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The Importance of Considering the Three Sustainable Pillars in Construction

Thursday, 23 June 2022 | Technical Topic Webinar

Presented By

Mrs. Karoline Figueiredo | EIT Lecturer, Researcher, Civil Engineer, PhD Candidate

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Introduction - Presenter

Karoline Figueiredo

Karoline Figueiredo holds a bachelor's degree in Civil Engineering and a Master's degree in Environmental Engineering, both from the Federal University of Rio de Janeiro, Brazil. She was a Visiting Researcher at Universitat Rovira i Virgili, Spain, and at Western Sydney University, Australia, and in both situations, she developed research about sustainable construction. She is currently a doctoral candidate, and her research focuses on improving the selection of construction materials in order to achieve a smart and sustainable built environment through the integration of the Building Information Modelling (BIM) methodology and Blockchain. She has expertise in Sustainable Construction and has developed several projects related to Smart Buildings and BIM applications. She is a lecturer in a postgraduate course at the Federal University of Rio de Janeiro, Brazil, responsible for planning and coordinating a unit about Building Information Modelling (BIM), and a lecturer at the Engineering Institute of Technology (EIT), Australia. She is currently working as a Book Editor for Woodhead Publishing – Elsevier, developing a book named "Materials selection for Sustainability in the Built Environment: Environmental, Social, and Economic aspects", to be published at the beginning of 2023.

Agenda

1	Welcome and Introduction
2	Development of sustainable building projects
3	Sustainability Pillars
4	Impacts generated by the construction industry
5	Life Cycle Thinking
6	Case study
7	Conclusion and Q&A

Development of sustainable building projects

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Regarding the construction of buildings and civil engineering works, the sustainability concept is related to how the attributes of the activities, products or services associated with this sector contribute to the ecosystem maintenance for future generations.

Development of sustainable building projects

Development of sustainable building projects

Green roofs and walls

Development of sustainable building projects

Green roofs and walls

Solar photovoltaic systems

Development of sustainable building projects

Green roofs and walls

Solar photovoltaic systems

Harvesting rainwater for use

Development of sustainable building projects

- Green roofs and walls
- Solar photovoltaic systems
- Harvesting rainwater for use
- Passive design

Development of sustainable building projects

- Green roofs and walls
- Solar photovoltaic systems
- Harvesting rainwater for use
- Passive design
- Use of recycled materials

Sustainability pillars

PROFITS

PEOPLE

PLANET

Impacts generated by the construction industry

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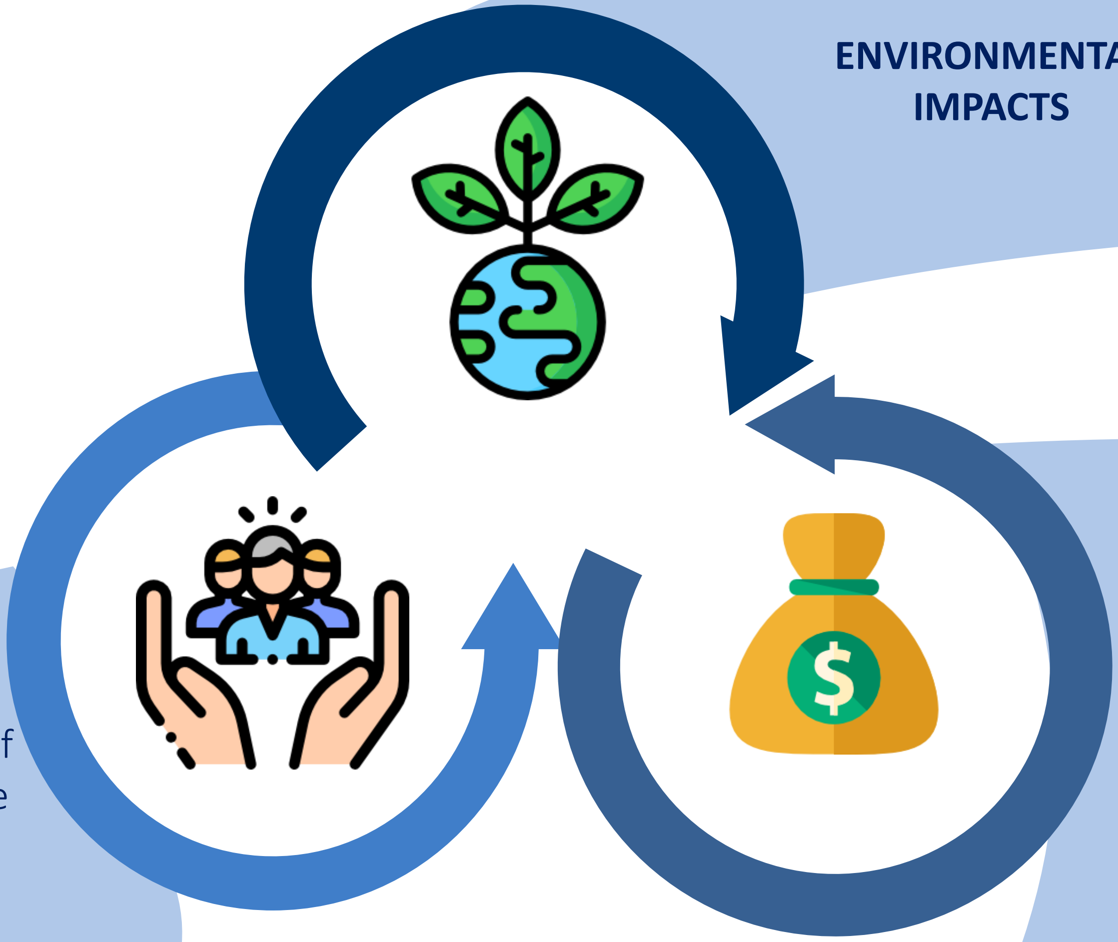
ENVIRONMENTAL IMPACTS

