FROM INFORMAL SETTLEMENTS TO SERIAL HOUSING IN BRAZIL: CONFLICTS AND SPATIAL FRAGMENTATION IN THE ADAPTATION TO A NEW FORM OF LIVING

Gianna Monteiro Farias Simões[*,**]
Solange Maria Leder[**,***]

*Universidade Federal Rural do Semi-Árido, Departamento de Ciência e Tecnologia, Mossoró, RN, Brazil
**Universidade Federal da Paraíba, Programa de Pós-graduação em Arquitetura e Urbanismo, João Pessoa, PB, Brazil
***Universidade Federal da Paraíba, Programa de Pós-graduação em Engenharia Civil e Ambiental, João Pessoa, PB, Brazil

Abstract

The rehabilitation of vulnerable populations from informal settlements is not limited to the provision of formal housing; the challenges of adapting to the housing unit are diverse. Thus the aim of this study was to analyze how a vulnerable population adapts to serial housing, focusing on conflicts and spatial fragmentation. The field research involved on-site assessments, observations and semi-structured interviews inside 156 housing units in Brazil. The difficulties related to this adaptation are diverse: the reduced size of the areas in the housing unit and the lot; the difficulty of extending the housing unit; low-quality materials; the lack of a place or area to generate income; the lack of social ties with the neighborhood; the lack of privacy; spatial fragmentation with divisions and private constructions in non-occupiable areas of the lot (setbacks and clearances) and the invasion of public areas. The adaptation process to the formal, serial housing unit particularly involves conflicts among neighbors. One of the consequences of failing to adapt to "formality" is the sale or rent of the housing unit, with 19.0% of housing units of the sample being occupied by non-original beneficiaries.

Keywords

Rehabilitation of vulnerable populations; Spatial adaptation; Neighborhood conflict; Fragmentation; Economic vulnerability.

DO ASSENTAMENTO IRREGULAR PARA A HABITAÇÃO SERIADA NO BRASIL: CONFLITOS E FRAGMENTAÇÃO ESPACIAL NA ADAPTAÇÃO A UMA NOVA FORMA DE MORAR

Gianna Monteiro Farias Simões[*,**]
Solange Maria Leder[**,***]

*Universidade Federal Rural do Semi-Árido, Departamento de Ciência e Tecnologia, Mossoró, RN, Brasil
**Universidade Federal da Paraíba, Programa de Pós-graduação em Arquitetura e Urbanismo, João Pessoa, PB, Brasil
***Universidade Federal da Paraíba, Programa de Pós-graduação em Engenharia Civil e Ambiental, João Pessoa, PB, Brasil

Resumo

O processo de reabilitação de população vulnerável não se resume à oferta de uma moradia formal; os desafios de adaptação à unidade habitacional são diversos. Assim, o objetivo deste estudo é analisar a adaptação à moradia seriada de população de risco, com foco nos conflitos e na fragmentação espacial. A pesquisa de campo compreendeu medições in loco, observações e entrevistas semiestruturadas no interior de 156 unidades habitacionais no Brasil. As dificuldades relacionadas a essa adaptação são diversas: o tamanho reduzido da área da unidade habitacional e do lote; a dificuldade de ampliação da moradia; a baixa qualidade dos materiais; a ausência de um local ou área para geração de renda; a ausência de laços sociais com a vizinhança; a falta de privacidade; a fragmentação espacial com divisões e construções privativas de áreas não ocupáveis do lote (recuos e afastamentos) e invasão em áreas públicas. O processo de adaptação à moradia formal e seriada envolve especialmente conflitos de vizinhança. Uma das consequências da inadaptação à "formalidade" é a venda ou aluguel da moradia, com 19,0% dos domicílios da amostra ocupados por beneficiários não originários.

Palavras-chave

Reabilitação de População Vulnerável; Adaptação Espacial; Conflitos de Vizinhança; Fragmentação; Vulnerabilidade Econômica.

FROM INFORMAL SETTLEMENTS TO SERIAL HOUSING IN BRAZIL: CONFLICTS AND SPATIAL FRAGMENTATION IN THE ADAPTATION TO A NEW FORM OF LIVING[1,2]

Gianna Monteiro Farias Simões
Solange Maria Leder

1. Introduction

A quantitative solution alone is inadequate to tackle the housing deficit (Bergan, 2005). The rehabilitation process of vulnerable populations is not limited to providing formal housing: adapting to the housing unit presents a variety of challenges, which are not confined to the Brazilian context (Sholihah; Shaojun, 2018; Sunikka-Blank, Bardhan; Haque, 2019; Debnath; Bardhan; Sunikka-Blank, 2019; Lueker; Bardhan; Sarkar; Norford, 2020; Debnath; Simões; Bardhan; Leder; Lamberts; Sunikka-Blank, 2020; Sarkar; Bardhana, 2020).

Aspects such as the poor quality of housing units (Mendes, 2014; Berr; Echeveste; Lorenzi; Formoso, 2015; Addo, 2015; Tubelo; Rodrigues; Gillott; Soares, 2018) and the inability of families to adapt to this new condition have, as a consequence, caused the house to be sold (Pequeno; Rosa, 2015; Elkady; Fikry; Elsayad, 2018; Sunikka-Blank; Bardhan; Haque, 2019; Debnath; Bardhan; Sunikka-Blank, 2019; Sarkar; Bardhana, 2020), which may imply that the family will return to a condition of vulnerability.

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In order to help families to adapt to the housing unit, several studies have suggested an increase in the constructed area of social housing, as a way of adjusting the unit to the needs and expectations of the family (Szucs, 2002; Fischer, 2003; Bergan, 2005; Marroquim, 2007; Bonatto; Miron; Formoso, 2011; Szucs, 2013; Conceição; Imai; Urbano, 2015; Simões, 2018; Vecchia; Kolarevic, 2020; Simões; Leder 2022a). However, with no appropriate technical follow-up, these interventions may cause problems, such as the tendency to build extensions up to the lot line, making optimal use of the prevailing wind impossible and causing the consequent loss of daylight (Simões; Leder; Labaki, 2021). With only small unoccupied areas available in the lot, public areas may then become targets for misappropriation and thereby cause conflicts between residents (Simões, 2018).

This article analyzes the adaptation of vulnerable populations settled in three favela rehabilitation housing communities, focusing on conflicts and spatial fragmentation (physical alterations of the housing units), as well as how the low-income population, which previously lived in informality, adapts to formality.

