

Sustainability Indicators in The Construction of a Triple Bottom Line Kindergarten Building

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Abstract

The focus of sustainability in the construction sector has typically been on the study of environmental impacts. Considering that sustainability involves a triple bottom line and is based not only on an environmental perspective but also on providing economic and social benefits to stakeholders, the approach based mainly on ensuring the lowest environmental impact should be complemented by introducing socio-economic factors. In this work, the construction process of a nursery school has been analysed in detail and the sustainability has been evaluated using a triple dimensional approach, where environmental, economic and social indicators have been considered simultaneously. The Life Cycle Sustainability Assessment (LCSA) methodology was used to obtain indicators for greenhouse gas emissions, construction costs and working hours, and to provide a comprehensive presentation of the results. The factors that have the greatest impact in each sustainability dimension are identified. In addition, the sustainability triangle is obtained by assigning different weights to the indicators according to the particular interests of the decision-makers, representing the overall sustainability of the building creation. In this way, it is hoped that the impacts caused by residential and commercial buildings can be improved through the criteria of environmental responsibility, economic viability and social equity.

1. Introduction

Sustainable construction is currently a challenge to achieve and a principle to follow. The construction sector is responsible for a large number of impacts, particularly the use of a huge amount of materials derived from natural resources and high energy consumption, both during the construction of buildings and throughout their lifetime [1], [2]. Materials used in the construction sector, which are highly manipulated and have undergone a manufacturing process, have very important environmental impacts with a very energy-intensive content. Sustainability studies in construction activities have mainly focused on obtaining and reducing these environmental impacts and providing methods to guide the design, construction and operation of high-performance green buildings [3], [4], [5]. Thus, the importance of applying renewable energy in the construction process, as well as the environmental impact caused by the application of certain construction materials and the minimization of energy consumption implied by their use, has been the subject of particular attention in the scientific literature.

However, the concept of sustainability is not just about taking environmental impacts into account. Its assessment should be based on a balanced vision of the three fundamental aspects that define any human activity: environmental impact, social benefit and economic viability. The Brundtland Report "Our Common Future" [6] and the first Earth Summit in Rio de Janeiro [7] marked a turning point in the way we value the environment in

the context of economic and social development. World leaders adopted "Agenda 21", a far-reaching programme of action to achieve sustainable development in the 21st century, addressing environmental, economic and social issues in an integrated manner.

Thus, the concept of sustainability is based on a triple bottom line (TBL) approach [8], in which three dimensions or pillars are considered simultaneously: environmental issues (planet), economic aspects (profit) and social concerns (people). In this sustainability triangle, each dimension is represented as a circle (Fig. 1). These three pillars are based on the successive development policies of the last three centuries: the economic pillar is concerned with the creation of wealth (18th century); the social pillar redistributes this wealth (19th century); and the environmental pillar monitors responsibility for the environment (20th century). Sustainability is therefore a balance between environmental protection, social welfare and economic growth, which allows the needs of present generations to be met without compromising the needs of future generations.

Considerable efforts have been made to define appropriate indicators to develop the concept of sustainability in practice, often led by intergovernmental processes of organisations such as the UN or UNESCO, and supported by major research projects as well as regional and local initiatives. Indicators serve as operational measures of progress towards or away from sustainability and are practical communication tools relating to the sustainability performance of a system. Thus, although indicators are used to express change, they can also generate change by raising awareness. In this sense, they are powerful policy tools, as they relate not only to the production of scientific knowledge, but also to the creation of political norms [9], [10].

An indicator is usually a directly observable or measurable variable (so they have associated metrics) and its definition must be well grounded in science. Indicators select threads, headlines or leverage points from complex and non-linear phenomena and reduce them to more easily understood evidence to provide information about the impact of events and trajectories, the effects of different courses of action, and the quality and direction of change [11]. Indicators can be quantitative, statistical, numerical or qualitative, but at least semi-quantitative indicators are preferred to objectively assess whether sustainability progress is being made [12]. In triple bottom line thinking, different methods and tools, usually based on a life cycle perspective, can be used to assess metrics and indicators such as water consumption, production costs and working hours associated with each sustainability dimension (Fig. 1).

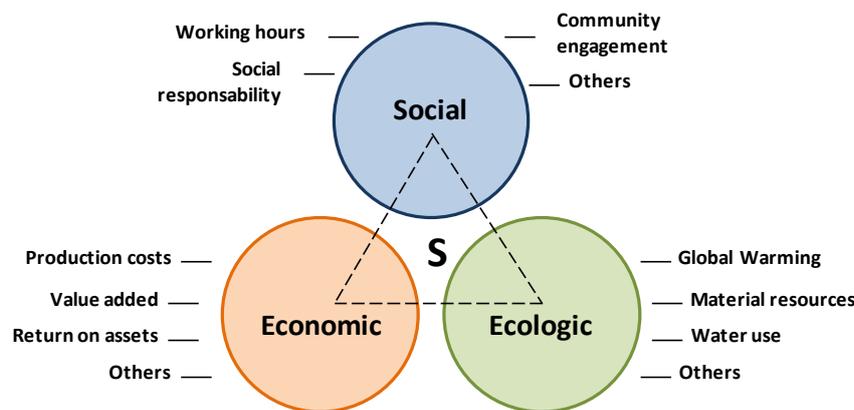


Fig. 1 Sustainability based on three dimensions and indicators used in each dimension

A number of studies have been carried out with the aim of applying this approach to improve the sustainability of manufactured products [13]. In this work, a building product is analyzed using this triple dimensional approach. Today, the decarbonization of the construction sector is not only a desirable goal, but also a great economic and welfare opportunity. According to the 2022 Global Status Report for Buildings and Construction [14], the built environment is estimated to account for about 7% of global employment and 11-13% of global GDP. This link between environmental and socio-economic issues needs to be addressed as a sustainability principle, by identifying appropriate indicators in construction processes, analyzing the main drivers of sustainability performance and proposing improvement strategies.

