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ECO-EFFICIENCY IN CIVIL CONSTRUCTION: MINIMIZING IMPACTS

ECOEFICIÊNCIA NA CONSTRUÇÃO CIVIL: MINIMIZANDO IMPACTOS

ECOEFICIENCIA EN LA CONSTRUCCIÓN CIVIL: MINIMIZANDO IMPACTOS

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ABSTRACT

The present work will present a comprehensive literature review on the subject, along with the practical implementation in a single-family residential project. The main objective is to establish the project as an example to be followed, promoting the adoption of sustainable practices in the residential construction of houses of social interest. The methodology adopted consisted of a bibliographic research on the methods that minimize impacts, analyzing the cost-benefit of their implementation in a popular house, where the financial cost of construction will be analyzed, focusing on the use of the chosen methods, in order to demonstrate their significant economic advantages and evaluate the feasibility. With the results, it was possible to achieve the established goal of providing knowledge that it is possible to minimize the impacts generated to the environment in civil construction, demonstrating that such alternatives have costs within the financing pattern by the Minha Casa Minha Vida program. In addition, the concern with social and environmental aspects stands out, as well as the encouragement of the practice of sustainability.

Keywords: Sustainability. Materials. Economy. Engineering.

RESUMO

O presente trabalho apresentará uma revisão bibliográfica abrangente sobre o tema, juntamente com a implementação prática em um projeto residencial unifamiliar. O objetivo principal é estabelecer o projeto como um exemplo a ser seguido, promovendo a adoção de práticas sustentáveis na construção residencial de casas de interesse social. A metodologia adotada consistiu em uma pesquisa bibliográfica sobre os métodos que minimizam impactos, analisando do custo benefício da implantação dos mesmos em uma de uma casa popular, onde será analisado o custo financeiro da construção, com foco na utilização dos métodos escolhidos, a fim de demonstrar suas vantagens econômicas significativas e avaliar a viabilidade. Com os resultados, foi possível atingir a meta estabelecida de fornecer um conhecimento que é possível minimizar os impactos gerados ao meio ambiente na construção civil, demonstrando que tais alternativas apresentam custos dentro do padrão de financiamento pelo programa minha casa minha vida. Além disso, destaca-se a preocupação com aspectos sociais e ambientais, bem como o estímulo à prática da sustentabilidade.

Palavras-chave: Sustentabilidade. Materiais. Economia. Engenharia.

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RESUMEN
Este artículo presenta una revisión bibliográfica exhaustiva sobre el tema, junto con su implementación práctica en un proyecto residencial unifamiliar. El objetivo principal es establecer el proyecto como un ejemplo a seguir, promoviendo la adopción de prácticas sostenibles en la construcción residencial de vivienda social. La metodología adoptada consistió en una revisión bibliográfica sobre métodos que minimizan los impactos, analizando el costo-beneficio de su implementación en un proyecto de vivienda social. Se analizará el costo financiero de la construcción, centrándose en el uso de los métodos elegidos, con el fin de demostrar sus ventajas económicas significativas y evaluar su viabilidad. Los resultados alcanzaron el objetivo establecido de proporcionar conocimiento sobre la posibilidad de minimizar los impactos ambientales en la construcción civil, demostrando que dichas alternativas presentan costos dentro del financiamiento estándar del programa Minha Casa Minha Vida. Además, se destaca el enfoque en los aspectos sociales y ambientales, así como el fomento de prácticas de sostenibilidad.

Palabras clave: Sostenibilidad. Materiales. Economía. Ingeniería.

1 INTRODUCTION

According to Lefebvre (2000), housing transcends the physical structure, involving a dialectical relationship between the space conceived, the perceived and the lived. It is central to the production of social space, reflecting social contradictions. Modern urban growth causes fragmentation and segregation, with the capitalist space tending towards homogenization and hierarchization, resulting in precarious housing for marginalized groups. Thus, the construction of quality housing is vital to meet basic needs and allow the appropriation of space, while participatory housing policies can promote a differential space and contribute to socioeconomic development and social transformation.