2. Theoretical Basis

2.1 Rehabilitation and the search for more space

In Brazil, there are substantial difficulties in keeping up with the ever-growing demand for new housing, particularly in medium and large cities (Palermo; Morais; Costa; Felipe 2007). This challenge was highlighted by Berr et al. (2015), not only in terms of supplying the necessary quantity of housing, but also in the reliability of the products throughout their lifespan.

Brazilian public policies employ a strategy of standardized typology and repetitive implantation in order to solve the housing deficit problem, which has resulted in public spaces of low spatial quality (Mendes, 2014). The Brazilian housing production for vulnerable populations is marked by a monotonous landscape, associated with poor-quality constructions, and lacking innovation (Mendes, 2014; Tubelo; Rodrigues; Gillott; Soares, 2018). In addition to the reduced size of the units, there is no integration between the peripheral habitational production and the spaces reserved for leisure and urban services (Pulhez, 2012; França, 2015). Araujo and Villa (2020) believe that the housing offered by Brazilian government programs generate a negative notion of well-being, with architectural and urbanistic limitations, which fail to adequately address the needs of the users.

Théry (2017) associated the *Programa Minha Casa Minha Vida* (My Life, My Home Program) (PMCMV), – the most significant housing program in Brazil, to a profound change in the landscape of many Brazilian cities due to the uniformity of the landscapes produced with standardized houses. Moreira, Euclydes and

Martins (2021) concluded that the PMCMV reproduces a housing logic with low-cost production and mass standardization that disregards the particularities of each family and location.

Additionally, the poor standard of housing delivered to the low-income population may affect user comfort with the suboptimal thermal conditions (Silva, 2015; Simões, 2018; Adaji; Adekunle; Watkins; Adler, 2019). In the UK, Lomas and Kane (2013) emphasized the influence of the house construction on thermal discomfort, which presents elevated temperatures and the consequent use of the electric energy system. Debnath, Bardhan and Sunikka-Blank (2019), in relation to India, associate the discomfort of the built environment to the poor design of housing units for slum rehabilitation and the lack of social spaces.

Facing the complex challenge of improving housing units in favelas and making them healthy (Pulhez, 2012; Pasternak, 2016), the adopted solution is often resettlement in new areas (Pequeno; Rosa, 2015). However, interventions in favelas continues to be an option (Denaldi, 2004), and projects need to involve the communities (Mitra; Mulligan; Schilling; Harper; Vivekananda; Krause, 2017). Martins and Farias (2019) reported on the urbanization of the Rocinha Favela, in Rio de Janeiro, which involved a process of reducing the built-up density, involving demolitions and the relocation of residents, which resulted in new urban spaces and cleaning up narrow, dark, unhealthy alleys.

The provision of new constructions in order to attend to the housing deficit includes the need to eradicate favelas and remove families living in precarious housing or areas of vulnerability (Kowaltowski; Pina; Ruschel; Labaki; Bertolli, 2005). Relocating vulnerable populations is called *favela rehabilitation*. Debnath et al. (2020) believe that when this process is of a poor quality, it may have a negative effect on the sustainable energy, health, well-being, and socialization of the populations involved.

This involves much more complex elements than just providing new housing. In Indonesia, Sholihah and Shaojun (2018) concluded that the policy of removing residents from highly congested slums with an inappropriate environment to somewhere more decent may, at first sight, seem to be a gesture of help so that people experiencing poverty may receive a better life. However, the authors identified an impoverishment of the induced displacement of the resettled population: both through the loss of land and the economic losses of social and cultural resources, such as the dispersion of relatives and neighbors and social disarticulation (Sholihah; Shaojun, 2018). In Lang'ata, in Kenya, relocated residents experienced a disruption in access to information and networks, which brought about significant challenges in terms of having income generating activities at the same level as before the relocation (Mitra; Mulligan; Schilling; Harper; Vivekananda; Krause, 2017).

In a deficient favela rehabilitation housing community, there may be a lack of cross ventilation, with the consequent need for devices that use electric energy (Simões; Leder, 2022b), and an interrelation between the lack of outdoor spaces and the lack of social interaction (Sunikka-Blank; Bardhan; Haque, 2019). Standard household practices performed in the slums of India – washing clothes, cooking, cleaning, and socializing with neighbors, that had previously taken place in the outside community spaces, with the move to vertical apartments, were re-oriented to the interior of the living spaces and, because of this, life became more private (Debnath; Bardhan; Sunikka-Blank, 2019).

Problems may occur if the high-density constructions are of a low quality; negative results include mental health issues and social isolation for residents (Badland; Pearce, 2019). A further relevant aspect related to the high density of some housing communities is that it may collaborate with the occurrence of problems of preservation and care for the constructed space, and thereby lead to social individuality among neighbors (Bergan, 2005). These degenerating values influence the collective life quality of the communities (Bergan, 2005).

Problems related to a lack of space in the housing units may be the cause of disputes among the neighbors. Spatial dependency impacts social issues therefore, it is essential to consider the spatial effects on the quality of housing units (Haque; Rana; Patel, 2020). One common practice in social housing is for people to modify the housing units with private constructions that extend into public spaces and parks (Bergan, 2005; Simões, 2018; Vecchia; Kolarevic, 2020). The approach by Kirby (2008) associated the loss of public spaces with a decrease in the capacity of individuals to meet and interact freely.

Considering the impact of these issues, favela rehabilitation policies may cause new problems, including moving out of the housing units. Debnath, Bardhan and Sunikka-Blank (2019) affirm that in the slum rehabilitation policies in India, the rebound effect may be observed among the occupants, whereby the rehabilitated occupants return to the horizontal slums.

2.2 Spatial Adaptive Behavior

In many cases, the favela housing units are constructed by the residents themselves (Ige; Nekhwevha, 2014), and the space is then transformed into a search for satisfaction (Ludovico; Brandão, 2018). The constructed environment is personified and territorialized through adaptations and interventions (Ludovico; Brandão, 2018). A similar scenario occurs in low-income housing communities, with physical adaptations in the housing unit that mischaracterize the original unit (Bergan, 2005; Simões, 2018; Simões; Leder; Labaki, 2021; Simões; Leder, 2022a).

The process of extending the housing units is defined as *evolutionary housing* (Ludovico; Brandão, 2018), and often occurs in a disorderly manner, through solutions that lead not only to the dysfunctionality of the spaces but also to a lack of efficiency (Ludovico; Brandão, 2018). Progressive housing modification reveals the constant remodeling undertaken by families (Skrabut, 2018).