2. Methodology

Life Cycle Assessment (LCA) is a systematic methodology for identifying, quantifying and further evaluating the environmental impacts of a product, service or activity. ISO standards have a dedicated series for LCA methodology and the main widely used and accepted standards for LCA are ISO 14040 [15], [16]. The Life Cycle Sustainability Assessment (LCSA) framework [17], [18] is considered a pragmatic method for assessing impacts across the three dimensions of sustainability. The LCSA methodology is increasingly used by researchers to obtain

data on the sustainability performance of a given system. As shown in Fig. 2, four main phases should be carried out: 1) objective and scope definition; 2) inventory of materials and resources required by the system; 3) sustainability impact assessment; 4) interpretation of results.

It should be noted that the application of the LCSA method takes into account a life cycle perspective, from cradle to grave. However, the study does not always have to include all stages. The depth of the study can be shortened and limited to cradle-to-gate or gate-to-gate stages. According to EN 15804:2012+A2:2019 [19] the following stages are identified in the life cycle of a construction product related to buildings and civil engineering works: A) product and construction process, B) use, C) end of life and D) recycling potential benefits. In each stage different phases are included. In this work, attention is paid to the phases included in Stage A, where A1-3 relates to raw material supply, transport and production, and A4-5 relate to the transport of manufactured materials to the construction site and specific construction or installation processes.

In the first phase of the LCSA, it is necessary to select the system boundaries and the functional unit (FU). For each study case, the FU should be adequately defined in order to express and compare sustainability results. For the analysis of buildings and construction products, one square metre is usually selected for a period of 50 years [20]. The collection of inventory data in the second phase of LCSA can be carried out using different tools. In recent years, specific software tools used in construction projects have evolved to meet sustainability requirements and include not only information related to material costs, but also additional environmental information. For this study, the 2024 version of the commercial package developed by CYPE was used, specifically Arquimedes (CYPE AQ) for the Bill of Quantities (CYPE BOQ), the Price Generator (GdP) cost database, the Life Cycle Analysis module (CYPE LCA) for the environmental information, the Waste Management module (CYPE WM) for the waste generated.

Once the bill of quantities has been completed, the information obtained includes not only the detailed cost of the works and various environmental information, but also additional information such as the number of hours of work required, the type of specialist work required, the average cost of wages, or the amount and type of waste generated.

In the third phase of the LCSA, a number of indicators are obtained that express the environmental, economic and social impacts, depending on various factors. In this work, the Global Warming Potential (GWP), the Budget of Material Execution (BME) and the time required by workers to develop an activity (T_w) are the indicators selected for each sustainability dimension. The definition of each indicator can be found in Table 1.

Table 1 Indicators used to measure impacts in each sustainability dimension

Environmental dimension	
GWP ₁₀₀ (KgCO ₂ -eq)	The Global Warming Potential (GWP) is the most used indicator in sustainability studies. It represents the total emissions of the greenhouse gases computing the radiative forcing over a time horizon (usually, one hundred years). It is generally calculated using the corresponding unit indicator, which is obtained from different databases. In the case of raw materials and other products, unit indicator is expressed as emissions per mass unit.
Economic dimension	
BME (€)	The Budget of Material Execution (BME) expresses the total cost to develop an activity. In this case, the activity carried out is the construction of a building that will be used to provide a day-care service. It is usually calculated using the following cost groups: raw materials, energy consumption, labour, consumables, indirect costs, and amortisation. Different products and services price tables as well as salaries tables are used to value this indicator.
Social dimension	
T_w (h)	The Working time is the time required by the workers to develop an activity. It can be defined including all workers or individually. "Workers" is a very relevant category to know the social impact and T_w is a quantitative indicator that can be easily compared. In this work, the accumulated working time is obtained as the sum of working hours of all workers involved in the construction process.