The construction industry is crucial to mitigate the housing deficit, being a vital sector for economies and responsible for job creation. However, it also negatively impacts environmental, economic, and social conditions. The adoption of eco-efficiency in construction is essential, given the significant amount of waste generated by conventional methods, which harm the environment and sustainable development.

This work presents a prototype of an accessible house for people with special needs, which incorporates sustainability principles, including rainwater harvesting systems and solar energy generation. The selection of materials prioritized those that generate the least environmental impact, considering the availability in the city of Teresina, Piauí.

To address the central question of the research, this study analyzes the cost-benefit of an affordable house with sustainable principles, aligning the project with the budget of track 1 of the Minha Casa Minha Vida program of Caixa Econômica Federal. The objectives include researching eco-efficient techniques for the construction of popular houses, preparing a budget for the eco-efficient house, evaluating the feasibility of the techniques applied and ensuring budget compliance. The general objective is to highlight the benefits of an eco-efficient social interest house, contributing to the improvement of living conditions and promoting socially and environmentally responsible development.

2 THEORETICAL FRAMEWORK

Eco-efficiency is an essential approach to a sustainable future, as highlighted by the World Business Council for Sustainable Development (WBCSD). This concept involves offering goods and services at competitive prices, meeting human needs and improving the quality of life, while progressively reducing environmental impacts throughout the entire life cycle of products. Eco-efficiency seeks production methods that are economically

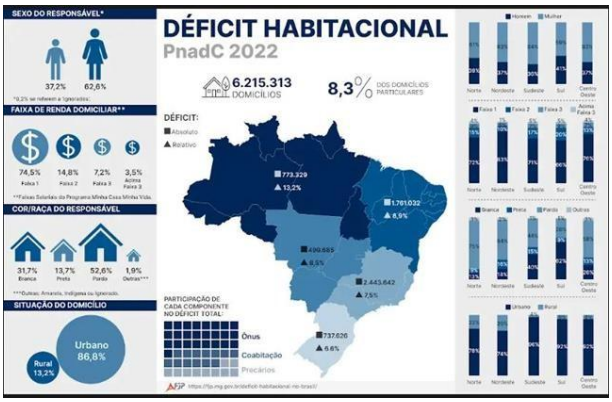
advantageous, minimizing the use of natural resources and promoting a balance between profitability and environmental responsibility.

From 1972, at the United Nations Conference on the Human Environment, sustainability became central to environmental policies, leading to the creation of the 2030 Agenda, which covers 17 Sustainable Development Goals (SDGs) and 169 goals aimed at guaranteeing human rights, eradicating poverty, combating inequalities and tackling climate change. This work focuses on SDGs 11 and 12, which promote sustainable cities and responsible consumption patterns, analyzing methods to minimize the impacts of civil construction.

Housing of popular interest is aimed at the low-income population that does not have access to housing. According to the João Pinheiro Foundation (FJP), the housing deficit in Brazil is estimated at around 6 million households. In Piauí, the state is the fifth with the highest housing deficit, with a rate of 11.5%, according to 2022 data from the Brazilian Institute of Geography and Statistics (IBGE). The housing deficit in Piauí is 153,527 homes, which means that 153,527 families do not have their own home.

Figure 1

Housing deficit data by state in Brazil



Source: FJP, 2022

The Minha Casa Minha Vida Program (PMCMV), launched in 2009, seeks to promote the right to housing and urban development, reducing inequalities and increasing the supply of housing for the low-income population, in addition to generating jobs. These actions are essential to mitigate the housing deficit and improve living conditions in Brazil.

The housing program is divided into the following income niches:

Table 1

Subsidy by income bracket

FAIXA DE RENDA	FAIXA 1	FAIXA 2	FAIXA 3
	até R$ 2640	até R$ 4400	até R$ 8000
VALORES MAXIMOS	R$ 170 mil	R$ 264 mil	R$ 350 mil
SUBSIDIOS	até 95%	até R$ 55 mil	-
JUROS	4% a 5% ao ano	4,75% a 7% ao ano	até 8,16% ao ano

Source: Federal Government. Elaborated by: Author, 2024

According to information provided by the João Pinheiro Foundation (FJP), the state of Piauí occupies the 5th position in the ranking of states with the highest housing deficit rate. As a result of this situation, there is a need for investments in housing construction to mitigate the existing deficit.

