

Comparative analysis of social housing in Brazil and Colombia from a resilient design perspective

Study cases: Passo Fundo and Tunja

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Abstract: With the accelerated growth of Latin American cities during the last decades, civil construction has skyrocketed considerably. With this, an increase in the demand for social housing, especially in the middle cities due to the search of the inhabitants to improve their quality of life and comfort. However, one of the biggest consequences of this urban growth is its environmental impact and therefore the increase in the effects of climate change. The objective of the work is to compare the characteristics of social housing projects in two medium cities in Latin America (Passo Fundo and Tunja). To this end, three methodological stages were proposed: geolocation, area/cost analysis and materiality analysis, which will allow, in addition to identifying relevances and singularities, to discuss their resilience potential. The overall picture of social housing in these cities was found to be very similar to each other. Likewise, it was concluded that, among other things, from the perspective of resilience, low environmental impact materials are not being used for the construction of these homes, despite the growing attempt to achieve more sustainable projects in the region.

Key words: quality of social housing; climate change; sustainability; construction technologies; clean technologies

1 Introduction

Latin America and the Caribbean are the most populous regions in the world, with nearly 80% of their inhabitants living in major cities (Hernández Moreno et al., 2021), which has led to high demand for housing, particularly social housing. However, over the past four years, a large portion of this population has moved to areas surrounding major capitals in search of a better quality of life (Joaquín Enrique, 2021). In fact, authors such as Kalinoski, Spinelli (2020), and Libertun de Duren (2017) assert that these cities are currently the focus of investment for social housing projects.

This trend intensified with the onset of the COVID-19 pandemic, which spurred construction and, in turn, the growth of intermediate cities. However, one of the major consequences of this urban growth is its environmental impact and, consequently, the exacerbation of climate change effects. For example, according to the report on "Development of Energy Poverty Indicators in Latin America and the Caribbean"(Calvo et al., 2021), environmental comfort conditions — a consequence of climate change—are considered critical for most countries in this region.

In this regard, as Espinosa and Fuentes (2015) argue, the discipline of architecture must provide suitable conditions for people and their relationship with the environment; therefore, it must be capable of incorporating climatic and contextual factors to work with them and achieve comfortable environments. From this perspective, the concept of resilient design—understood, in this case, as the intentional design of buildings to adapt to the expected impacts of global warming

(such as extreme temperatures) (Resilient Design Institute, 2020)—becomes crucial for addressing such challenges, where these cities represent an opportunity.

Thus, knowing that it is necessary to develop resilient social housing that strengthens sustainability in medium-sized Latin American cities, we must ask: what is the current general and constructive panorama for social housing in these cities?

To answer this question, two cities in South American countries were selected as case studies: Passo Fundo (Brazil) and Tunja (Colombia).

Brazil, in the wake of the 2008 global crisis, spurred growth in civil construction, and since 2009 has been implementing the program "Minha Casa, Minha Vida" (Brazil et al., 2016; Federal Government, 2020). This is a Federal Government program aimed at promoting the construction of housing units for families from various socioeconomic backgrounds across the country, through which a large portion of social housing projects are carried out.

Colombia, on the other hand, does not have a program as consolidated as "Minha casa, Minha vida," although subsidies do exist to help people access social housing. In addition, housing policies vary from one administration to the next (every four years), leading to a lack of continuity in various processes. For example, the latest proposed program, called "Mi casa ya," is focused on the youth population but replaces the VIPA program for savers, which is reaching its final stage (Arredondo Daza, 2019; Ministry of Housing, 2020).

That being the case, Passo Fundo and Tunja are mid-sized cities that share similar conditions in terms of climate, population, and size. With this in mind, the objective of this article is to compare the characteristics of social housing projects in both locations and highlight aspects such as their location, floor area/cost, and materials used. This will allow us to identify their most relevant features, as well as their differences, and discuss their potential for resilience.

2 Methodology

The methodology of this study is qualitative and exploratory in nature; documentary and bibliographic research is used to obtain the data.

That said, the following section presents a characterization of the cities selected for the study, followed by the research stages.