In the social housing units, the adaptive behavior of modifications may result in significant increases in the constructed area. However, this may reverberate in the comfort and sanitary conditions of the environments, with impacts on the health of residents and the electricity consumption of the building (Simões; Leder; Labaki, 2021; Simões; Leder, 2022a; Simões; Leder, 2022b). The conditions of comfort are impaired by the reformulations of the housing unit, especially with the addition of construction mass, occupying the setbacks, and confining surrounding environments (Simões; Leder; Labaki, 2021).

Self-construction in formal social housing neighborhoods or in favelas share common problems, such as non-compliance with building regulations, the occupation of urban risk areas, several building pathologies and a disregard for bioclimatic aspects (Fim; Silva; Braga; Oliveira; Pereira, 2019); in addition to poor-quality design solutions that interfere with environmental comfort and sanitary conditions (Kowaltowski; Pina; Ruschel; Labaki; Bertolli, 2005; Bergan, 2005; Araujo; Villa, 2020); the removal or reduction of windows, thereby decreasing natural ventilation and daylight (Brito, 2020; Simões, 2022); an increase in air humidity (Vecchia; Kolarevic, 2020); non-compliance with safety standards, the use of makeshift materials, structural deficiencies (Sarmento, 2017); waste of material and generation of debris dumped in public areas, such as sidewalks and streets (Araujo; Villa, 2020).

Housing degradation affects the sanitary conditions of the environment and the health of residents (Sarmento, 2017; Brito, 2020). Poor quality housing, commonly provided to low-income populations, presents limited adaptability to the demands inherent to the building's lifecycle (Palermo; Morais; Costa; Felipe, 2007; Triana; Lamberts; Sassi, 2015; Leite, 2019; Villa; Vasconcellos; Bortoli; Araujo, 2022).

3. Methods

3.1 Documentary research and characteristics of the object of study

The documentary research was conducted together with the architects from the Municipal Social Housing Department in the city of João Pessoa (SEMHAB), with the collection of data related to housing production focused exclusively on the means of rehabilitation for vulnerable families.

The housing communities were completed in 2013, built through two social programs, the Social Housing Subsidy Program (PSH) and the PMCMV. Moreover, the City Hall serves a low-income population residing in precarious housing or areas of risk for mudslides and river flooding. The method used in this research was a case study of three housing communities located in João Pessoa, namely *Taipa Nova Vida* (TNV1 and TNV2), *Gadanho* (G), and *Timbó* (T). These were considered as case studies because they represented architectural types replicated in six or more other locations of the municipality. The floor area corresponds to the minimum culturally accepted program of two bedrooms, a small living room, a kitchen, bathroom, and laundry.

Due to the great difficulty in accessing the interior of the houses, the non-probabilistic convenience sampling technique was used, which signifies that as much on-site information as possible was collected. For the field research, the following investigation techniques were used: a survey in loco in the open areas of the housing communities of the study (observing participants and routes), the application of questionnaires, and the acquisition of oral reports with residents inside the housing units.

Participants and routes in all of the housing communities were observed with the aim photographing the dynamics of the activities, mapping the modifications inside and outside the sample houses (up to the level of the façade), as well as the illegal appropriations (all of the private area outside the lot line), and collecting discussions related to the investigated theme from the resident conversation groups on the sidewalks. A drone was used to capture aerial views in *Taipa Nova Vida* due to the difficulty involved in mapping the extensions with high walls.

Questionnaires were applied to residents who agreed to participate in the study: one resident per housing unit was submitted to a semi-structured interview. At this stage, users were interviewed and a physical and photographic survey of the houses was conducted for a later diagnosis of the spatial adaptation. Consent was given verbally (in person). Although all units were approached, several residents refused to take part. Therefore, not all houses were surveyed. Each interview and approach per house lasted an average of one hour.

Oral reports by the residents were collected during the semi-structured interview since it was considered that these reports might help in reaching some conclusions. The field survey extended over a long period of investigation, with three delimited moments:

- [G and T] – 1st (February-April 2017) and 2nd (October 2020);
- [TNV1 and TNV2] – 3rd (December 2021 - February 2022).

3.2 Data treatment and analysis

The modifications of houses identified in the field survey were modeled in Revit software (2024) in order to obtain a 3D model for analysis.

Excerpts from resident statements (anonymous) have been fully reproduced throughout the article. It was only possible to identify several issues through the resident reports discussions, which had not been addressed in the questionnaire.

Based on objective perceptions of the housing conditions, some analyses categorized the families according to their economic vulnerability/risk (low, medium, high – extreme poverty). The social vulnerability index was used, which is a simple indicator that captures different aspects of the interior of the housing units (precariousness of the physical characteristics of the home, number of renovations undertaken, the state of furniture, and electronic equipment). The first aspect - the physical characteristics of the home - is directly related to the vulnerability status of the family, or, contrastingly, to an improved standard of living.

Statistical tests such as the Shapiro-Wilk, Kruskal-Wallis, Test of Dunn and Spearman's correlation were performed in the Rstudio for some analyses. Only the statistically significant results in $p\text{-value}<0.05$ are considered indicators of effects.

4. Results and Discussion

The application of the questionnaire resulted in 156 completed questionnaires/houses (53.0% of the total number of built houses). It should be noted that the answers that were used were related to questions that covered the interviewees' profiles and house modifications.

4.1 General Aspects of the Housing Projects

The rehabilitation communities for vulnerable populations studied in this research were constructed according to a new guideline from the João Pessoa City Hall, prioritizing the implantation of the new settlements in areas close to the original locations (informal settlements) (Figure 1). According to the interview with an employee from SEMHAB, the objective of the strategy was to respect the population's work, educational, and social ties.

Figure 1. Relocation map of the favela rehabilitation housing communities
Source: Own elaboration, 2023. Maps (Filipeia Mapas da Cidade, 2021) .

In relation to the *habitare* prior to the social housing rehabilitation under analysis, the settlements were made up of extremely precarious housing units or were established in areas of wetlands and at risk of landslides or river flooding (Figure 1). These were illegal, since they occupied areas of environmental protection. Reports during the interviews, although there were some positive comments, demonstrated the main negative aspects of living in informal settlements, but there are also positive comments, such as those presented below.

> Where I used to live was smaller; there was only one bedroom. The rain used to pour into the house. I lost all of my furniture and documents.
> The other house was two of these (*size of the bedroom*). The worst thing was the sewage entering the house.