Air pollution, climate change, water pollution, landfill wastes, burning of fossil fuels, dust generation, etc.



SOCIAL IMPACTS

Workforce development, relocation of local residents, health risks due to the release of waste, comfort impacts, loadings on the neighbourhood, degradation of cultural heritage, etc.

ECONOMIC IMPACTS

Costs directly related to the purchase or rental of the site, provide income for small businesses, construction costs, operational energy costs, operational water costs, taxes, professional fees, etc.

Impacts generated by the construction industry

A strong association exists between construction and the three main pillars of sustainability.

The construction industry is responsible for the generation of between 2 and 3 billion tonnes of building waste a year and contributes to 5-7% of the total GDP and at least 7% of the employed population in most countries.

The development of sustainable building projects is a task linked to multiple criteria.

A considerable amount of time is consumed in the early stages of designing construction projects on comparing different construction materials, resources, and methods.

Traditionally, the project decisions are not based on the potential building impacts.

The project decisions are usually based on satisfying only technical requirements or economic limits without profoundly considering environmental and social aspects.

Life Cycle Thinking

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[LCA] + [LCC] + [sLCA]

LIFE CYCLE ASSESSMENT

LIFE CYCLE COSTING

SOCIAL LIFE CYCLE ASSESSMENT

LIFE CYCLE **SUSTAINABILITY** ASSESSMENT

Life Cycle Thinking

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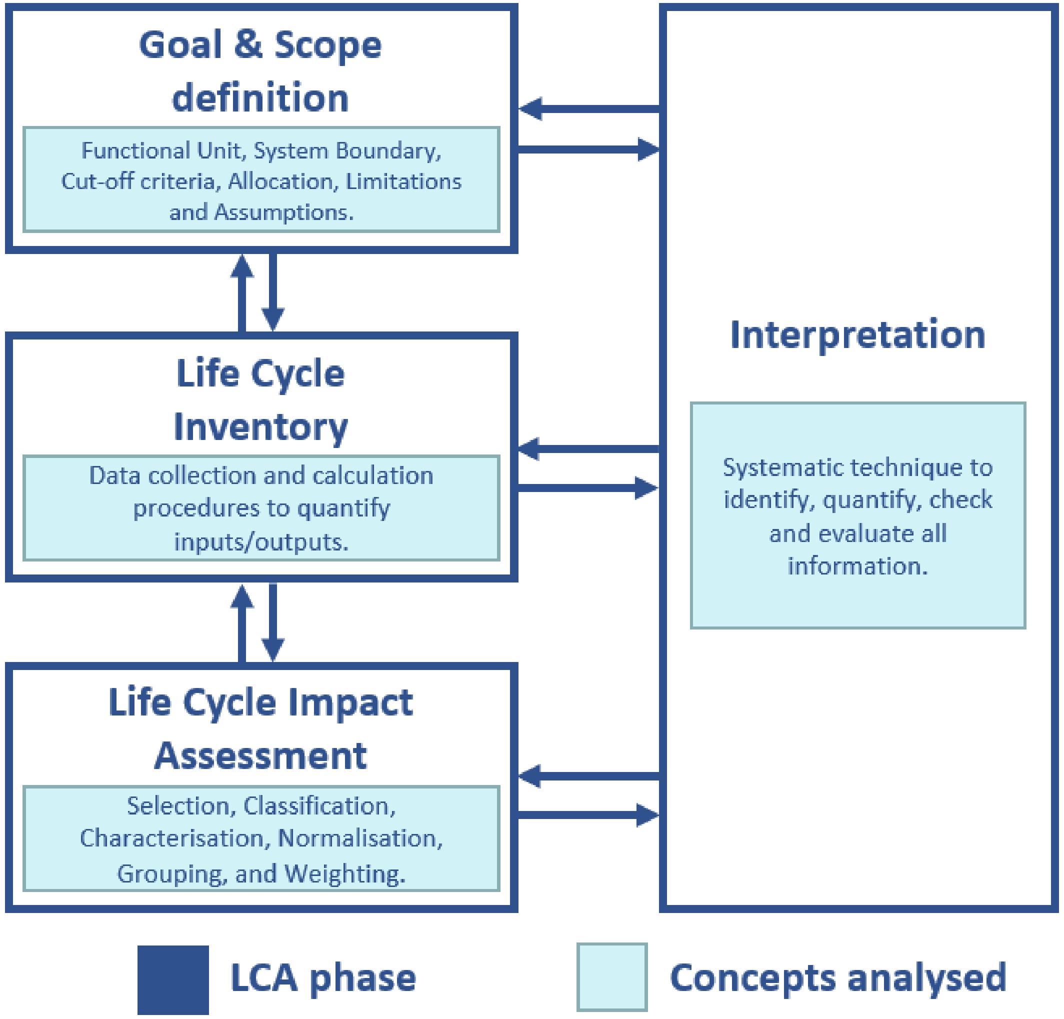
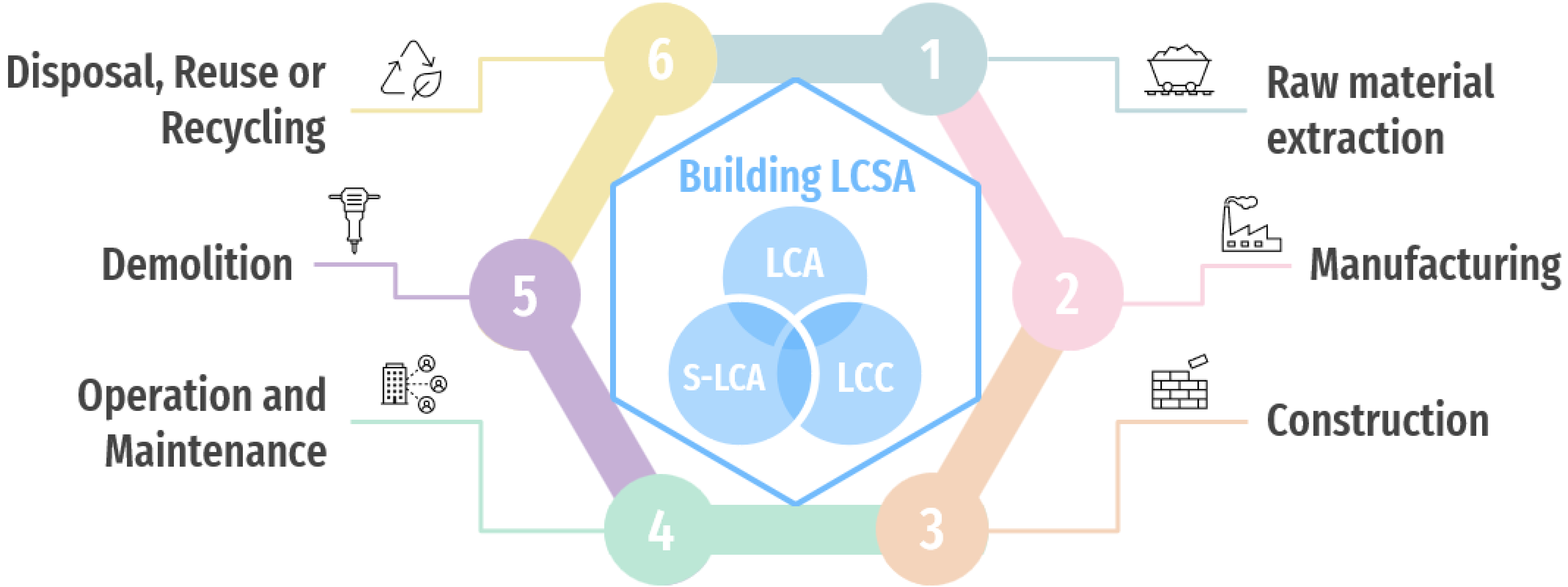


Source: Adapted from the ISO 14040 standard

Life Cycle Thinking



Source: Created by Karoline Figueiredo.

Life Cycle Thinking

A high degree of detail is required when considering an entire building in the assessment.

A building has a long life-cycle and is composed of many different materials and elements. Besides, a building assessment involves both quantitative and qualitative data.

The three pillars of sustainability have different maturity levels.

It makes it challenging to integrate the three approaches in a building assessment, which hinders the broad implementation of Building LCSA.

How to consider the three pillars of sustainability in a balanced way?

Dictionary

WHAT IS BALANCE ?