The Minha Casa Minha Vida program from 2009 to date has contracted more than 73.2 thousand housing units in Piauí. In the image below is present one of the last contemplation for Piauí 4322 units.

Figure 2

Housing units in the state of Piauí

Source: Ministry of Cities, 2024

Table 2

Occupational deficit by income group

Year	Specification	PMCMV banners				Housing Deficit
		Track 1	Track 2	Track 3	Above Track 3	
2022	Piaui	100.679	14.381	8.300	1.454	124.814

Source: FJP,2022

According to the data observed in the table, the income range of the Minha Casa Minha Vida program with the highest housing deficit in Piauí is range 1. Based on this, the present study sought to design a house with eco-efficiency principles that would fit into this category.

3 METHODOLOGY

According to Sousa et al (2021), bibliographic research is the survey or review of published works on the theory that will direct the scientific work, which requires dedication, study and analysis by the researcher who will perform the scientific work and aims to gather and analyze published texts, to support the scientific work.

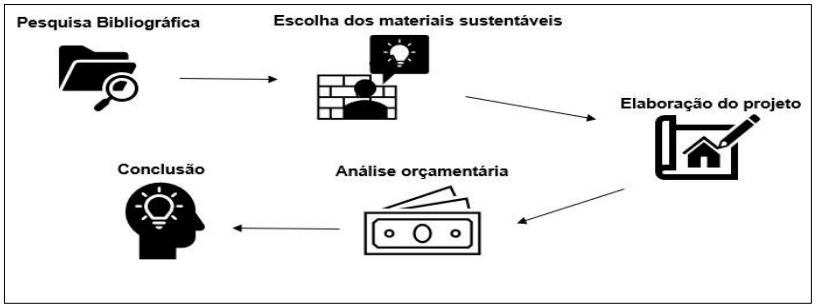
Explanatory research has as its main objective the understanding or explanation, through analyses that use correlations to study relationships between dimensions or characteristics of individuals, groups, situations or events. Explanatory research, as its name implies, will always explain something. (Garces, 2010)

The present research is classified as bibliographic and explanatory that with the collection of data from a documentary research, it is sought to demonstrate the eco-efficiency in the construction of houses of popular interest.

The methodological basis of the study was the guide Sustainability in social housing. First, an understanding of the theme of reducing the impacts generated in civil construction was sought through articles, magazines and monographs. After surveying the possibilities, with the help of the Autodesk Revit computer program, the project of a single-family residence was elaborated, then a budget analysis was made of it, with the objective of proving the economy of the use of the chosen means.

Figure 3

Survey Flowchart



Source: Author, 2024

4 CHOICE OF MATERIALS

Based on the bibliographic research carried out, the following materials and methods were chosen to reduce the impacts on the project design:

- Structural brick:

It promotes cleaner works, with less waste of materials and labor, reducing execution time and cost.

- Sandwich tile:

It has better thermal and acoustic performance, does not require the use of a ceiling and is easy to maintain. It contributes to the reduction of energy consumption, reducing the need for air conditioning and fans.

- Rainwater harvesting system:

Rainwater is not recommended for human consumption due to pollution. According to the UN, each person needs 3,300 liters per month, resulting in about 13,200 liters for a family of four. In the city of Teresina, the average monthly volume of precipitation is 108.6 mm. Using NBR 15527/2019, with a collection area of 74.07 m², it is possible to store approximately 5.47 m³ of water, which covers 19% of the daily consumption of 480 L for a four-person household.

- Water reuse system:

This system allows the capture of water that would otherwise be discarded, which after treatment is stored and used in toilets, irrigation and cleaning, without mixing with the drinking water system.

- Solar energy:

Solar energy is a renewable and sustainable source. For an average cost simulation of R$ 200.00 per month, it is necessary to calculate the number of board modules to meet this demand.