The adverse reports were associated with the highly precarious housing units, the lack of sanitation, and constant flooding. On the other hand, the positive reports referred to the detached buildings on the lots, the existence of backyards, and sometimes, a larger housing unit.

In relation to the new housing unit, the main factors of dissatisfaction mentioned were: (i) the size of the housing unit; (ii) a smaller backyard; (iii) unsuitable architectural type (attached multi-family houses); (iv) the difficulty of extending the housing unit; (v) the low quality finishing; (vi) the lack of space to store recycling material (source of income); (vii) the limitation and difficulty to climb stairs; (viii) the rupture of social ties with the neighborhood; (ix) the lack of privacy due to the positioning of the windows and access doors in some units.

4.2 Levels of economic vulnerability and the impact on the adaptation process

Although the housing units were constructed for low-income families, it was possible to identify distinct levels of economic vulnerability based on the objective perceptions related to the internal conditions of the residences. This distinction between groups of low-income populations was confirmed in the statistical tests. The results indicated that there is a significant difference between the medians of three groups of economic vulnerability and the number of renovations completed (Kruskal-Wallis chi-squared = 24.695, df = 2, p-value < 0.05 (< 0.001) (Figure 2 (a), Table 1). Statistic relations between an increase in the number of renovations and a decrease in the level of economic vulnerability were observed (Spearman`s correlation S = 389560, p-value < 0.05 (< 0.001), rho 0.38).

Economic vulnerability is associated with undertaking the required improvements to adjust the housing unit to the needs of the families or to coexisting with problems arising from the communities.

With the desire to undertake renovations in the housing unit, the results demonstrate that there is a negative association with a reduction in the level of economic vulnerability, which may be linked with the significant number of renovations already completed by the less vulnerable group (Kruskal-Wallis chi-squared = 6.4064, df = 2, p-value < 0.05 (0.04); Spearman`s correlation S = 714295, p-value < 0.05 (0.03), rho – 0.17) (Figure 2 (b), Table 1). Therefore, the evidence confirms the existence of distinct levels of economic vulnerability and that the high vulnerability group undertook fewer renovations and presented an equal desire in the number of renovations to the group that had already renovated the housing unit many times. The absolute impossibility of undertaking all the renovations due to the difficult financial situation of many families in high economic vulnerability may have limited any actions to just the most urgent maintenance desires in the housing unit.

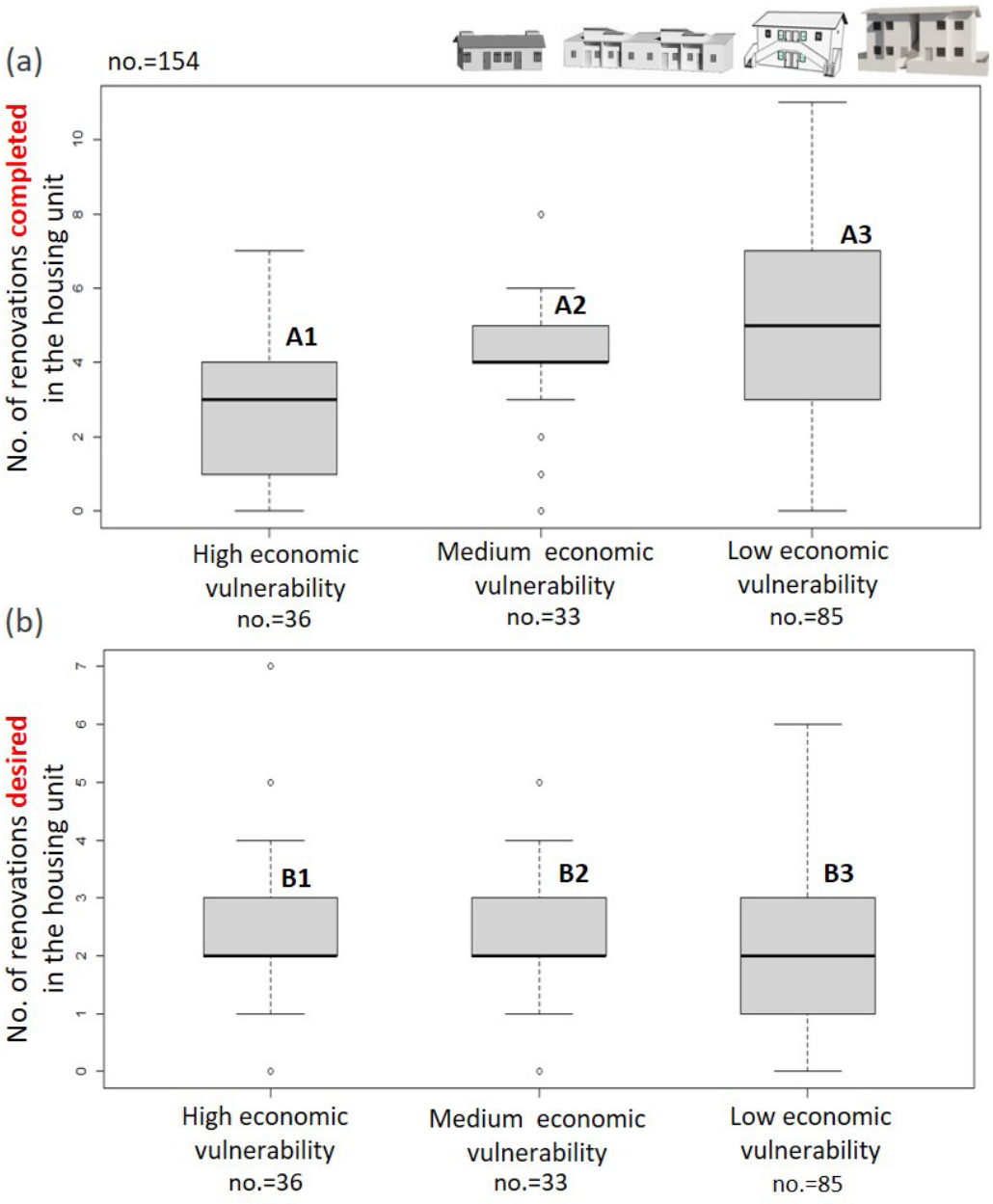

Figure 2. Relation between the level of family economic vulnerability and the number of renovations desired and completed

Source: Own elaboration, 2022.