SUSTAINABILITY ASSESSMENT OF A CONSTRUCTION PRODUCT

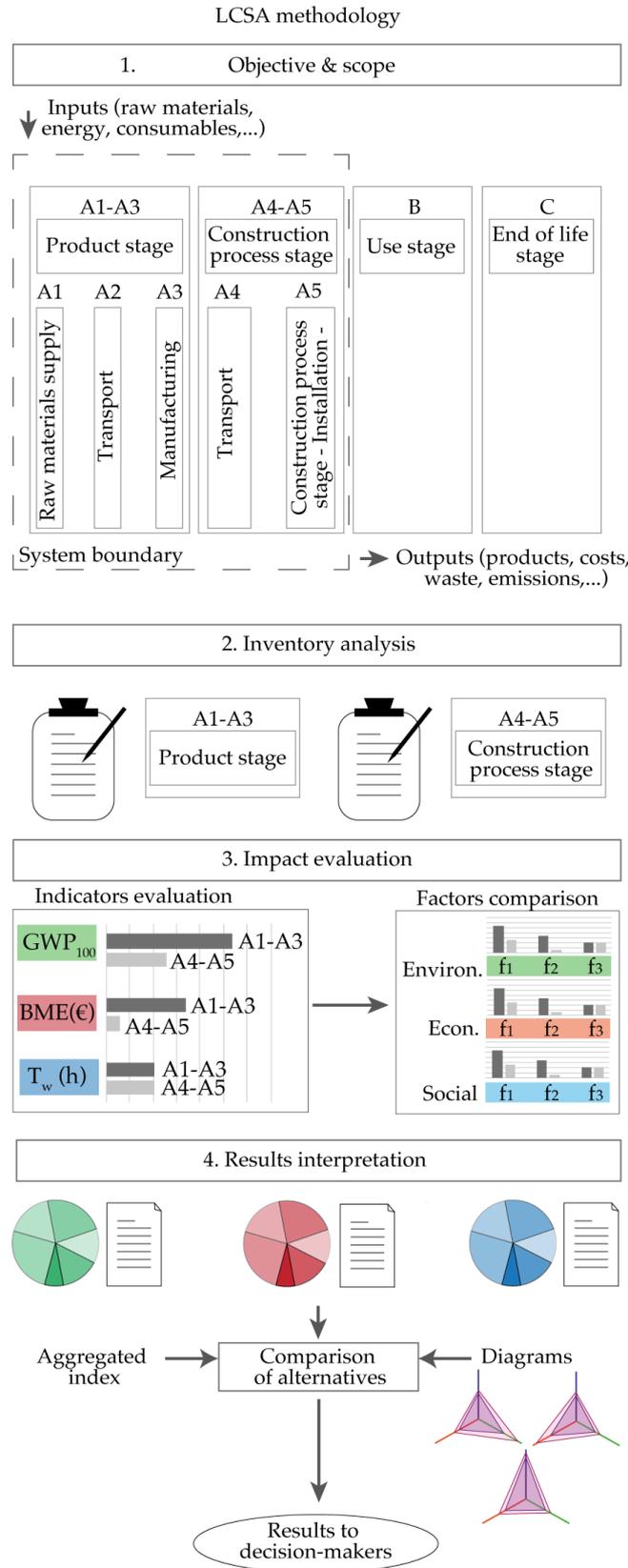


Fig. 2 Methodological scheme to achieve sustainability assessment of a construction product

The selected indicators are considered particularly useful because they can be used to study other similar systems and provide a quantitative assessment, which facilitates comparative studies. Finally, in the fourth phase of the LCSA, the results are interpreted and recommendations for the decision-making process are proposed. Simplified indicators or diagrams can also be developed to facilitate the communication of sustainability results to decision makers. As much as a composite index is used or diagrams based on the three sustainability dimensions (sustainability triangle) are developed, the weighting methods of the individual dimensions can have a decisive impact on the sustainability interpretation of a system [21], [22].

3. Case Study

In this work, the building constructed to serve as a public kindergarten is studied. The educational school takes in children from 4 months to 3 years of age who live in the village itself and in other small localities within a radius of 20 km in a rural region of Spain. It is a single floor building of 268.3 m² with four classrooms of approximately 30 m², which are used according to the needs of the day care service. Fig. 3 shows the layout and main façade of this building. It shows the distribution of the classrooms with their associated toilets, as well as the areas dedicated to the office, storage, food preparation or terrace. In each case, the surface area is indicated. It also shows how each area is accessed. According to the LCSA methodology, the sustainability study of the building construction is carried out in four steps, which are developed below.