2.1 Study contexts

2.1.1 Passo Fundo

It is a medium-sized Latin American city located in southern Brazil. It belongs to the state of Rio Grande do Sul and covers an area of approximately 459.4 km² (see Figure 1). This indicates that, despite being a medium-sized city, it is the largest in the northern part of this state. Furthermore, according to the Brazilian Institute of Geography and Statistics (IBGE) (2021), Passo Fundo has an estimated population of 206,103 inhabitants, which also makes it the most populous and urbanized area in the region. On the other hand, its climate is humid subtropical, according to the Köppen classification [i] . Regarding its main economic activities, it stands out for services in the health and education sectors (ACISA, 2019).

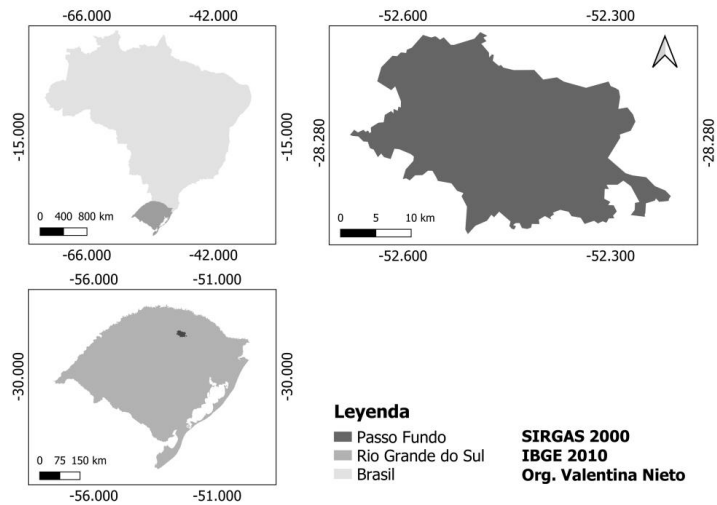


Figure 1. Location of Passo Fundo. Source: own elaboration

2.1.2 Tunja

It is a medium-sized Colombian city located in the center of the country (see Figure 2). It is the capital covers an area of 121.5 km² with a population of approximately 180,568, according to projections from the latest national census (DANE, 2019). In terms of climate, Tunja has a temperate and humid climate, according to the Köppen classification, as it is located in an intertropical zone. It stands out as an emerging university city that has preserved its original historic district (Roa, n.d.).

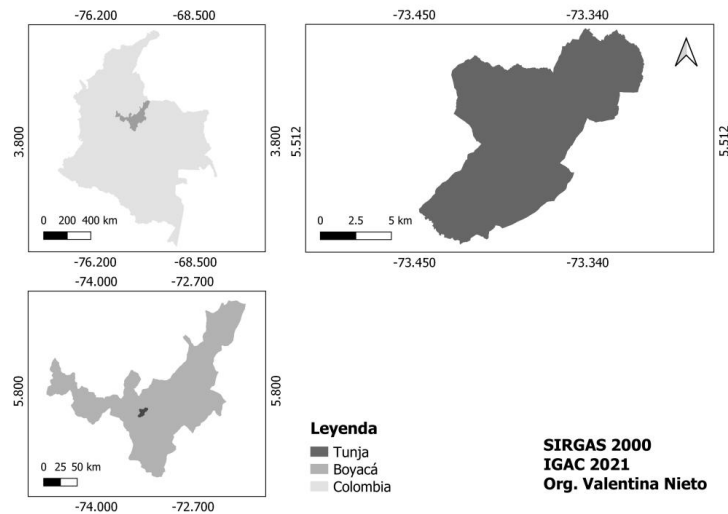


Figure 2. Location of Tunja. Source: own elaboration

2.2 Stages

2.2.1 Geolocation

The study begins by mapping the locations of the main social housing projects in the selected cities using QGIS software. In this first stage, location and density characteristics are analyzed using tools such as heat maps.

2.2.2 Area or cost analysis

In a second stage, general aspects of the projects are compared, such as the number of units, their respective floor areas, and the approximate economic values established for these homes.