balance
/ˈbæl.əns/

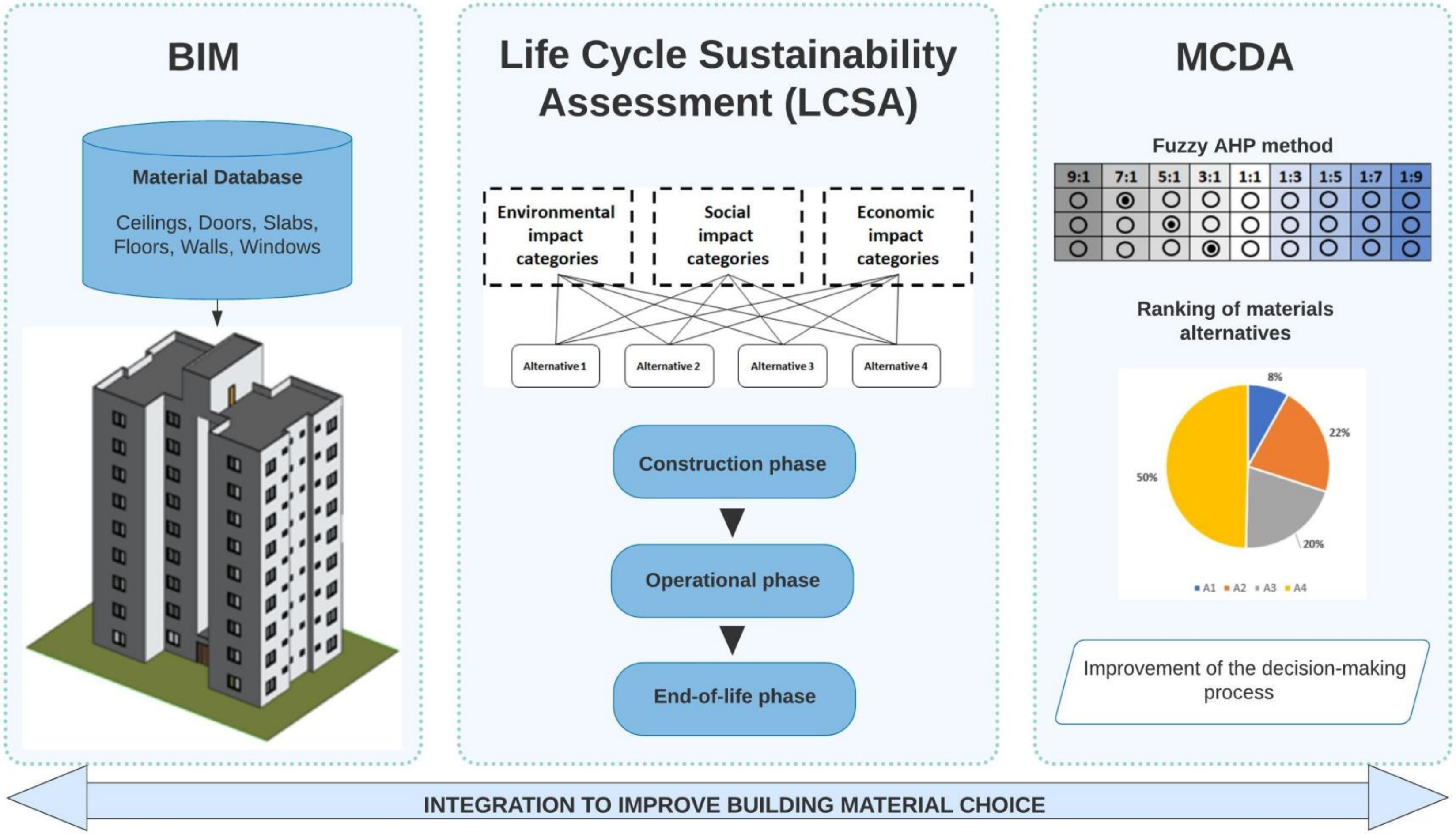
a state where things are of equal weight or force;

to give several things equal amounts of importance, time, or money so that a situation is successful;

the state where things exist in equal amounts or are of equal importance.

Balance is a condition in which different elements are equal *or in the correct proportions*.

Case Study



Source: FIGUEIREDO, Karoline et al. Sustainable material choice for construction projects: A Life Cycle Sustainability Assessment framework based on BIM and Fuzzy-AHP. Building and Environment, v. 196, p. 107805, 2021.