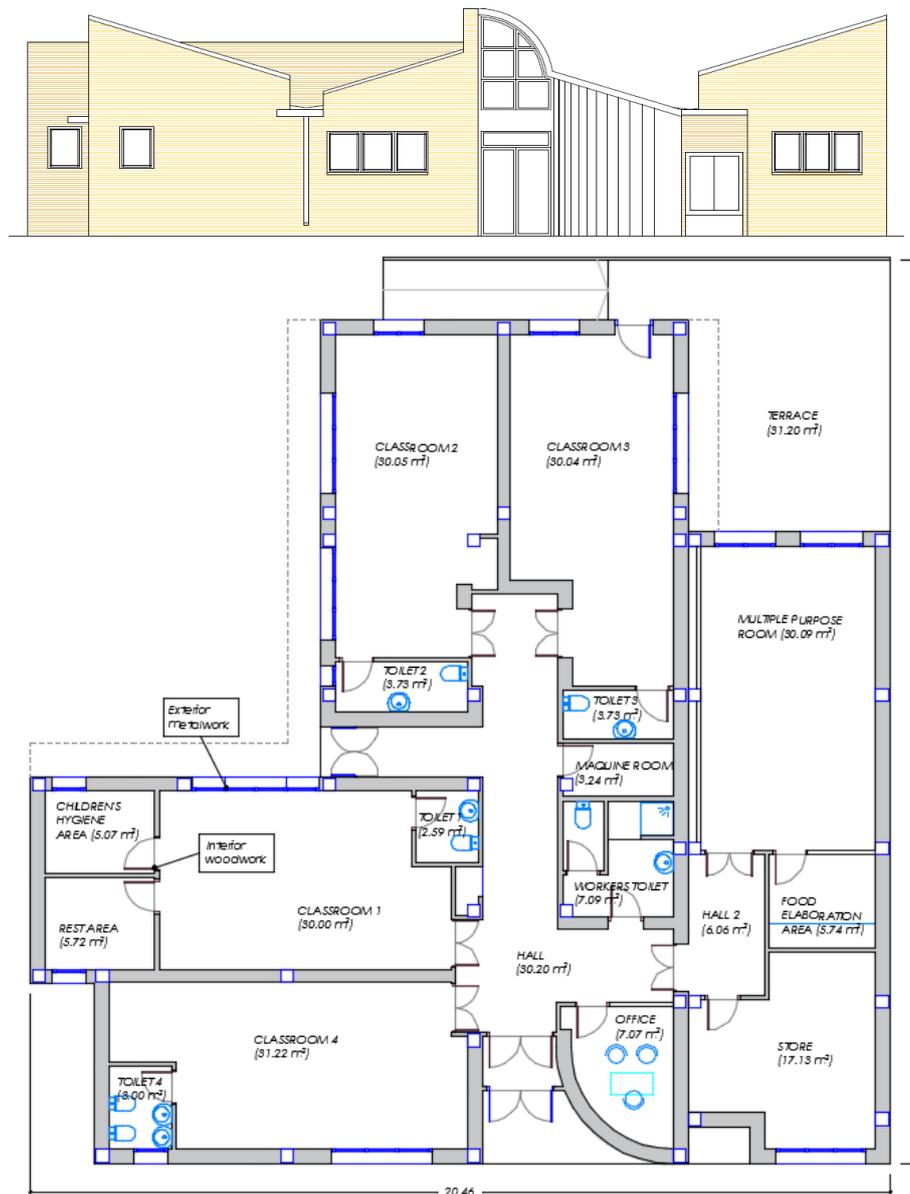


Fig. 3 Building to provide a day-care service. Plant layout and main facade

3.1 Objective and Scope

The objective is to evaluate the sustainability of the construction of a kindergarten building using indicators related to three dimensions. The transformation of an empty site into a suitable building to provide the educational service is addressed. Therefore, the scope of the LCSA study is the construction phase, including the product phase (A1-A3) and the construction process phase (A4-A5) according to EN 15804:2012+A2:2019 [19]. The appropriate units to measure the progress of each activity have been used to express inventory data and, finally, one square meter has been used as a functional unit to express sustainability indicators.

3.2 Inventory Data

All the activities required in building construction were organized into a total of 11 groups or categories, in accordance with their sequential development in practice. The data associated with each activity are summarized in Table 2. In the case of category 1. Previous actions, a number of activities are considered, ranging from land clearing to the installation of chests. Finally, category 11. Other includes activities related to fire protection, safety and health. The impact of the materials and resources used, the main workers involved and the corresponding economic costs of the activities were determined. In particular, the values of the GWP indicator in the product (A1-3) and construction (A4-5) phases, the number of workers and working time for the A5 phase and, finally, the total costs associated with the development of each activity are detailed.

All data are expressed per unit, which is used to measure the progress of the activity. In particular, looking at the activities of group 7. Carpentry and locksmithing, we can see that the first activity (installation of 36 external metal elements) leads to greenhouse gas emissions of 182.4 and 0.59 KgCO₂-eq/unit in the product and construction process phases, respectively; moreover, four workers are required, taking 4.63 h/unit, and the budget execution cost of the activity development is 888.36 €/unit.

3.3 Impact Evaluation

Indicators for the three sustainability dimensions were obtained. Indicators have been calculated individually for each activity category and globally for the entire building construction. They are expressed per m² (according to the FU used in construction) and can be consulted in Table 3. It can be seen that category 3. Masonry, generates 114.06 KgCO₂-eq/m² of greenhouse gas emissions, the cost of execution is 241.51 €/m² and workers take a total of 7.81 h/m². Global indicators have also been calculated. A total greenhouse gas emission of 651.75 kgCO₂-eq/m² was obtained, a final material execution budget of 1866.11 €/m² was calculated, and a total working time in the construction phase of 50.26 h/m² was determined.

High values in the indicators obtained for a particular category of activities represent a high incidence on the global indicator. In order to facilitate the identification of the categories that have the greatest impact on the global indicators, the percentage distributions of the impact caused by the building activities are shown in Fig. 4. We can see that the category 2. Structure and roof have the most significant impact in all sustainability dimensions. This category accumulates more than 57% of the GWP and more than 34% of the BME and Tw indicators, mainly due to the large amount of resources required to carry out all the activities involved. In particular, the execution of the floor structure or the finishing of the tiled roof are activities that accumulate high impacts, as can be seen in Fig. 4, where the percentage contribution of 2. Structure and roof, has been broken down to detect the impact of each activity involved in this category. In this way, the most important impact factors can be identified for each sustainability indicator. Activities that have the greatest impact on the sustainability of the building construction phase are identified, strategies to reduce their impact could be analysed and an effective improvement in the sustainability of construction works could be achieved.