2.2.3 Materiality analysis

Finally, the physical attributes of the projects in question are analyzed. In this case, particular attention is given to the construction systems used and the building heights, and the characteristics of the building envelope are discussed.

3 Results

3.1 Geolocation

On one hand, the 10 projects of Range I of the 'Minha Casa Minha Vida' Program in Passo Fundo were located, which correspond to social housing. It was found that, for the most part, these projects are located in residential areas near the outskirts of the city's urban area (see Figure 3). For this reason, these projects are close to areas with abundant vegetation but are far from the municipality's main service areas.

On the other hand, Figure 4 shows the 10 most representative social housing buildings in Tunja. In this second case, it was observed that, although a high percentage is also located toward the outskirts, the projects are more dispersed within the city's urban perimeter. This increases their proximity to the various services needed by their residents.

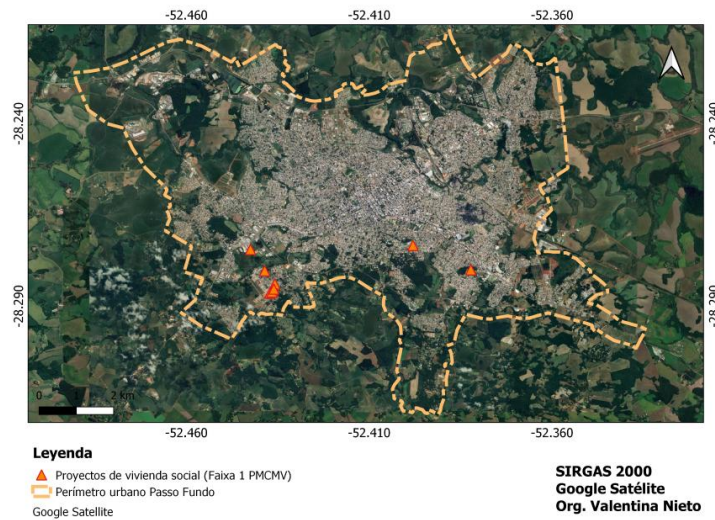


Figure 3. Geolocation of Social Housing Projects in Passo Fundo. Source: own elaboration

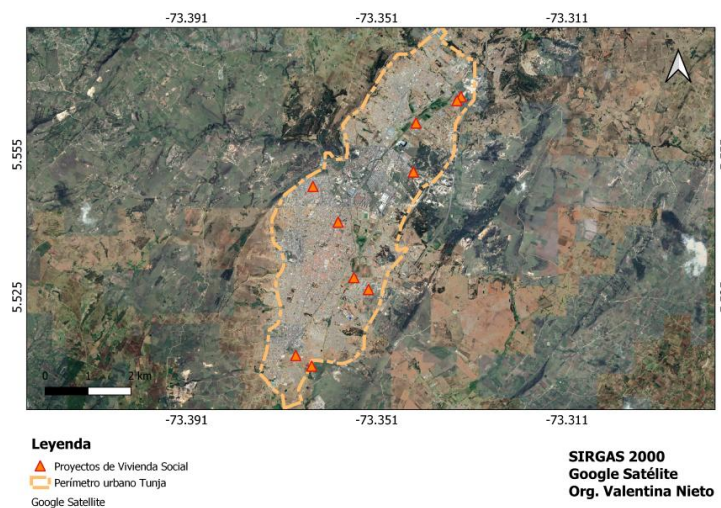


Figure 4. Geolocation of Social Housing Projects in Tunja. Source: own elaboration

Likewise, it was found that these projects tend to be located together or close to one another. However, as shown in

Figure 5, this concentration is greater in the Brazilian city, where they are concentrated in the southwestern area. In the Colombian city, although there is greater dispersion among the buildings mentioned, there is a concentration toward the northern and southern ends.



Figure 5. Heat maps of Passo Fundo and Tunja. Source: own elaboration

3.2 Area or cost analysis

Once the previous stage was completed, the number of housing units in each selected project was identified, along with their areas and costs, based on information provided by the construction companies on their websites (Tables 1 and 2). In this regard, it was observed that in Passo Fundo the number of units tends to be lower (24 to 100) than in Tunja, where, in general, projects exceed 100 units.