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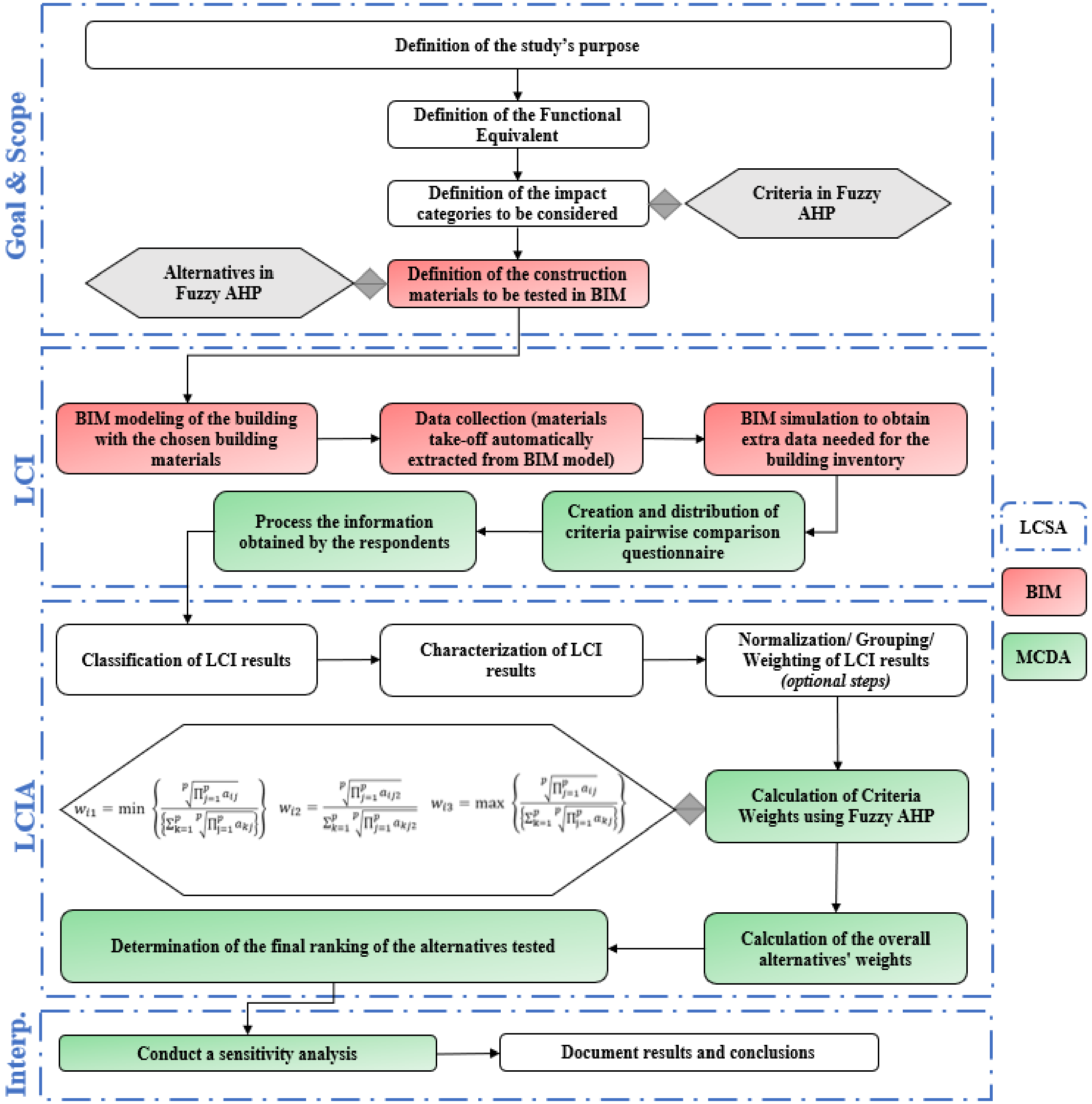

Source: FIGUEIREDO, Karoline et al. Sustainable material choice for construction projects: A Life Cycle Sustainability Assessment framework based on BIM and Fuzzy-AHP. Building and Environment, v. 196, p. 107805, 2021.

Case Study

Dimensions and criteria to be considered in the analysis

Dimensions (D_i)	**Criteria (C_j)**	**Units**
(D_1) Environmental	(C_1) Global Warming Potential	kg CO_2 eq.
	(C_2) Acidification Potential	kg SO_2 eq.
	(C_3) Eutrophication Potential	kg N eq.
(D_2) Economic	(C_4) Life-cycle cost	Brazilian Real (R$)
(D_3) Social	(C_5) Fair Wage Potential	FWeq.

Source: FIGUEIREDO, Karoline et al. Sustainable material choice for construction projects: A Life Cycle Sustainability Assessment framework based on BIM and Fuzzy-AHP. Building and Environment, v. 196, p. 107805, 2021.