On the other hand, we also observe that categories such as 3. Masonry and 10. Heating and Air Conditioning also have a significant contribution to the total impact calculated in all dimensions. However, categories such as 6. Flooring and tiling have a very low contribution to the environmental impact, but a significant contribution to the economic and social indicators.

3.4 Results Interpretation

In order to facilitate the interpretation of sustainability results according to a three dimensional approach, some tools are defined and used. In this study, the sustainability triangle is used both to graphically represent the sustainability balance between different dimensions and to interpret the sustainability variations between different construction alternatives.

The study can focus on global indicators or on indicators obtained for a selected category. In this study, the category 7. Carpentry and locksmithing is analyzed considering three different construction alternatives: A1 that is based on external metal and internal wood (initial construction alternative), A2 that is based on external PVC and internal wood and A3 that consists of external and internal wood. The sustainability indicators for each alternative have been obtained using the methods and specific tools already mentioned.

Table 2 Data inventory for those activities involved in the creation process of the day-care building

Construction and assembly activities	Meas.	Units	GWP ₁₀₀		Workers (A5)		Cost
			A1-2-3 (KgCO ₂ -eq/unit)	A4-5 (KgCO ₂ -eq/unit)	Nº	Tw (h/unit)	A1-5 (€/unit)
1. Previous actions							
1.1 Land clearing	506	m ²	0.00	0.65	1	0.01	1.28
1.2 Trench excavation and backfilling	184.5	m ³	0.48	7.72	1	0.80	20.26
1.3 Demolitions and carpentry removal	49.3	m ²	0.00	2.13	4	6.45	29.11
1.4 Waste transport to landfill	205.9	m ³	0.00	6.52	1	0.20	5.43
1.5 Sewage connections and underg. sewerage mains	81.7	m	16.07	1.39	5	3.34	82.07
1.6 Chests	8	pc.	190.23	7.09	2	4.10	340.34
2. Structure & roof							
2.1 Concrete for foundations	75.2	m ³	250.9	3.31	2	0.68	100.37
2.2 Sill under screed	267	m ²	1.72	1.39	1	0.30	13.84
2.3 Floor structure	694	m ²	56.25	1.65	10	3.68	91.74
2.4 Concrete wall	24.4	m ³	270.27	4.47	7	6.36	401.37
2.5 Columns and roof beams	10.7	m ³	314.94	6.58	6	24.19	705.3
2.6 Eaves solid slab	21.2	m ²	50.23	1.18	6	2.10	131.31
2.7 Control tests	25	pc.	0.00	0.00	3	2.50	59.73
2.8 Tiled pitched roof	332.2	m ²	87.72	1.76	4	4.34	226.56
3. Masonry							
3.1 Facades	571.3	m ²	38.32	3.31	2	2.16	83.5
3.2 Inner partitions	218.5	m ²	16.96	0.28	2	1.7	37.07
3.3 Miscellaneous (ducts, copings, lintels)	75	m	6.24	0.09	6	2.77	46.10
3.4 Received bricklaying	38	pc.	6.26	0.12	2	3.77	52.76
3.5 Masonry installation aids	362	m ²	6.31	0.12	2	0.77	8.85
4. Insulation & waterproof							
4.1 Thermal insulations	554.8	m ²	14.73	0.27	4	0.68	19.27
4.2 Waterproofing of slab foundations	25	m ²	7.35	0.10	2	0.27	17.83
5. Coatings & finishes							
5.1 Gypsum plaster trims	660.2	m ²	2.94	0.06	2	0.68	21.59
5.2 Cement plaster	134.7	m ²	10.17	0.96	2	1.07	30.99
5.3 Suspended ceilings	269	m ²	1.32	0.30	2	0.51	18.50
5.4 Painting and enamelling on locksmithery	813	m ²	0.65	0.01	2	1.05	17.25
6. Flooring & tiling							
6.1 Self levelling mortar	269	m ²	4.30	0.28	2	0.07	41.27
6.2 Indoor and outdoor floorings	268.5	m ²	4.43	0.39	4	1.70	56.24
6.3 Bathroom and office tiling	134.7	m ²	15.55	0.72	2	0.76	48.27
6.4 Skirting	300	m	0.89	0.01	1	0.15	8.20
7. Carpentry & locksmith							
7.1 Exterior aluminium carpentry and shutters	36	pc.	182.4	0.59	4	4.63	1776.73
7.2 Wooden interior carpentry	23	pc.	8.38	1.46	2	2.47	679.21
7.3 Handrail	12	m	0.44	0.00	2	1.09	112.63
8. Sanitation & plumbing							
8.1 Collectors, gutters and downpipes	71.5	m	34.43	0.75	7	1.93	52.59
8.2 Indoor sewage networks	7	pc.	27.72	0.17	2	15.83	285.37
8.3 Bathroom and kitchen plumbing installations	7	pc.	107.56	0.26	2	32.74	497.71
8.4 Sanitary equipment	18	pc.	36.13	0.21	2	4.06	622.43
9. Electricity							
9.1 Earthing system	2	pc.	86.7	1.65	2	19.61	1003.05
9.2 General protection box	1	pc.	61.2	0.43	4	1.77	296.97
9.3 General power supply line	100	m	5.71	0.44	4	0.29	34.97
9.4 Interior distribution network	1.75	pc.	987.73	10.18	2	129.00	7073.42
9.5 Luminaires	50	pc.	12.84	0.08	2	0.33	247.38
10. Heating & AC							
10.1 Underfloor heating	265	m ²	18.65	0.55	4	1.71	93.95
10.2 Oil-fired boiler	1	pc.	895.26	9.00	2	8.31	6082.04
10.3 Electric water heater	1	pc.	69.43	0.15	2	1.64	209.89
10.4 Mineral wool duct	29.4	m ²	4.64	0.13	2	0.77	44.51
10.5 Air conditioning system	42	pc.	25.98	0.23	2	39.36	1812.51
11. Others							
11.1 Fire protection	54	pc.	18.22	0.09	3	2.87	194.53
11.2 Health & Safety	4	pc.	0.00	0.00	0	0.00	2.060