Similarly, when comparing the sizes of these housing units, it was found that, in the case of Passo Fundo, the sizes range from approximately 40 m² to 50 m². Meanwhile, for Tunja, the range is wider, as it includes some apartments ranging from 29 m² to 60 m². However, the majority of them fall within the same range as those in the city of Brazil.

With regard to the prices set for these homes, it was necessary to convert the figures given in each country's local currency (Brazilian reais and Colombian pesos) into U.S. dollars in order to compare them and view them from a global perspective. In this way, it was determined that the costs of social housing are very similar in both countries (\$32,570.62 and \$31,174.18, respectively). Despite this, it can be said that, in the case of Brazil, although the units tend to be smaller, their prices are slightly higher than in the second country.

Table I. Data on Social Housing Projects in Passo Fundo (PMCMV Tier I)

Passo Fundo				
	Project name	Number of Units	Unit Area (m ²)	Approximate Unit Value (US Dollars)
1	Donaria II	58	44.7	\$ 30,522.15
2	Bosque das Cerejas	24	50.45	
3	Bosque das Pitangas	24	42	
4	Bosque Uvaías	24	40.47	
5	Residencial Recanto Planaltina I e II	220	42.03	
6	Bosque dos Araças	100	45	\$ 34,619.09
7	Bosque dos Araticuns	24	40.47	

Source: own elaboration

Table 2. Data on Social Housing Projects in Tunja

Tunja						
	Project name	Number of Units	Unit Area (m ²)			Approximate Unit Value (US Dollars)
1	Oikos Monte Verde Reservado	48	58.36	53.1	26.42	\$ 34,820.96
2	Terranova Coral		48	56		\$ 28,734.43
3	Urbanización Remansos de San Francisco	189	50.16			\$ 23,517.05
4	Argami	250	37	82		\$ 30,627.09
5	Amalfi	143	45	43		\$ 37,902.37
6	Avium Tunja	416	54			\$ 41,074.60
7	Mirador de San Carlos	246	29.93	34.11	42	\$ 22,901.75
8	Manta Real	572	61.14	49.15	52.79	\$ 22,252.98

Source: own elaboration

3.3 Materiality analysis

Finally, the physical characteristics of the housing units were examined, particularly their building envelope and construction systems, as these are key factors when discussing sustainability and resilient design. To this end, the three most representative projects in both cities were used as a reference (see Figure 6). First, it was observed that housing projects in Tunja are characterized by their height, as they generally exceed five stories, unlike the projects in Passo Fundo.

Regarding construction systems, it was found that a common feature in both cases is the reinforced concrete structure and enclosure of masonry (Pedott et al., 2020). Nevertheless, in the case of the Colombian city, structural masonry and industrialized tunnel-type systems are also common (Fonseca Granados, 2019). Additionally, it was found that in Tunja, exposed brick facades are traditional, whereas in Passo Fundo, facades usually feature exterior cladding and paint.



Figure 6. Social Housing Projects in Passo Fundo and Tunja. Source: Google satellite (accessed May 2022). Sources: retrieved from Google street view

From the perspective of sustainability and resilience, the building envelope plays a fundamental role in light of the effects of climate change, as it is the element through which heat gain and loss occur. For this reason, an important aspect to examine, among others, is its thermal transmittance or U-value, which, the lower it is (less than 2), the better it will insulate against the outdoor climate. In line with the above, Table 3 describes the main characteristics of the building envelope types most commonly used in social housing projects in these cities.