- LED Usage:

LED lamps offer benefits such as energy savings, high durability and do not contain toxic materials, such as mercury, and can be disposed of in a common way, contributing to the preservation of the environment. (Campos, L).

5 DEFINITION AND ELABORATION OF THE PROJECT

For the elaboration of the project, a small house standard was taken into account. From the Autodesk Revit computer program, the floor plan and the 3D were prepared.

The land used in the study is located in the Santa Isabel neighborhood, Rua Estevam Carvalho, 381, which has a size of 38 m x 66 m.

Figure 4

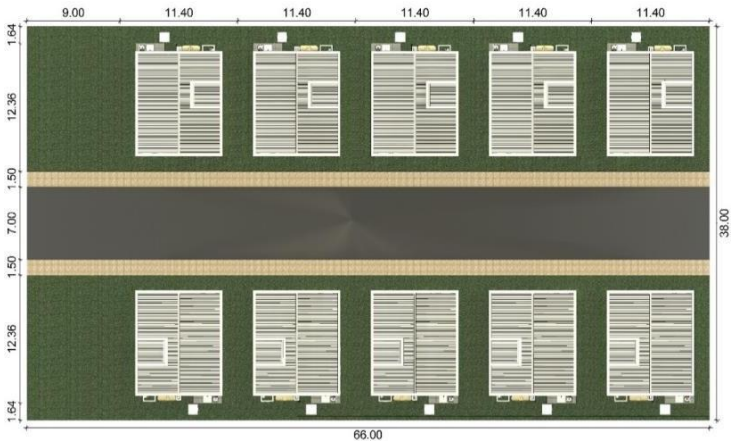
Location of the land

Source: Author, 2024

According to data from the PDOT (Master Plan for Territorial Planning), the parameters of land use and occupation in moderate occupation zone 2 establish a maximum utilization index of 3 and an occupancy rate of no more than 80%. This zone has different degrees of urban infrastructure supply and varied characteristics, including small and non-polluting industries, establishing an urban dynamic compatible with housing and being considered secondary for densification (PDOT, Art 79). Based on these parameters, it was possible to adapt the project to the terrain, predicting the feasibility of a small residential.

Figure 5

Location plan of the houses on the possible land



Source: Author, 2024

The house consists of two bedrooms, a bathroom, a laundry area, a hall, a living/dining room and a kitchen. As a result, it resulted in a project with a total area of approximately 84 m² built.

Figure 6

Floor plan with elevations

Source: Author, 2024

5.1 ENVIRONMENTS

According to ordinance 725, the minimum area for the houses would be 40 m², but as the project provides for a house with accessibility principles, the smallest square footage was 84 m². The following are the requirements present in the ordinance and how they were fulfilled:

a) Ceiling height: minimum 2.6 m, 2.3 m allowed in the bathroom.

Figure 7

Housing section

Source: Author, 2024

As shown in the image, the rules about the ceiling height were obeyed, with the ceiling height higher than the minimum ranging from 3.01 m to 3.25 m in the rooms of the house, as the roof used does not need a ceiling.

Figure 8

Housing section

Source: Author, 2024

b) Minimum program: Living room + 1 double bedroom + 1 bedroom for two people + kitchen + laundry area + bathroom + balcony (for multifamily).

Figure 9

Layout of the dwelling

Source: Author, 2024

All minimum requirements were met according to the design guidelines of Caixa Econômica Federal, which establishes essential parameters for the construction of affordable

housing. The presence of a balcony, although mandatory only for buildings, was incorporated into the house as a differential, considering the common practice in the Northeast region, where balconies are valued as spaces for living and leisure.

I) Double bedroom: Minimum furniture: 1 bed (1.40 m x 1.90 m), 1 bedside table (0.50 m x 0.50 m) and 1 wardrobe (1.60 m x 0.50 m). Minimum circulation of 0.50 m between furniture and walls.

II) Bedroom for two people: Minimum furniture: 2 beds (0.90 m x 1.90 m), 1 bedside table (0.50 m x 0.50 m) and 1 wardrobe (1.50 m x 0.50 m). Minimum circulation of 0.80 m between beds and 0.50 m in other circulations.