	Test result (p-value) – Kruskal-Wallis test, Dunn test, and Spearman's correlation (S)	
	Kruskal-Wallis test	**Dunn test**
[G+TNV1+T+TNV2] Level of economic vulnerability and number of renovations **completed** in the housing unit	chi-squared = 24.695, df = 2, p-value < 0.05 (< 0.001)*	A1 ≠ A2 (p-value < 0.05 (0.00*)
		A1 ≠ A3 (p-value < 0.05 (0.00*)
		A2 = A3 (p-value > 0.05 (0.06)
	Spearman's rank correlation Rho	
	S = 389560, p-value < 0.05 (< 0.001)* rho 0.38	
[G+TNV1+T+TNV2] Level of economic vulnerability and number of renovations **desired** in the housing unit	chi-squared = 6.4064, df = 2, p-value < 0.05 (0.04)*	B1 = B2 (p-value > 0.05 (0.25)
		B1 = B3 (p-value > 0.05 (0.05)
		B2 ≠ B3 (p-value < 0.05 (0.01*)
	Spearman's rank correlation Rho	
	S = 714295, p-value < 0.05 (0.03)* rho – 0.17	

Table 1. Relation of economic vulnerability and renovations desired and completed in the housing unit

Note: A1 and B1 (high economic vulnerability), A2 and B2 (medium economic vulnerability), A3 and B3 (low economic vulnerability). Significance level = * p-value < 0.05 (H0 is rejected: medians of the groups are different).

Source: Own elaboration, 2022.

4.3 Building functionality, the need for renovations, and maintenance actions

In order to reduce the production costs of social housing units, apart from the reducing the dimensions of the housing unit, other strategies were also employed, such as low-quality doors and windows, hollow bricks (known as cobogó) instead of windows in the bathroom and kitchen (except in TNV2), untiled flooring inside the house, and no walls separating the lots (except in TNV2).

An assessment of the functionality of the housing units after the first few years of use demonstrated that the low quality of housing associated with high economic vulnerability obliges residents to coexist with several problems, such as a high number of registered broken doors and rusted windows – many unusable –, the burnt cement floors with many flaws, and constantly damp walls in the wet areas, resulting from inadequate waterproofing (Figure 3). There are different scenarios; high economic vulnerability does not allow making changes with better quality materials (Figure 3, left), or when it is possible to make these changes, they occur very gradually (Figure 3, right).

Figure 3. Collage presenting the poor quality of the housing unit and problems of use: high economic vulnerability (left); low economic vulnerability (right)

Source: Own elaboration, 2023.

4.4 Extending the housing unit

There is a recurrent demand for more space in the housing unit so as to adapt the house to the number of residents and, any new family members that emerge, in order to prevent sons and daughters from paying rent, to obtain more space to install furniture and electrical appliances, and to provide more comfort for the whole family with a more spacious house. The percentage of properties that added more than 15.0 m² is high (equivalent to approximately 45.0% of the area, or more, in relation to the original size), especially the ground floor houses: 60.7% in TNV1 and 54.5% in G; 34.4% in TNV2 and, 25.7% in T.

The main motivating factors for residents to renovate the housing units were: (i) to increase the size of the housing unit (26.9% of the sample); (ii) to increase the security of the house with more resistant door frames (26.3%), (iii) to protect from the sun and rain (24.4%); (iv) to improve the quality of the materials (19.9%); (v) to have more privacy (10.9%) and to improve the aesthetics of the house (10.9%); and (vi) to create a work area (7.1%). In other words, the causes are markedly related to the flaws of the project, such as insufficient area to accommodate the family, a lack of privacy and no area for a workspace (reasons 1, 5 and 6).

Very often, the extensions compromise the environmental quality and aesthetics of the housing unit through mischaracterizing the original elements, interrupted renovations, and a lack of finishing techniques. Similar findings were also reported by Bergan (2005) in Brazil, who identified a complete mischaracterization of the façades of the housing units, as well as a number of interventions that adopted construction criteria pre-established by the residents. In Peru, Skrabut (2018) identified that the residents reproduce the same construction practices adopted in the informal settlements, following a typical urban disorder of these spaces.

4.5 Adapting the housing unit to generate income

The high number of unemployed residents in the studied communities has resulted in the demand for a workspace in the housing unit, as a means of income. Thus, with this in mind, annexes have been built specifically for these uses, especially for small businesses (neighborhood general stores), (Figure 4). Five types of annex for different types of commercial uses were mapped (Figure 5), making it possible to comprehend how the house is transformed. These are: a) annexes in the occupied rear setback with no direct connection to the street, the spaces are used as production areas, with the sale of products produced outside the community (e.g., clay handicrafts, woodwork, etc.); b) a construction annexed in part of the front setback for commercial use; c) a construction covering all of the front setbacks for commercial use; d) front room and part of the front setback destined for commerce; e) constructions in the public spaces, through the informal occupation of areas destined for vegetation and leisure. This type of annex and new buildings (independent of the original) are built for commercial and residential use. Of the 37 annexes mapped, the most common types were type b (46.0%) and c (32.4%) (Figure 5).

Figure 4. Collage showing commercial trade areas
Source: Own elaboration, 2023.