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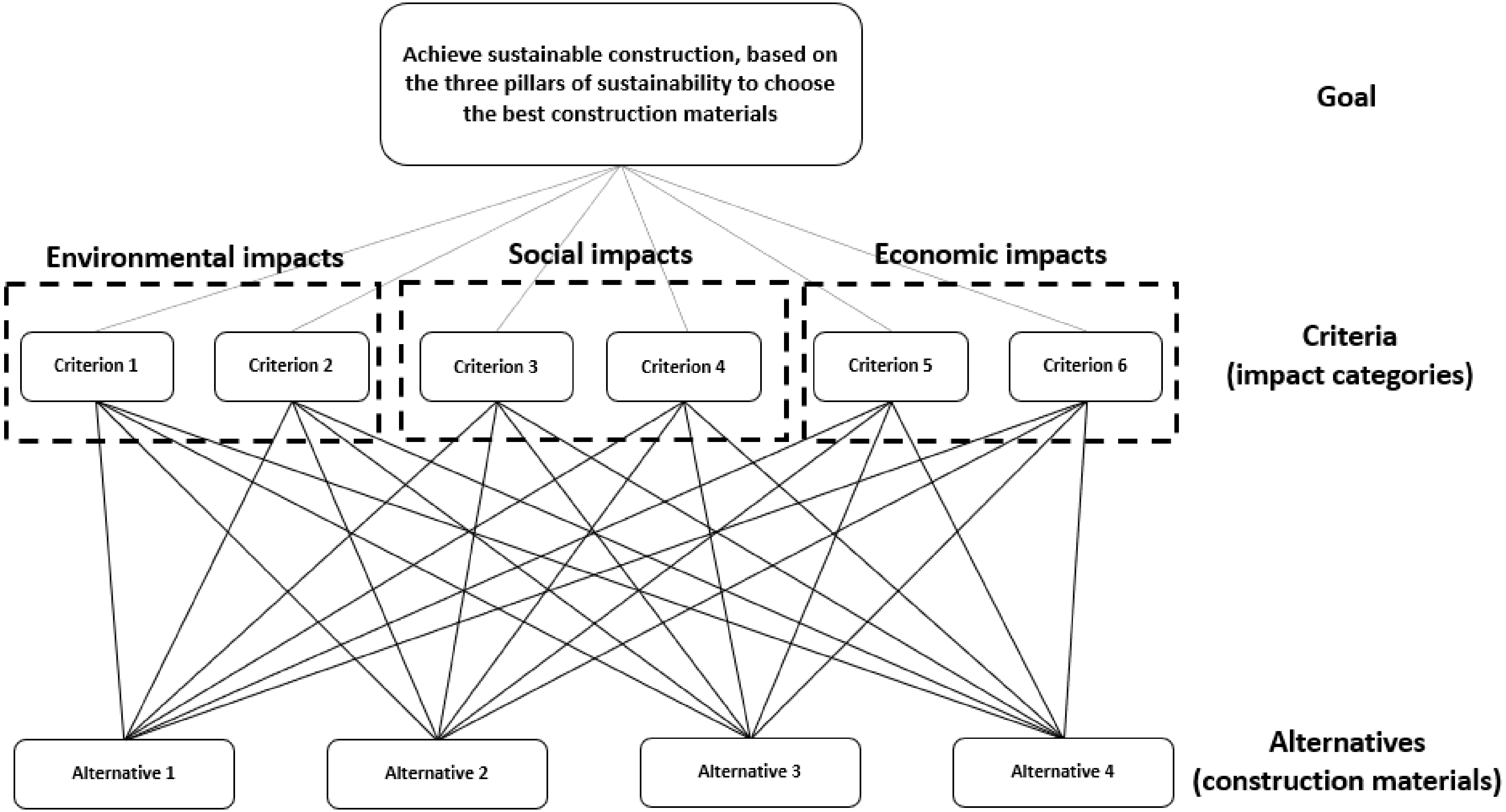

Source: FIGUEIREDO, Karoline et al. Sustainable material choice for construction projects: A Life Cycle Sustainability Assessment framework based on BIM and Fuzzy-AHP. Building and Environment, v. 196, p. 107805, 2021.

Case Study

Database concerning the four alternatives, where B.L. stands for 'Building Life.'

BIM Category	Alternative 1			
	Materials	Material mass (kg)	Service Life (years)	Transportation distance (km)
Ceilings	Acoustic ceiling system, fiberglass	4390	50	72
	Suspended grid	1827	50	72
	Paint, interior acrylic latex	318.6	7	24
Doors	Kiln-dried Ash hardwood lumber of 4′	5810.31	50	38
	Wood stain, water-based	36.87	10	38
Slabs	Structural concrete, 4001–5000 psi	565,175	60 (B.L.)	17
	Steel	5448	60 (B.L.)	17
Floors	Ceramic tile, unglazed	35,242	60	72
	Cement mortar	6294	60	72
	Cement grout	780.6	60	72
Walls	Brick, 1/2″ joint	929,061	150	17
	Lime mortar	161,037	60	72
	Grout fill: thickset mortar	260,827	60	72
	Reinforcing Steel	16,451	60	17
	Paint, exterior acrylic latex	1052	10	24
Windows	Glazing, monolithic sheet, tempered	6610	40	40
	Aluminium, (100x20x2) mm, 1,28 kg/m	1002.45	60	63
	Paint, enamel, solvent-based	63.9	15	63
BIM Category	**Alternative 2**			
	Materials	**Material mass (kg)**	**Service Life (years)**	**Transportation distance (km)**
Ceilings	Ceiling tile, aluminium (3.37 kg/m^2)	5498	70	63
	Suspended grid	1827	50	63
	Powder coating, metal stock	636.3	50	1
Doors	Domestic softwood, US, AWC - EPD	2333	30	38
	Polyurethane foam (PUR) rigid board	135.68	75	29
Slabs	Glass Fibre Reinforced Concrete	567,321	60 (B.L.)	40
	Steel	81,409	60 (B.L.)	18
Floors	Terracotta tile	89,152	75	72
	Thickset mortar	13,280	60	72
	Cement grout, Latricrete - EPD	372,1	60	72
Walls	Concrete masonry unit (CMU), solid	1,217,571	100	72
	Mortar type N	71,158	60	72
	Paint, exterior acrylic latex	1052	10	24
Windows	Glazing, double, insulated (air)	4715	40	40
	Aluminium extrusion, anodized, AEC - EPD	3318.6	60	63
	Paint, exterior metal coating, silicone-based	20.95	30	24

Source: FIGUEIREDO, Karoline et al. Sustainable material choice for construction projects: A Life Cycle Sustainability Assessment framework based on BIM and Fuzzy-AHP. Building and Environment.

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Brazilian data regarding the resource requirement of workers in the construction sector.

