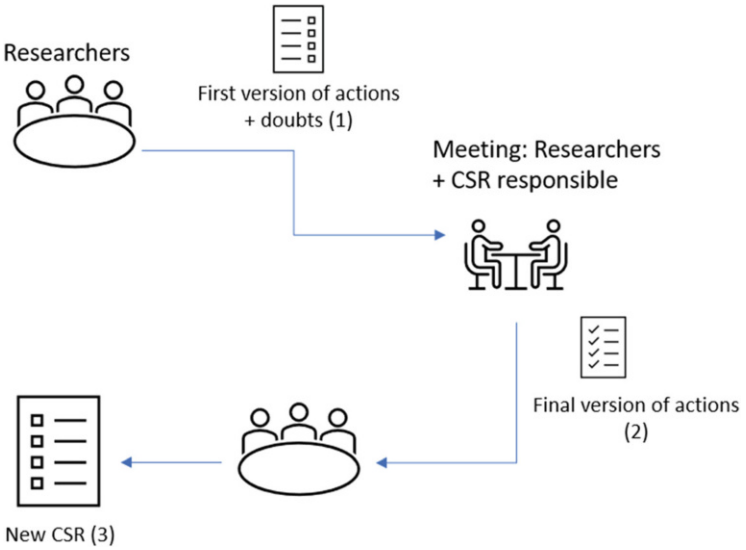


Fig. 15.4 Process to analyze and improve the CSR of the company

raise employees' awareness of the environmental importance and impact of their actions, last year, they, for example, removed all plastic cups and cutlery and replaced them with glass cups and wooden cutlery. The company has achieved the certification of the *HappyIndex AtWork*, which is based on the evaluations given by the employees and which recognizes them as a company in which the workforce feels happy and motivated. Lastly, we can add that they have drawn up their own code of ethics which is based on the principles of honesty, integrity, and respect.

With these special characteristics of the company in mind, we decided to analyze their CSR. Their concern for their employees and their well-being, for the planet, and so on was clear, but would they have also considered aspects related to software sustainability within the CSR?

The process presented in Fig. 15.4 explains the different steps which were carried out. Firstly, the researchers analyzed different documents which were provided by the company: specifically the CSR, the code of ethics, a special program to translate some general actions of the CSR into concrete actions, and a final report. With the aim of selecting the list of actions to be proposed to the company, we compared these documents with our list of proposed actions based on software sustainability (see Tables 15.6, 15.7, and 15.8). As a result, a set of actions was selected—Step 1 in Fig. 15.4. However, since the actions of the CSR are general in nature, the researchers had doubts as to some of these actions (i.e., they were not sure whether these actions were to be taken into account or not). To clear up these doubts, a meeting was held among researchers and the company in question, as a result of which the final set of actions that would be proposed to the company was obtained—Step 2 in Fig. 15.4.

In Table 15.9, the final list of included actions is shown.

Table 15.9 Actions included in the CSR

Dimension		
Economic	Human	Environmental
E2	H1	M1
E5	H2	M6
E7	H3	M8
E11	H4	
	H5	
	H6	
	H7	
	H8	
	H9	
	H11	
	H12	
	H13	

Once the actions were identified, a study of the coverage was made. In Fig. 15.5, the percentage of coverage in respect to the actions defined by us is shown. As can be seen, some 40% of the actions have been considered: a value which, although good as a starting point, can be improved.

Taking into account the total number of actions that we had defined for each dimension, we obtained the following coverage graphic (see Fig. 15.6). As can be noted, the dimension with more actions is the human dimension, where the percentage of coverage is above 90%. In the economic dimension, the company took into consideration 36% of the actions. The worst result is in the environmental dimension, in which only 13% of the actions were considered.