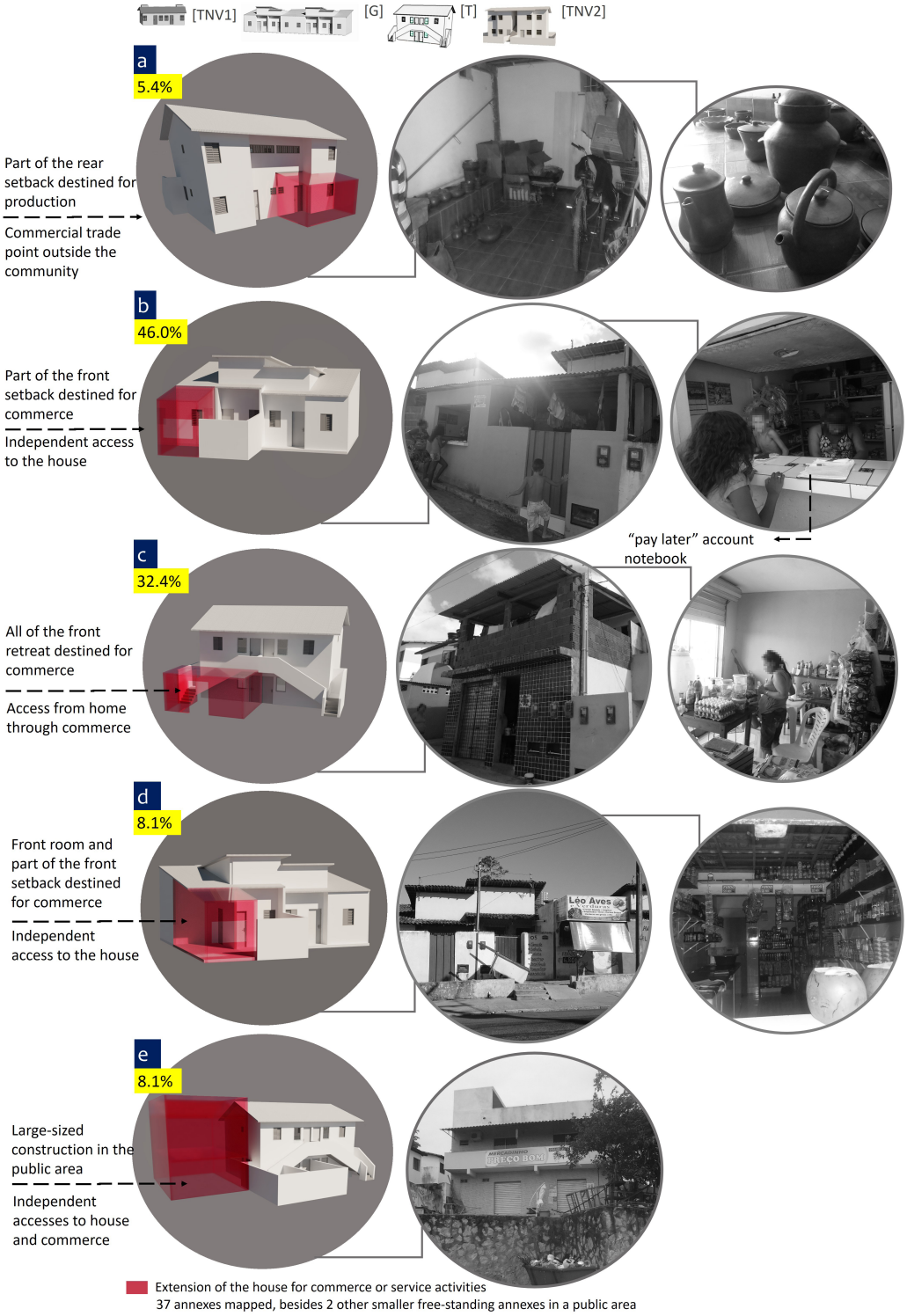

Figure 5. Forms of house extension for commerce/services

Source: Own elaboration, 2023.

The use of housing units for commercial purposes is more common in the low economic vulnerability group, although commercial trade points only sometimes result in success. ("There are days that I only sell one candy. There is a lot of competition here, and people don't have money. I'm almost giving up."). In cases of failure these areas are given other purposes or remain deactivated.

For the majority, the most recurrent form of generating income is the collection and separation of recycling materials. The lack of formal education makes obtaining a regular job difficult, which explains the high number of unemployed. With no space to store the collected material, which, after separation, is sold to the recycling company, the interior of the housing unit is used as a warehouse for recycled material. This practice compromises the spaces for the activities of the family's daily routine and may also cause health problems, submitting these individuals to several contamination risks.

Other Brazilian studies have reported a diversity of informal businesses in the housing communities studied (Bergan, 2005; Moura, 2014; Villa; Vasconcellos; Bortoli; Araujo, 2022). In Africa, Badmos et al. (2020) identified that 63.0% of those interviewed worked informally in the respective communities, most of them as self-employed. In another study in Africa, Ige and Nekhwevha (2014) reported that many residents work in the precariousness of informal businesses that offer few perspectives to advance. In Brazil, Treuke (2020) affirmed that spatial isolation allied to the absence of work opportunities has a negative effect on the living conditions of the residents in low-income communities and strongly confines them to the local social context.

4.6 Architectural type and adaptation difficulties

Besides dissatisfaction with the size of the housing unit, one other significant concern is the architectural type adopted in the houses delivered to the population. In the attached houses (G), the resident reports highlight the lack of a setback between the houses as the main motive for disagreements between neighbors. With shared walls, privacy inside the rooms is compromised, and makes future extensions difficult ("The project was different, with detached houses, then; afterwards, they said the lot was too small."; "I hear everything the neighbor does.").

In the duplex type (T and TNV2) conflicts are even greater. Residents on the upper floors demonstrate great dissatisfaction because their name was not drawn to receive a ground floor house ("There's no space to do anything." – from a resident of a first-floor unit). Attempts to exchange are recurrent, but almost always without success. The difficulty to extend the upper floor is much greater because it requires expenses with the structure. Additionally, living in an apartment is not something

that the interviewed population enjoys. The argument is that residents of the ground floor are able to extend the kitchen, in addition to building a terrace and other environments in the setbacks between the buildings. The residents of the upper-floor units have no possibility of doing this, and, if they did, the costs would be extremely high, since the structure would have to be built from the ground floor. In addition to this, when neighbors refuse to give their consent, the conflicts increase.

These extensions are unsupervised, and the setbacks and clearances have been entirely built over. Of the four architectural types studied, the TNV1, with semi-detached two by two houses with a setback on either side, was the type that received the least dissatisfaction from users regarding its architectural design.

4.7 Sharing the common area

Another form of conflict is related to sharing common areas. For example, access to the upper floor of the housing unit in the duplex type (TNV2) is through a central staircase shared by the two units, with the access doors facing one another. The need to keep the door open for natural ventilation leads to conflicts in everyday life due to the lack of privacy (dissatisfaction arises with pets wandering freely, children playing with no adult supervision, loud music, religious practices, alcohol habits, among other issues). According to a resident from the upper floor of a TNV2 type house: "The worst thing was to have put the doors so close together (*one in front of the other*). There should have been an entrance on each side".

Hence, most residents express the desire to replace the centrally shared staircase with a private one. However, aside from being costly, this solution is not viable due to the lack of space to accommodate two private stairways. In the mapping, the construction of a private stairway was identified in one unit (TNV2). However, this independent access became possible only after the privatization of a nearby public area, thereby enabling a connection with the street.

In the duplex type (T), access to the upper unit is independent, with a separate stairway. However, despite this, the residents added a half wall on the boundary between the neighboring unit in order to obtain more privacy, even though this wall represented one more barrier for the prevailing wind and influenced the internal thermal comfort of the housing unit.