III) Kitchen: Minimum width of 1.80 m. Minimum furniture: sink (1.20 m x 0.50 m), stove (0.55 m x 0.60 m) and refrigerator (0.70 m x 0.70 m), with provision for a cabinet under the sink.

IV) Living/dining room: Minimum width of 2.40 m. Minimal furniture: sofas with seats equal to the number of beds, table for 4 people and bookcase/TV cabinet.

V) Bathroom: Minimum width of 1.50 m. Minimum furniture: 1 washbasin without column, 1 toilet with flush box, and 1 box (0.90 m x 0.95 m) with shower point, including space for grab bars.

VI) Service area: Minimum furniture: 1 tank (0.52 m x 0.53 m) and 1 washing machine (0.60 m x 0.65 m), with guaranteed front access for both.

VII) Accessibility: Obstacle-free space in front of the doors of at least 1.20 m. In the restrooms, it must be possible to register a maneuvering module without displacement that allows 360° rotation (D = 1.50 m) (observing item 7.5.c of NBR 9050). In the other rooms, it must be possible to register a maneuvering module without displacement that allows 180° rotation (1.20 m x 1.50 m), free of obstacles, as defined by NBR 9050, with the exception of the balcony, which must be integrated into the adapted units.

Figure 10

Accessibility plan

Source: Author, 2024

6 ECONOMY

Each material and method used in the project was selected with a view to savings. The bibliographic research, as mentioned in the methodology, helped in the choice of the best resources.

In the study by Dias (2019), structural masonry is highlighted for its advantages, such as easy access to materials and agility in the construction method, and is therefore applied in the project. Gomes (2023) points out that thermoacoustic tiles reduce air conditioning costs and increase productivity; Thus, the sandwich tile was implemented, especially considering the high temperatures in the region.

The reuse and collection of rainwater were incorporated into the project to promote savings in the use of water, an increasingly scarce resource. In addition, Villalva and Gazoli (2012) state that solar energy is the main renewable source, chosen for its ability to meet energy needs in a sustainable way.

Finally, Campos et al. (2012) indicate that replacing 5 million mercury vapor lamps with LED lamps could significantly reduce CO2 emissions. LED lamps, because they do not contain toxic materials and because of their energy efficiency, were adopted in the project.

7 BUDGET ANALYSIS

The quantities that appear in the spreadsheet were extracted through the house project made in Autodesk Revit, then inserted in Excel. The discount of spans was considered, in all areas surveyed in the project.

The budget comparison was made with the help of the computer tool Orçafascio and Excel, using parameters obtained by the National System of Research on Costs and Indices of Civil Construction (SINAPI), the Sergipe Construction Budget System (ORSE), the SBC Base and the Secretariat of Infrastructure (SEINFRA).

The basis for the elaboration of the sustainable project was mainly aimed at the financial and environmental side, proving that sustainable practices can be applied in social interest contracts, which was shown through the spreadsheet, which exposes the practices used in the projected house.

8 RESULTS AND DISCUSSIONS

8.1 BASIC UNIT COST

The Basic Unit Cost (CUB) is an economic index widely used in Brazil to measure the cost of building real estate. It serves as a basis for estimating expenses in civil construction projects, and is widely adopted by engineers, architects, builders, and developers.

Figure 11

Acronym used by the CUB

R1-B	***Residência unifamiliar padrão baixo:*** 1 pavimento, com 2 dormitórios, sala, banheiro, cozinha e área para tanque.

Source: CUB, 2024.

Figure 12

Reference value for low-standard houses

VALORES EM R$/m²

PROJETOS - PADRÃO RESIDENCIAIS

PADRÃO BAIXO	
R-1	1.482,99
PP-4	1.416,01
R-8	1.332,82
PIS	976,88

Source: CUB, 2024

Thus, for the calculation of the parametric budget we have:

Total project area m²x CUB = 84 X 1482.99 = R$ 124,571.16

8.2 SUMMARY BUDGET

Following the flowchart of the research, after the bibliographic review and choice of materials, the house was designed with a built area of approximately 84 m², the project elaborated was used as a parameter to obtain the budget, it was sought to detail the stages of construction and verify at the end if the value of the house fits within the limit of the category "band 1" of my house my life (MCMV).