Table 3. Characterization of the social housing envelope in Passo Fundo and Tunja. Based on the work carried out by Granados (2019)

System/Envelope		Characteristics	U-Value
Passo Fundo and Tunja	Confined Masonry	It is based on the placement of masonry units forming a wall that is then confined with cast-in-place beams and columns. Reinforcement is placed within the confinement beams and columns. For the wall to be structural, it must continue from the foundation to the roof to resist horizontal forces and vertical loads. On the other hand, there are non-structural confined walls, which do not support loads other than their own weight. Their function is to separate and delimit spaces.	2.84 w/m ² K
Tunja	Industrialized System	It is composed of panels and reinforced concrete walls with high-strength welded wire mesh. This system delivers good on-site performance and better resource utilization, as it is a type of mass production. In this case, by using modular metal formwork, standardized housing units can be generated, which increases construction speed and reduces the number of on-site personnel.	2.95 w/m ² K
	Structural Masonry		
	Reinforced Cavity Masonry	It is a type of masonry with parallel faces, which may or may not be reinforced, separated by a continuous reinforced concrete cavity.	2.86 w/m ² K

4 Discussion

According to Valladares (2020b), over the past decade, governments in Latin America and the Caribbean have incorporated social housing development plans to meet the growing demand for housing. However, these programs generally do not take into account the use of clean materials and technologies in their design and construction processes (Cubillos – González and Cardoso, 2020) or, in some cases, such as in Colombia, it is an optional decision for the construction companies involved in these projects.

For example, in Tunja, according to authors such as Mendoza, Burbano (2021), and Salingaros et al. (2019), some users rate social housing projects as average from a physical and environmental perspectives. Conversely, they have a positive view of the layout of interior spaces, although construction materials are also rated as average.

Meanwhile, in Passo Fundo, despite the adoption of BIM, constructive solutions, and the creation of the sustainability certification 'Sello Azul' (Blue Seal), the situation has not changed significantly enough in the "Minha Casa Minha Vida" program. This is because, in the 10 years since the certification was created, few projects across the entire program have been validated and certified as meeting the necessary sustainability requirements (Cardoso et al., 2019).

Given the above, optimizing the building envelope in affordable residential buildings could significantly contribute to climate change resilience in Latin American cities, as it extends indoor thermal comfort and reduces the costs of using active systems in the medium and long term. An example of this is the study conducted by Tubelo et al. (2021), which found that building envelope optimization options with the smallest increase in initial costs (12% and 9%) showed a

significant improvement in indoor thermal conditions (40% and 45%). Likewise, the optimization options with the highest initial costs (57% and 65%) improve comfort conditions by 76% and 73%.

In this regard, as Cubillos–González (2019) notes, in order to incorporate the use of clean technologies and achieve resilient social housing, it is also essential to strengthen certain factors, such as: credit support, government subsidies for innovation in the sector, and the identification of companies' innovation capabilities. Furthermore, promoting the creation of regulations that mandate the implementation of these technologies in construction so that builders are compelled to design according to sustainability parameters (Cubillos–González et al., 2020).

5 Final considerations

Based on the results obtained, it can be said that the general panorama of social housing in Latin American mid-sized cities is very similar to each other. Among the common features is the location of these projects in areas near the outskirts of the cities. In addition, it is observed that the average floor area for the units

The living area of these homes generally ranges between 40 m² and 50 m². Similarly, the cost of these homes averages \$30,000 in each city. However, the area-to-cost ratio is slightly better in the city of Colombia, as it offers units with both larger floor areas and lower costs.

Regarding construction characteristics and materials, the most commonly used systems in both cases are reinforced concrete structures and confined masonry. However, the industrialized system is also becoming prevalent in Tunja. This situation can be explained by the difference in height among the social housing units in each city, as low-rise projects predominate in Passo Fundo, whereas in the Colombian city these projects are five stories or taller.

Furthermore, from a resilience perspective, it is recognized that materials with low environmental impact are not being used for the construction of social housing in the study areas, despite growing efforts to achieve more sustainable projects in the region. This is a consequence of the prevailing economic interests of construction companies and, consequently, the low interest in innovation due to some of these countries.

For future studies, it is recommended to evaluate primarily aspects of both interior and exterior design to obtain a more detailed overview of the characteristics of these homes and to consider more appropriate solutions based on resilient design parameters. Integrating aspects of flexibility, technology, and innovation into these projects can extend the life cycle of social housing and make it more sustainable over time, addressing current and future demands related to climate variability in mid-sized cities in Latin America.

Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

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Note

[i] The Köppen system establishes the boundaries between one climate and another, taking into account the distribution of vegetation, temperatures, mean annual and monthly precipitation, and the seasonality of precipitation.