Table 3 Sustainability indicators obtained for each category of construction activities

	Environmental GWP ₁₀₀ (KgCO ₂ -eq/m ²)	Economic BME (€/m ²)	Social T _w (h/m ²)
1. Previous actions	23.46	56.80	2.89
2. Structure and roof	377.08	662.63	17.11
3. Masonry	114.06	241.51	7.81
4. Insulation and waterproofing	31.7	43.13	1.42
5. Coatings and finishes	16.60	114.14	5.89
6. Flooring and tiling	7.47	131.79	2.43
7. Carpentry and locksmithing	25.42	190.80	0.88
8. Sanitation and plumbing	15.35	73.51	2.05
9. Electricity	9.69	98.16	1.22
10. Heating and air conditioning	27.22	194.18	7.97
11. Others	3.69	59.46	0.58
Total	651.75	1866.11	50.26

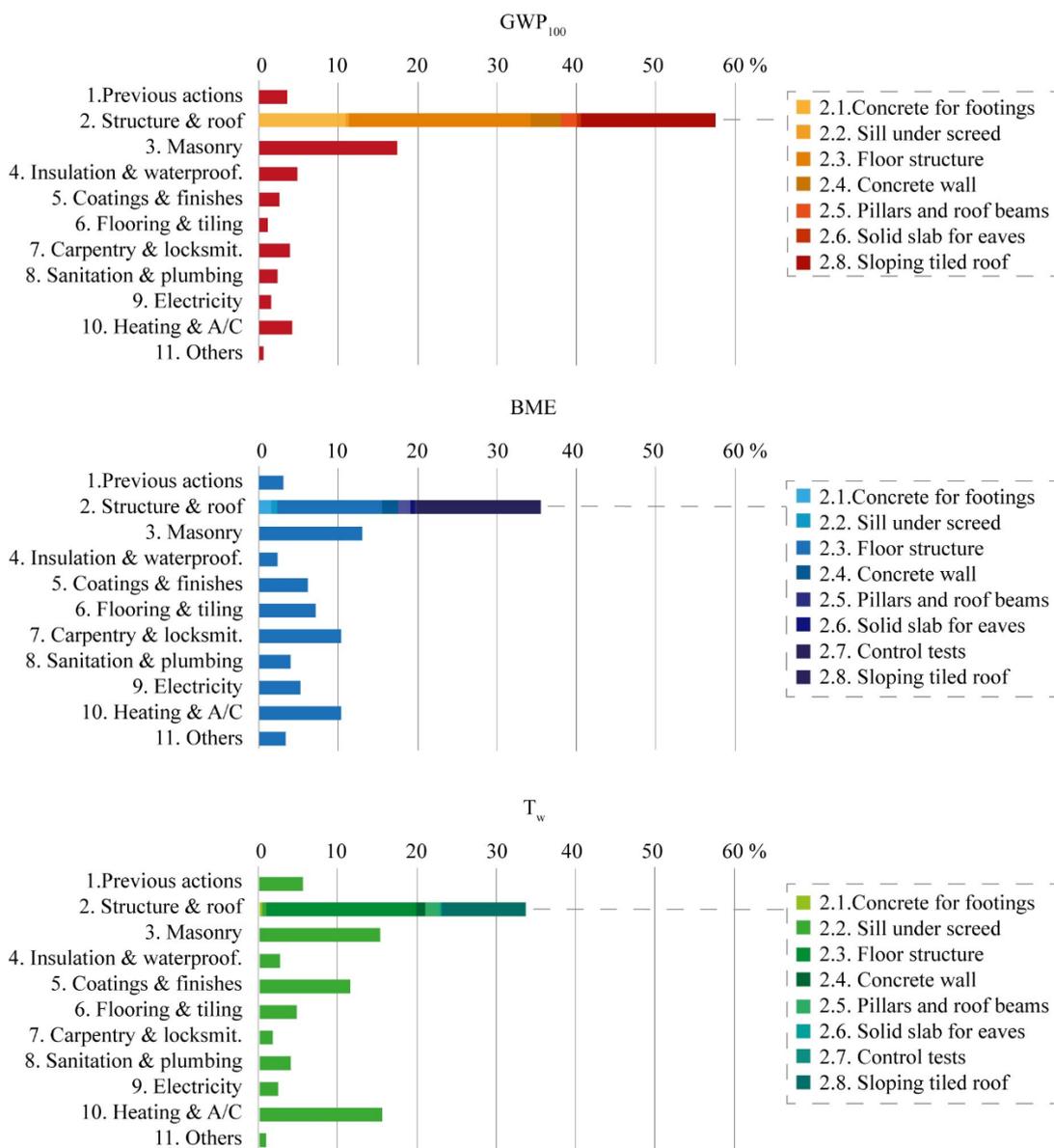


Fig. 4 Percentage distribution of the impact generated by each category of activities