Table 3

Synthetic budget of the projected house

Synthetic budget				
Description	**Un.**	**Quant**	**V. unit.**	**Total**
Foundation				**R$ 11.594,35**
Excavation				**R$ 663,31**
Mechanized excavation	m³	16,78	R$ 39,53	R$ 663,31
Trench bottom preparation				**R$ 1.905,70**
Trench compaction	m²	31,03	R$ 8,47	R$ 262,82
Lean concrete ballast.	m³	1,55	R$ 917,92	R$ 1.422,77
90 l jerica horizontal transport	m3xkm	0,216	R$ 1.019,07	R$ 220,11
Concreting				**R$ 6.698,48**
Concrete footing, fck 30 MPa.	m³	4,65	R$ 774,37	R$ 3.600,82
Formwork for footing.	m²	18,77	R$ 129,77	R$ 2.435,78
90 l jerica horizontal transport.	m3xkm	0,6495	R$ 1.019,07	R$ 661,88
Frame				**R$ 2.326,86**
Steel shoe frame ca-50 10 mm	Kg	173,07	R$ 11,59	R$ 2.005,88
Horizontal steel transport d= 10 mm.	kgxkm	25,96	R$ 2,07	R$ 53,73
Manual backfill of trenches.	m³	10,58	R$ 25,26	R$ 267,25
Superstructure				**R$ 18,313.93**
Structural masonry				**R$ 18,313.93**
Structural masonry 14x19x39.	m²	177	R$ 69,81	R$ 12.356,37
Vertical masonry frame structure. d=10mm.	Kg	26,51	R$ 9,67	R$ 256,35
Masonry strap frame structure. d= 10 mm.	Kg	37,39	R$ 9,16	R$ 342,49
Cutting and bending of CA-50 steel, d= 10.0 mm.	Kg	63,9	R$ 8,25	R$ 527,17
Frame lintel/white lintel. Estr. d= 8.	Kg	20,58	R$ 14,82	R$ 304,99

Cutting and bending steel CA-50 d= 8.0 mm.	Kg	20,58	R$ 8,97	R$ 184,60
Vertical grouting	m³	1,05	R$ 1.220,52	R$ 1.281,54
Grouting of upper belt.	m³	1,94	R$ 1.185,44	R$ 2.299,75
Horizontal transport steel d= 8 mm.	kgxkm	1,88	R$ 3,24	R$ 6,09
Horizontal steel transport d= 10 mm.	kgxkm	15	R$ 2,07	R$ 31,05
90 l jerica horizontal transport.	m3xkm	0,71	R$ 1.019,07	R$ 723,53
Frames				**R$ 8.254,12**
Aluminum sliding window 2 leaves for glasses.	m²	10,5	R$ 349,11	R$ 3.665,65
Aluminum maxim-air type window.	m²	0,24	R$ 674,94	R$ 161,98
Manual horizontal transport, window.	m2xkm	1,611	R$ 37,82	R$ 60,92
Wooden door 80x210cm.	un	2	R$ 353,37	R$ 706,74
Aluminum door 1 sliding leaf	m²	1,68	R$ 506,48	R$ 850,88
Aluminum shutter door	m²	1,68	R$ 593,29	R$ 996,72
Aluminum door to open with lambri.	m²	1,89	R$ 745,68	R$ 1.409,33
Manual horizontal transport, door.	Unxkm	5	R$ 80,38	R$ 401,90
Coatings				**R$ 22.146,6**
Single mass 1:2:8 line (area 5m² to 10m²).	m²	36	R$ 26,01	R$ 936,36
Single mass 1:2:8 (area >10m²).	m²	282	R$ 33,42	R$ 9.424,44
90 l jerica horizontal transport.	m3xkm	0,912	R$ 1.019,07	R$ 929,39
Ceramic coating 25x35cm (1/2 height).	m²	4	R$ 73,48	R$ 293,92
Ceramic coating 33x45cm (1/2 height).	m²	11	R$ 78,04	R$ 858,44
Ceramic coating 20x20cm (1/2 height).	m²	8	R$ 64,86	R$ 518,88
Ceramic baseboard 7cm high.	m	59,92	R$ 6,90	R$ 413,44
Horizontal transport cover. ceramic.	m2xkm	11,46	R$ 30,37	R$ 348,04
Horizontal transport, of 18 liter can.	LXKM	71,14	R$ 2,10	R$ 149,39
Acrylic sealer base.	m²	295	R$ 4,03	R$ 1.188,85
Economical acrylic latex paint.	m²	295	R$ 8,61	R$ 2.539,95
Pva coral putty (18l) on plaster	m²	295	R$ 15,36	R$ 4.531,20
Horizontal transport, of 18 liter can.	LXKM	6,81	R$ 2,10	R$ 14,30
Floors				**R$ 9.491,59**
Subfloor mortar 1:4 ratio.	m²	15	R$ 61,23	R$ 918,45
Subfloor mortar line 1:4 (á. Dry).	m²	62	R$ 52,49	R$ 3.254,38
Horizontal transport with 90 l jerica	m3xkm	0,46	R$ 1.019,07	R$ 468,77
Ceramic floor 35x35cm (area 5m2 to 10m2).	m²	15	R$ 54,36	R$ 815,40
Ceramic floor 35x35cm (area>10 m2)	m²	62	R$ 47,54	R$ 2.947,48
Horizontal transport, coating. ceramic.	m2xkm	10,95	R$ 30,37	R$ 332,55