		Professionals needed in each alternative			
		Construction phase			
Category	Brazilian average wage (Brazilian Real – R$)	Alternative 01	Alternative 02	Alternative 03	Alternative 04
Bricklayer's mate	R$ 1442.05	14	10	14	10
Bricklayer - level 1	R$ 1507.78	0	3	0	0
Bricklayer - level 2	R$ 2010.37	10	9	7	8
Bricklayer - level 3	R$ 2372.24	2	0	4	5
Bricklayer - level 4	R$ 2734.10	0	2	0	0
Master builder	R$ 3091.89	1	1	1	1
Site engineer	R$ 9483.29	1	1	1	1
		O&M phase			
Bricklayer/painter	R$ 1.846,12	2	2	2	2
		End-of-life phase			
Bricklayer's mate	R$ 1442.05	2	2	2	2
Master builder	R$ 3091.89	1	1	1	1

Environmental impacts for the alternatives evaluated in this study.

	Impact Category	Construction phase	O&M phase	End-of-life phase	Total
Alt. 01	(C1) Global Warming (kg CO_2eq)	3123	50,521	44,940	**98,584**
	(C2) Acidification (kg SO_2eq)	14.47	311.7	191.6	**517.77**
	(C3) Eutrophication (kg Neq)	1178	17.23	10.49	**1205.72**
Alt. 02	(C1) Global Warming (kg CO_2eq)	6364	216,551	41,924	**264,839**
	(C2) Acidification (kg SO_2eq)	29.49	885.1	187.4	**1101.99**
	(C3) Eutrophication (kg Neq)	2.40	41.82	9.99	**54.21**
Alt. 03	(C1) Global Warming (kg CO_2eq)	2636	212,205	32,161	**247,002**
	(C2) Acidification (kg SO_2eq)	12.21	951	134.3	**1097.51**
	(C3) Eutrophication (kg Neq)	0.99	45.35	7.49	**53.83**
Alt. 04	(C1) Global Warming (kg CO_2eq)	2599	547,488	51,254	**601,341**
	(C2) Acidification (kg SO_2eq)	12.04	4817	172	**5001.04**
	(C3) Eutrophication (kg Neq)	0.98	112	11	**123.98**

Source: FIGUEIREDO, Karoline et al. Sustainable material choice for construction projects: A Life Cycle Sustainability Assessment framework based on BIM and Fuzzy-AHP. Building and Environment, v. 196, p. 107805, 2021.

Case Study

Results of energy simulations in the BIM models.

Alternatives	Annual Energy Consumption for Lighting (kWh)	Annual Energy Consumption for HVAC (kWh)
Alternative 1	21,591	81,225
Alternative 2	19,802	62,709
Alternative 3	20,234	71,739
Alternative 4	23,606	63,825

Fair Wage Potential for the different workers' categories.

Category	FWP_n (FWeq.)
Bricklayer's mate	0.7593
Bricklayer - Level 1	0.8841
Bricklayer - Level 2	1.1788
Bricklayer - Level 3	1.3910
Bricklayer - Level 4	1.6031
Master builder	1.8129
Site Engineer	5.9674
Bricklayer/Painter	1.0825

Life-cycle cost for the alternatives evaluated in this study, with the costs presented in Brazilian Real.

Alternatives	Construction cost	Energy cost	Maintenance cost	End-of-life cost	Total life-cycle cost
Alt. 01	R$ 4,149,370.18	R$ 15,056,422.71	R$ 465,604.26	R$ 58,000.00	R$ 19,729,397.15
Alt. 02	R$ 4,225,102.32	R$ 12,082,950.40	R$ 614,177.41	R$ 58,000.00	R$ 16,980,230.13
Alt. 03	R$ 5,730,095.63	R$ 13,468,569.17	R$ 749,241.23	R$ 58,000.00	R$ 20,005,906.03
Alt. 04	R$ 5,426,852.74	R$ 12,803,436.88	R$ 619,001.18	R$ 58,000.00	R$ 18,907,290.80

Source: FIGUEIREDO, Karoline et al. Sustainable material choice for construction projects: A Life Cycle Sustainability Assessment framework based on BIM and Fuzzy-AHP. Building and Environment, v. 196, p. 107805, 2021.

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Dear respondent, please compare in pairs the relative importance between the following criteria regarding the environmental, economic, and social impacts of buildings.

Criterion A	9:1	7:1	5:1	3:1	1:1	1:3	1:5	1:7	1:9	Criterion B
(C1) Global Warming	○	◉	○	○	○	○	○	○	○	(C2) Acidification
(C1) Global Warming	○	○	◉	○	○	○	○	○	○	(C3) Eutrophication
(C1) Global Warming	○	○	○	◉	○	○	○	○	○	(C4) Life-cycle cost

1:1 - Criterion A is **equally important** than Criterion B

9:1 - Criterion A is **absolutely more important** than Criterion B

1:9 - Criterion B is **absolutely more important** than Criterion A

Source: FIGUEIREDO, Karoline et al. Sustainable material choice for construction projects: A Life Cycle Sustainability Assessment framework based on BIM and Fuzzy-AHP. Building and Environment, v. 196, p. 107805, 2021.

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Fuzzy and nonfuzzy criteria weights.