The sustainability triangle proposed in this paper is an adaptation of the representation used by Hofstetter et al. [23] to weight different environmental impacts. In this triangle, the environmental dimension is located in the right-hand corner, economic performance in the left-hand corner and the social dimension in the top corner. The shape of the triangle depends on the weights proposed for each dimension. Different cases are considered, referred to as cases 1-4. In case 1, each sustainability dimension is given an equal weight of 1/3; in the other cases, a dominant dimension is considered. The dominant dimension is given a weight of 0.5 and the remaining dimensions are given equal weights of 0.25. The sum of the weighting factors is 1. Fig. 5 summarises the weights assigned to each dimension and the resulting graphs.

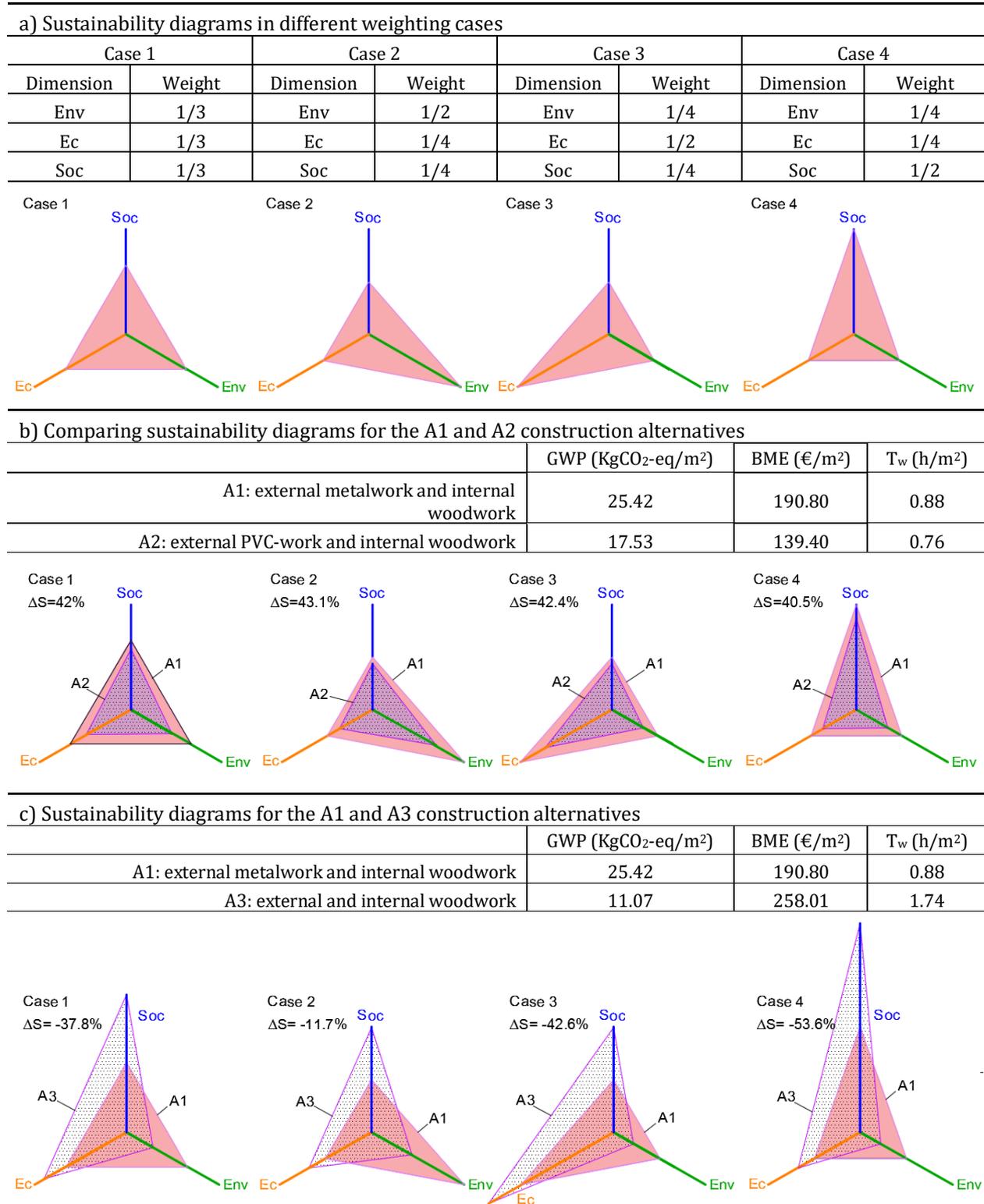


Fig. 5 Comparing sustainability of three construction alternatives using the sustainability triangle

First, diagrams of the resulting sustainability triangles in different weighting cases are shown. The interpretation of the triangle shape can be easily done by following the dominant direction. Case 1 represents a balanced sustainability between all dimensions. Cases 2-4 represent sustainability with a dominant dimension in line with the assigned weights. This type of presentation becomes more important when comparing different alternatives. Thus, two construction alternatives (A2 and A3) are proposed, related to the carpentry and locksmith activities, which are compared with the initial alternative (A1). The indicators calculated for each alternative are detailed in Figure 5 and changes in sustainability performance can be quickly visualised.