4.8 Spatial fragmentation – demarcation of the private area

The construction of a wall around the lot lines is usually the first investment in the housing units analyzed. With regard to the ground floor architectural types, the delimitation of the private lot is evident (Figure 6 (a)); however, in the two-story building, there is conflict (Figure 6 (b)). Since this issue is unclear, the subdivision of the land is conducted in a diversified manner (Figure 6 (b) – T), according to

an understanding and agreement among the residents. In the duplex type (T), several types of lot division were observed during the field surveys. The division is unbalanced; the buildings on the ground floor appropriate more significant areas (Figure 6 (b), item 2, 3). The need to delimit private areas on the lot results from the expectation of extending the housing unit, and this however is not always possible for the residents of the TNV2 type because the area of the lot that they receive is not adjoining to the unit (central stretch in the rear setback, not adjacent to the façade and with no connection to the street), which make extensions difficult on the upper floor (Figure 6 (b) – TNV2 – blueprint).

According to the architects from the City Hall, the manner in which the lot should be divided in the duplex type (T) is specified as in item 1 (Figure 6 (b)) for the resident of the ground floor to receive half of the frontal area and all of the rear setback, whereas the upper-floor resident has the other half of the frontal area and the side setback (Figure 6 (b), item 3). Nevertheless, there are cases where only access to the stairway remained for the upper-floor resident (Figure 6 (b), item 2). ("When I moved here, the neighbor (*ground floor resident*) already had the wall and I just had the stairway" (*upper floor resident*)). As a result, it is common for neighbors in the block to experience conflicts related to how the ground area is divided, which often leads to communication breakdowns.

In the duplex type (TNV2), the construction of a low wall with a height of approximately 1.0 m delivered with the construction of the house facilitated the demarcation of the territory destined for each resident, thereby avoiding conflicts over division. However, this strategy failed to satisfy the residents on the upper floors with the small private area reserved for them on the ground floor (10.0 m^2 for the upper floor vs 57.0 m^2 for the ground floor unit). In addition to this, the area granted to the upper floor is unconnected to the rest of the housing unit (Figure 6 (b), TNV2).

The lot division of the duplex (T) type proposed by the City Hall (Figure 6 (b), item 1) also results in conflicts because the window of the first bedroom on the ground floor faces the side setback (alley), which belongs to the upper floor resident (Figure 7). The lack of privacy on the ground floor has caused disagreements that have resulted either in the removal of the window or the impossibility of opening it (Figure 7 (a)). A resident from the ground floor type T commented: "The problem is that the neighbor wants me to remove the side window." When the ground floor resident opts to remove it, solutions are devised so that the space does not become totally enclosed, such as using the previously mentioned hollow bricks (*cobogó*) at higher levels or glass bricks (Figure 7 (b), (c)). However, the sanitary conditions of this environment will be compromised, with no adequate ventilation and daylight, causing thermal discomfort because of the heat, thereby affecting the health of the residents.

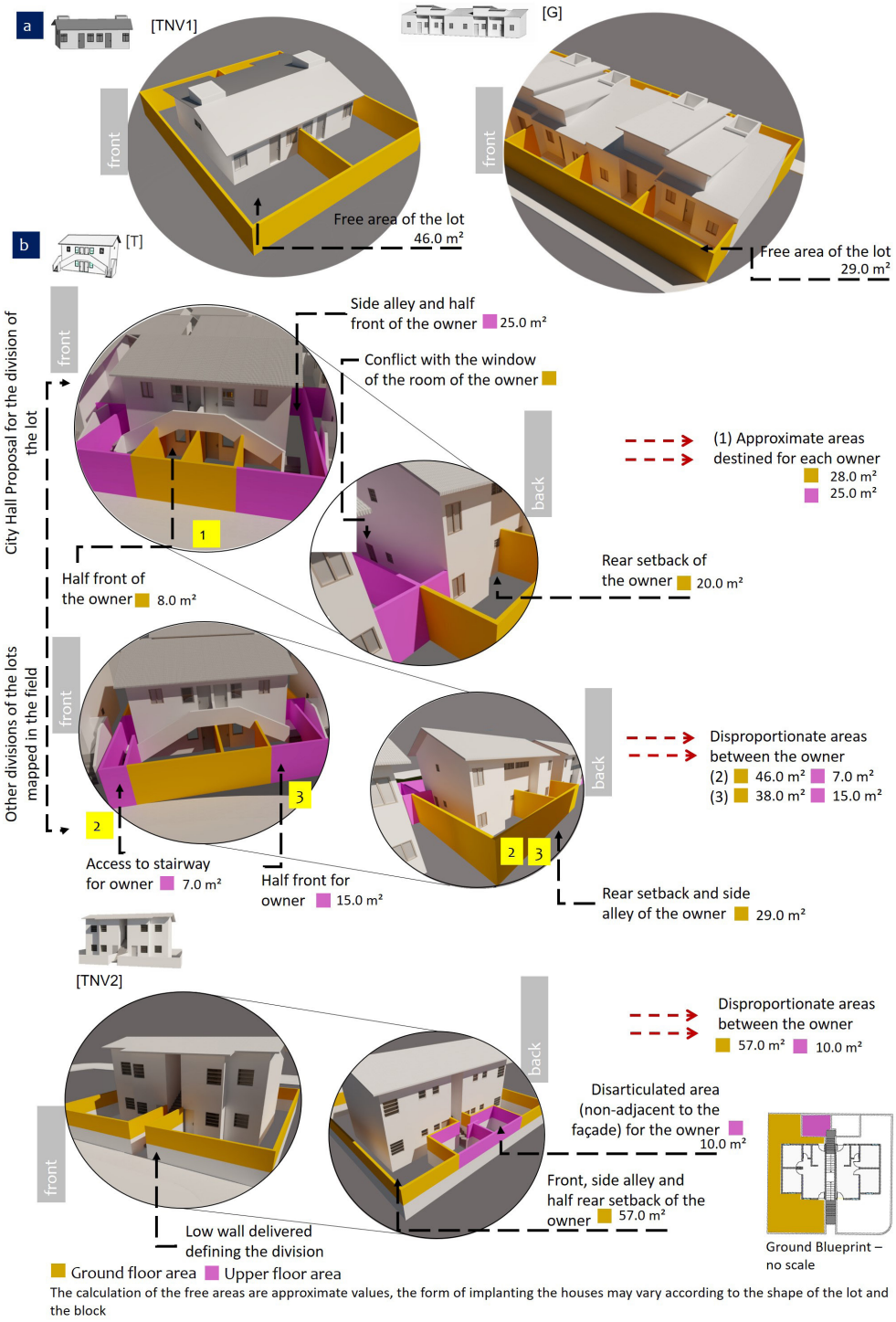

Figure 6. Division of the lot for the ground floor (a) and duplex (b) types

Source: Own elaboration, 2023.