What stands out from these investigations is that, despite their avowed concern for environmental issues, the company's percentage of coverage in the environmental dimension is very low. Consequently, special attention was paid to this problem, and interviews were carried out with the aim of detecting whether there had been any misunderstanding. We concluded, however, that although the company is aware of the impact that their daily actions have on the environment, such as the use of

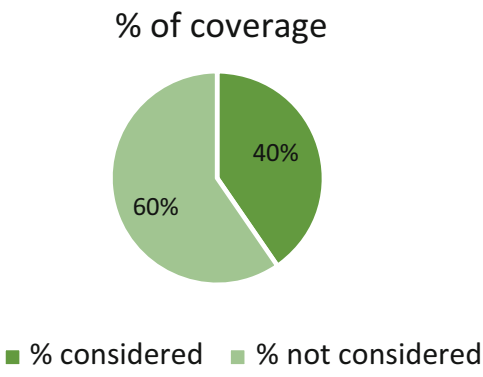


Fig. 15.5 Percentage of coverage considering the total number of actions

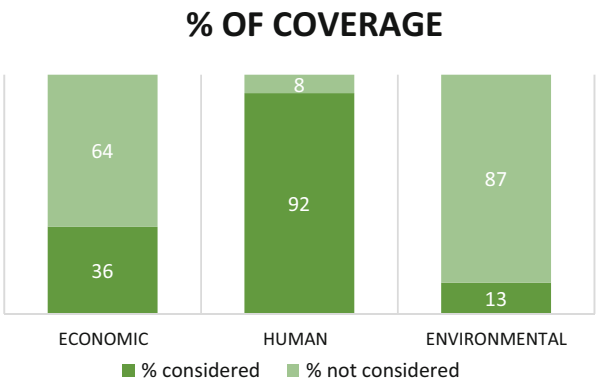


Fig. 15.6 Percentage of coverage for each dimension

Table 15.10 Label according to the % of coverage

% of coverage	Label for the dimension
81–100	A
61–80	B
41–60	C
21–40	D
0–20	E

plastics, not having the refrigerator open for a long time, etc., they had not considered the damaging impact of software on the environment, and this in spite of the fact that their work is focused on software development.

In addition, we have defined a label system that assigns to each company a value ranging from A to E. This value is assigned depending on the level achieved on each dimension, according to the percentage of coverage shown in Table 15.10. In order to assess it, first off, it is necessary to determine the label of each dimension according to Table 15.10.

In order to assess the final software sustainability level, the labels are converted into numbers (the correspondences are shown in Table 15.11), and the software sustainability level (SS) can be calculated following the next formula:

$$\begin{aligned} \mathrm{S\,S} = (&\%\mathrm{ofcoverageEconomic} + \%\mathrm{ofcoverageHuman} \\ &+ \%\mathrm{ofcoverageEnvironmental})/3 \end{aligned} \tag{15.1}$$

And, finally, we calculate the Software Sustainability label using the information in Table 15.10.

Bearing all this in mind, the analyzed company has the values shown in Table 15.11, concluding that its software sustainability level is C.

With the aim of improving the software sustainability level of the company, a list of actions to be included for the next version of the CSR was suggested by the researchers to the company—see Step 3 in Fig. 15.1. The criteria for the selection of these actions were twofold. The first is the difficulty of applying the action, and the

Table 15.11 Labels for the company

Dimension	Label
Economic dimension	D
Human dimension	A
Environmental dimension	E
Software sustainability	C

Table 15.12 Recommended actions to be included

Dimension		
Economic	Human	Environmental
E6	H10	M3
E8		M5
E10		M7
		M9
		M14
		M18
		M19
		M21
		M22

second is the benefit that the company could obtain from implementing the action (as shown in the two right-hand columns in each of Tables 15.6, 15.7, and 15.8). The list of the actions finally chosen is shown in Table 15.12.

As a future work, the company should include these actions into their CSR. Once some or all of them are included, a new analysis should be done to determine whether their software sustainability level has improved or not.

15.5 Conclusions and Future Work

It is essential that companies consider certain basic aspects of software sustainability within their CSR. We have carried out an initial analysis of the CSRs of leading software-related companies with the aims of (1) analyzing whether they take software sustainability into account and (2) determining an initial set of actions that should be included in future versions of their CSRs.

Subsequently, we have applied this process to a Spanish company which collaborated with us so that we could check the degree of coverage of the proposed actions and recommend subsequent improvements to its CSR, based on the analysis carried out. The new version of the CSR will need to be further revised and refined to include more actions in a gradual way.

As to future work, we want to extend the study with more companies so as to refine and complete the proposed actions, as well as to corroborate their applicability.

The results of this work are not static, but rather require an annual review in order to ensure that the vision of actions toward sustainability is both realistic and reflects how this issue evolves over time.

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