Execution of the intertr. 20x10 cm, thickness 6 cm.	m²	10,48	R$ 72,00	R$ 754,56
Cover				**R$ 22,161.65**
Met. tile thermoacúst. E=30mm,2 waters.	m²	84,07	R$ 180,70	R$ 15.191,45
Steel Weft Purlins for Roofing (2 pitches.)	m²	84,07	R$ 46,69	R$ 3.925,23
Gutter in galvanized steel sheet n 24.	m	11,2	R$ 82,56	R$ 924,67
Concrete	m	34	R$ 34,52	R$ 1.173,68
Rufo in galvanized steel sheet n 24.	m	18	R$ 52,59	R$ 946,62
Facilities				**R$ 28,714.47**
Electric				**R$ 12,552.26**
Single switch point including wiring	un	8	R$ 78,04	R$ 624,32
Plafon type luminaire, with 12/13 w led.	un	8	R$ 32,97	R$ 263,76
Ceiling light point, box and wiring	un	8	R$ 198,12	R$ 1.584,96
Power consumption measurement point	un	1	R$ 2,644.32	R$ 2,644.32
100w outlet point installation	un	14	R$ 223,11	R$ 3.123,54
Solar energy generator kit 2.22 kwp	un	1	R$ 4.311,36	R$ 4.311,36
Hydraulics				**R$ 1.543,45**
Cold water point for tank	un	1	R$ 460,15	R$ 460,15
Cold water point for toilet	un	1	R$ 81,54	R$ 81,54
Cold water point in a washbasin pipe	un	1	R$ 70,70	R$ 70,70
Cold water point sink w/basin w/mat.	un	1	R$ 638,65	R$ 638,65
Cold water point in pvc pipe shower	un	1	R$ 79,25	R$ 79,25
Hydrometer dn 3/4", 5.0 m3/h.	un	1	R$ 145,90	R$ 145,90
Flying ball valve, dn 50 mm.	un	1	R$ 67,26	R$ 67,26
Health				**R$ 2.960,66**
Sewer point tank and washbasin type 10.	En	3	R$ 272,82	R$ 818,46
Sanitary point, material and execution	En	3	R$ 256,62	R$ 769,86
Primary sanitary sewer point (VASO)	un	1	R$ 405,37	R$ 405,37
Sewer-siphoned box 150x150x50mm	un	3	R$ 306,81	R$ 920,43
Pineapple cast iron drain 150mm	un	1	R$ 46,54	R$ 46,54
Water reuse/rainwater harvesting				**R$ 7520,03**
Masonry strut. ceramic blocks 14x19x39	m²	1	R$ 69,81	R$ 69,81
Waterproofing in an underground cistern	m²	3	R$ 58,78	R$ 176,34
Manual digging trench prof. up to 1.30 m.	m³	0,6	R$ 81,65	R$ 48,99
1/3 hp centrifugal pump	un	1	R$ 782,57	R$ 782,57
Water tank in polyethylene, 500 liters.	un	1	R$ 331,90	R$ 331,90
Concrete plate cover thickness 5cm	m²	1	R$ 65,27	R$ 65,27
PVC pipe, R series, rainwater, DN 50 mm.	m	19,5	R$ 18,58	R$ 362,31