Criteria	Fuzzy Weights	Defuzzified Weights	Nonfuzzy Normalized Weights
C_1	$\widetilde{w}_1 = (0.1216; 0.1616; 0.2184)$	$w_1 = 0.167$	$w_1 = 0.166$
C_2	$\widetilde{w}_2 = (0.0638; 0.0849; 0.1172)$	$w_2 = 0.089$	$w_2 = 0.088$
C_3	$\widetilde{w}_3 = (0.0337; 0.0417; 0.0544)$	$w_3 = 0.043$	$w_3 = 0.043$
C_4	$\widetilde{w}_4 = (0.3800; 0.4610; 0.5234)$	$w_4 = 0.455$	$w_4 = 0.451$
C_5	$\widetilde{w}_5 = (0.1876; 0.2508; 0.3218)$	$w_5 = 0.253$	$w_5 = 0.252$

Alternative weights concerning the particular criteria.

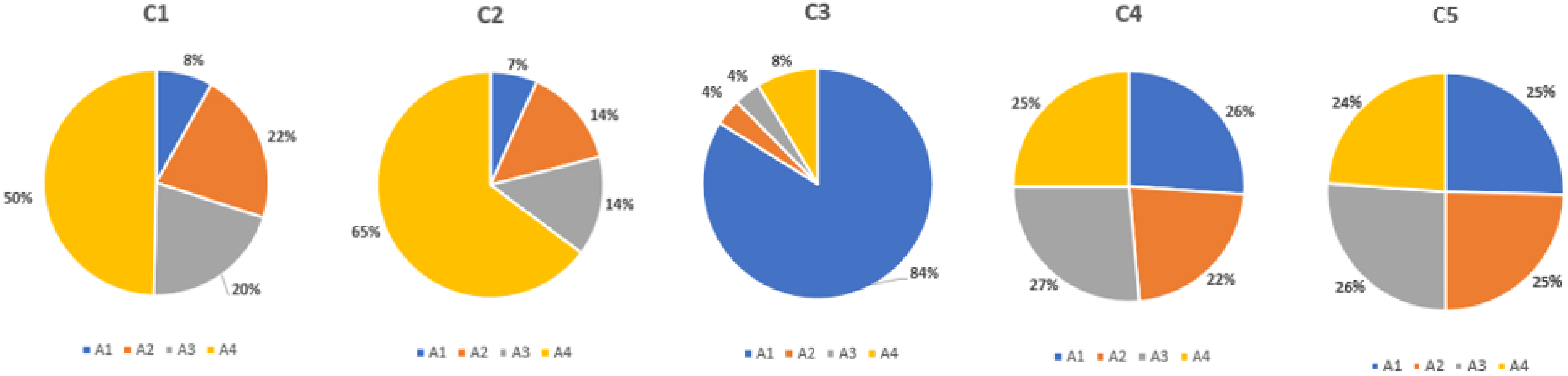
	A_1	A_2	A_3	A_4
C_1	$u_1^1 = 0.081$	$u_1^2 = 0.219$	$u_1^3 = 0.204$	$u_1^4 = 0.496$
C_2	$u_2^1 = 0.067$	$u_2^2 = 0.143$	$u_2^3 = 0.142$	$u_2^4 = 0.648$
C_3	$u_3^1 = 0.839$	$u_3^2 = 0.038$	$u_3^3 = 0.037$	$u_3^4 = 0.086$
C_4	$u_4^1 = 0.261$	$u_4^2 = 0.225$	$u_4^3 = 0.265$	$u_4^4 = 0.250$
C_5	$u_5^1 = 0.254$	$u_5^2 = 0.246$	$u_5^3 = 0.262$	$u_5^4 = 0.238$

Overall weights of the alternatives.

Alternatives	Overall weights	Ranking
A_1	$u_1 = 0.2372$	3rd
A_2	$u_2 = 0.2137$	1st
A_3	$u_3 = 0.2332$	2nd
A_4	$u_4 = 0.3159$	4th

Source: FIGUEIREDO, Karoline et al. Sustainable material choice for construction projects: A Life Cycle Sustainability Assessment framework based on BIM and Fuzzy-AHP. Building and Environment, v. 196, p. 107805, 2021.

Case Study



Source: FIGUEIREDO, Karoline et al. Sustainable material choice for construction projects: A Life Cycle Sustainability Assessment framework based on BIM and Fuzzy-AHP. Building and Environment, v. 196, p. 107805, 2021.

Conclusion

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The development of a sustainable built environment should be viewed in the context of a duty to future generations.

Conclusion

Thank you!

Course Highlight

Professional Certificate of Competency in Building Information Modelling (BIM)

Building Information Modelling (BIM) is a concept that revolutionised the way construction projects are conceived by developing intelligent virtual models. When applying BIM, the resulting 3D model is a data-rich digital representation of the facility. It provides professionals with the necessary information to perform practical building analysis. This course aims to discuss several possibilities for adopting the BIM methodology for enhancing the decision-making process in building projects. For this, different tools and methods associated with BIM will be presented and applied to case studies.

Duration: 3 months, live and online
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SCAN ME

Q&A

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