Comparing the sustainability diagrams of alternatives A1 and A2 shows a reduction in impact in all three dimensions. The result is a sustainability triangle with a smaller area, which allows us to say that A2 is a more sustainable option. This can be quantitatively assessed using the percentage difference between the areas of the triangle, called ΔS . Positive values of ΔS indicate less impact and more sustainable behaviour. As the impact reduction percentages are different in each dimension, the initial sustainable triangle in Case 1 evolves from an equilateral triangle to a scalene triangle. In all cases, positive values of ΔS are obtained. However, it can be seen that the impact reduction in case 2 (dominant environmental dimension) with $\Delta S=43.1\%$ is slightly higher than in case 4 (dominant social dimension) with $\Delta S=40.5\%$.

If we compare the sustainability diagrams of the A1 and A3 alternatives, we see a very different behaviour. If we compare the indicators of A3 with those of A1, we can see that the impact in the environmental dimension decreases, but that the impact in the economic and social dimensions increases significantly. As a result, in all cases we obtain a sustainability triangle with a larger area, particularly concentrated in the socio-economic area. Negative values of ΔS are calculated, which allows us to say that A3 is a less sustainable option. In case 2, where the environmental dimension is given a weight of 0.5, the percentage variation of the triangle areas is -11.7% . In the rest of the cases, we obtain more significant negative values of ΔS .

This shows the usefulness of the methods used in this work to evaluate the sustainability of a construction product, taking into account a three-dimensional approach. Likewise, the importance of the tools used to communicate the results to the decision makers is considered proven. In future work, the study can be extended to other alternatives and other construction products.

4. Conclusions

This work demonstrates the use of specific methods and tools to determine sustainability indicators associated with construction processes. A sustainability approach based on three dimensions and supported by criteria of environmental responsibility, economic viability and socio-ethical principles is applied. The LCSA methodology is used to identify appropriate indicators in each dimension. In particular, greenhouse gas emissions or global warming potential (GWP), material budget (BME) and labor time (Tw) are evaluated to determine the environmental, economic and social impact.

According to the LCSA methodology, the sustainability study is carried out in four steps: 1) objective and scope definition; 2) inventory analysis; 3) sustainability impact assessment; 4) interpretation of results. The scope of the study is the construction phase of the building, which will be used as a public nursery school. A detailed data inventory is carried out for all activities identified in this phase. Indicators are obtained using the commercial package developed by CYPE, in particular the Life Cycle Analysis module. The results are expressed for categories (group of activities) and globally for the building construction. A percentage distribution of the impacts generated by the activities involved in the construction process is taken into account and the main sources of impacts are identified.

A total greenhouse gas emission of $651.75 \text{ kgCO}_2\text{-eq/m}^2$ was obtained, a final material execution budget of 1866.11 €/m^2 was calculated and a working time in the construction phase of 50.26 h/m^2 was determined. The results showed that the activities related to category 2. Structure and roof have the greatest impact in all sustainability dimensions, mainly due to the large amount of resources required to carry out all the activities involved. Categories such as 3. Masonry and 10. Heating and air conditioning also contribute significantly to the total impact calculated in all dimensions. However, categories such as 6. Flooring and tiling make a very small contribution to the environmental impact but a significant contribution to the economic and social indicators.

The sustainability triangle is used in this study to both graphically represent the sustainability balance between different dimensions and to interpret the sustainability variations between different construction alternatives. The study of three alternatives within category 7. Carpentry and locksmithing provides significant differences in sustainability behaviour, which is shown in different areas of the sustainability triangle. As the value of the triangle area represents the global impact in three dimensions, a more sustainable alternative is obtained when the triangle area is reduced. This is the case when external metal work is replaced by external PVC work. In addition, changes in global impact and sustainability variation can be produced by different weighting cases of the dimensions.

Finally, it can be concluded that a significant improvement in sustainability studies can be achieved by applying methods such as LCSA to the evaluation of indicators that take into account not only the effects of

environmental impacts, but also other socio-economic aspects according to a balanced vision of the three fundamental pillars. It is expected that these methods can be extended to the study of strategies to improve building construction or refurbishment processes.

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Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design:** J.L. Santolaya, N. Muñoz, L. Diago_Ferrer; **data collection:** L. Diago_Ferrer; **analysis and interpretation of results:** L. Diago_Ferrer, J.L. Santolaya; **draft manuscript preparation:** L. Diago_Ferrer, N. Muñoz, J.L. Santolaya. All authors reviewed the results and approved the final version of the manuscript.

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