Tube, PVC, Weldable, DN 25 mm,	m	9,88	R$ 5,88	R$ 58,09
Single glove, pvc, r series, dn 50 mm	un	1	R$ 14,06	R$ 14,06
Knee 90 degrees, PVC, R series, DN 50 mm.	un	4	R$ 14,12	R$ 56,48
Knee 90 degrees, PVC, weldable, DN 25mm.	un	5	R$ 4,87	R$ 24,35
Hor. , threadable, 3/4".	un	1	R$ 118,14	R$ 118,14
Ball register, pvc, weldable dn 50 mm.	un	1	R$ 67,26	R$ 67,26
Flange/ring seal adapter, dn 25mmx3/4.	un	4	R$ 17,26	R$ 69,04
Vertical cistern 1000 liters with filter	un	1	R$ 2.849,99	R$ 2.849,99
Precast slab.	m²	6	R$ 193,46	R$ 1.160,76
Filter for reuse water.	un	1	R$ 1264,67	R$ 1264,67
Appliances, metals and countertops				**R$ 4.138,07**
Conventional siphoned toilet.	un	1	R$ 739,15	R$ 739,15
Suspended synthetic marble tank.	un	1	R$ 345,80	R$ 345,80
Stainless steel built-in sink.	un	1	R$ 285,01	R$ 285,01
Shower.	un	1	R$ 126,14	R$ 126,14
Chrome table faucet, 1/2" or 3/4".	un	2	R$ 78,72	R$ 157,44
Chrome faucet 1/2" or 3/4".	un	1	R$ 57,49	R$ 57,49
Long chrome faucet 1/2" or 3/4"	un	1	R$ 92,10	R$ 92,10
"L" grab bar 70 x 70 cm.	un	1	R$ 625,16	R$ 625,16
"L" grab bar 80 x 80 cm.	un	1	R$ 687,47	R$ 687,47
1" plastic valve for sink.	un	4	R$ 9,44	R$ 37,76
Flexible type siphon in pvc 1 x 1.1/2.	un	4	R$ 12,00	R$ 48,00
Flexible coupling 1/2" x 40cm.	un	4	R$ 11,93	R$ 47,72
Marble countertop 120 x 60cm.	un	1	R$ 340,71	R$ 340,71
Horizontal transport, benchtop.	Unxkm	0,15	R$ 80,38	R$ 12,05
Polar white granite countertop	m²	0,8	R$ 670,09	R$ 536,07
Grand total	**R$ 120,676.71**			

Source: Author, 2024

Comparing the value found by the Basic Unit Cost (CUB) to the budgeted value, it was noticed that the house with sustainable principles ended up with a value 3.13% lower than the average price of low-standard houses in Piauí, a saving of approximately R$ 3894.45 reais.

9 CONCLUSION

In view of environmental issues, the need to reduce waste generated by civil construction, which affects sustainable development, was highlighted. The project proposed

strategies for this reduction, including the replacement of materials and the adoption of eco-efficient practices.

As for the results of the study, the information obtained showed that the possibilities of methods and materials, in addition to being eco-efficient, provide savings in their use. In addition, it was demonstrated that the application of these methods and materials results in a housing cost compatible with the maximum limit for financing the Minha Casa Minha Vida Program, which is R$ 170,000.00 for families with an income of up to two minimum wages. The amount found in the project's budget was R$ 120,676.71, which shows the feasibility for the category 1.

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