Figure 7. Lack of privacy due to the window on the side setback: window permanently closed (a), replacing the window with hollow bricks (*cobogó*) (b) and glass bricks (c)

Source: Own elaboration, 2023.

Other studies have also identified the need to block up windows because of privacy issues, visual comfort, routine, exterior view, or security (Balvedi; Ghis; Lamberts, 2018; Simões, 2018; Sunikka-Blank; Bardhan; Haque, 2019; Lueker; Bardhan; Sarkar; Norford, 2020; Debnath; Simões; Bardhan; Leder; Lamberts; Sunikka-Blank, 2020).

4.9 Spatial fragmentation – invasion of public areas

Spatial fragmentation, which began with the division of the lots may also be perceived in the dispute for space beyond the limits of the private lot. The mapping of the occupation in the housing units analyzed revealed the illegal privatization of several public areas ("There was a place where more than ten meters were left over; the "wise guy" there made another house and is still going to build something else."). Thus, public areas, which should be maintained as green areas or reserved for leisure spaces and community equipment, are walled, and incorporated into private lots (Figures 8 and 9). Another Brazilian study also identified the advance of private areas into a public park and even the construction of new buildings (Bergan, 2005).

Another issue to be considered concerns the possibility of the low-income residents owning a car. The dispute around the public areas also resulted in the individualization of the commonly used parking areas (Figures 8, 9 and 10 (e)).

The illegal occupation of common-use spaces observed in the field were modeled and are presented in Figure 10. In general, the extensions of the housing unit occupy the entire lot, with few alternatives of contact with the external environment remaining for the building (Figure 10 (a)). The informal occupation is highlighted as follows: sidewalk (Figure 10 (b), (c)); access to the housing communities (Figure 10 (d)); communal areas for parking (Figure 10 (e)); green areas (Figure 10 (f)); areas destined for future constructions of new blocks of housing units (Figure 10 (g)) and areas for the construction of community equipment such as a school, daycare center, health center and sports area (Figure 10 (h)).

The territory goes through a process of fragmentation that also reflects in the relations of the neighborhood. Since the conflicts of adaptation are diverse, many residents do not socialize and live segregated in the privacy of their homes.

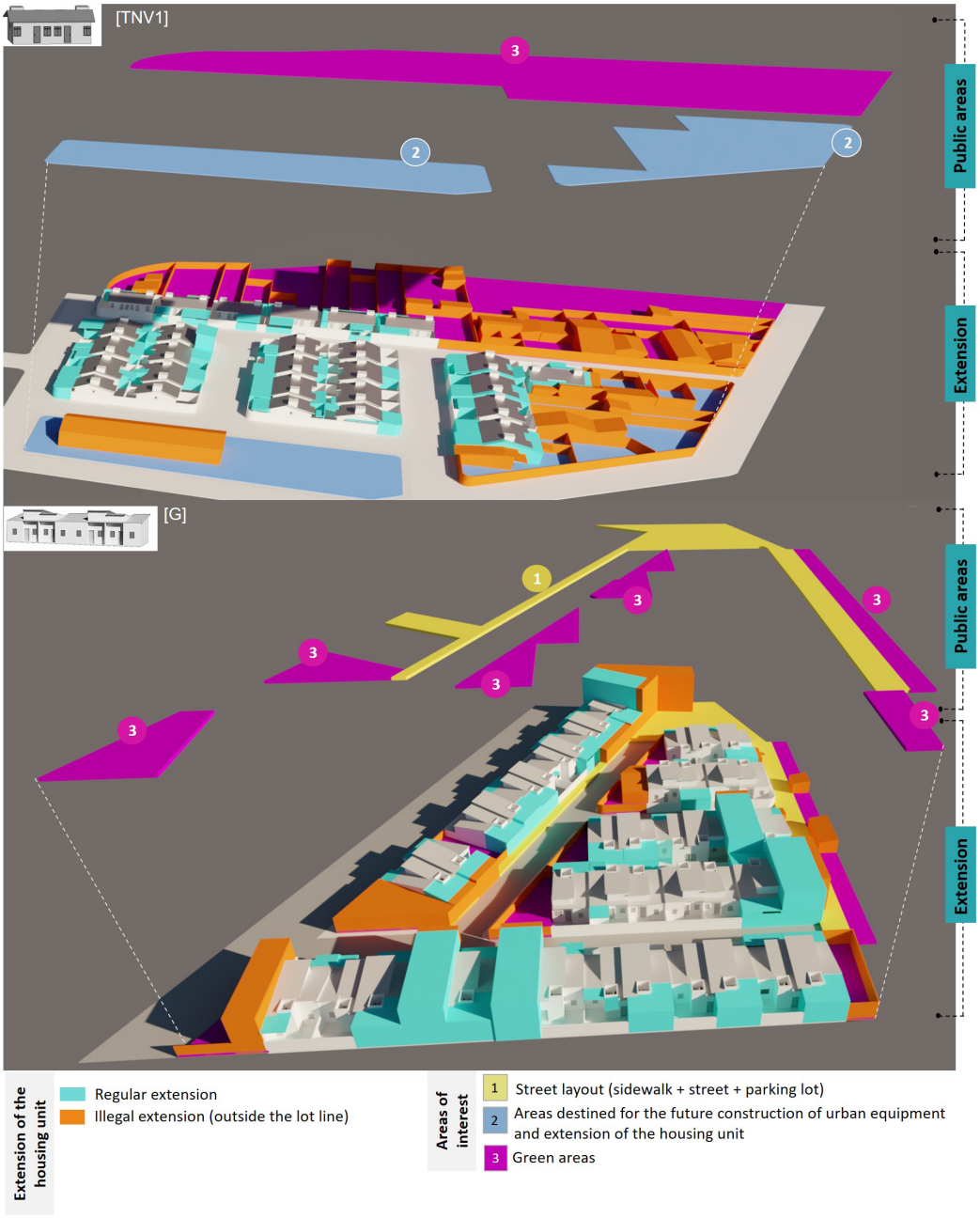

Figure 8. Intra-lot extension and public areas (ground floor types)
Source: Own elaboration, 2023.

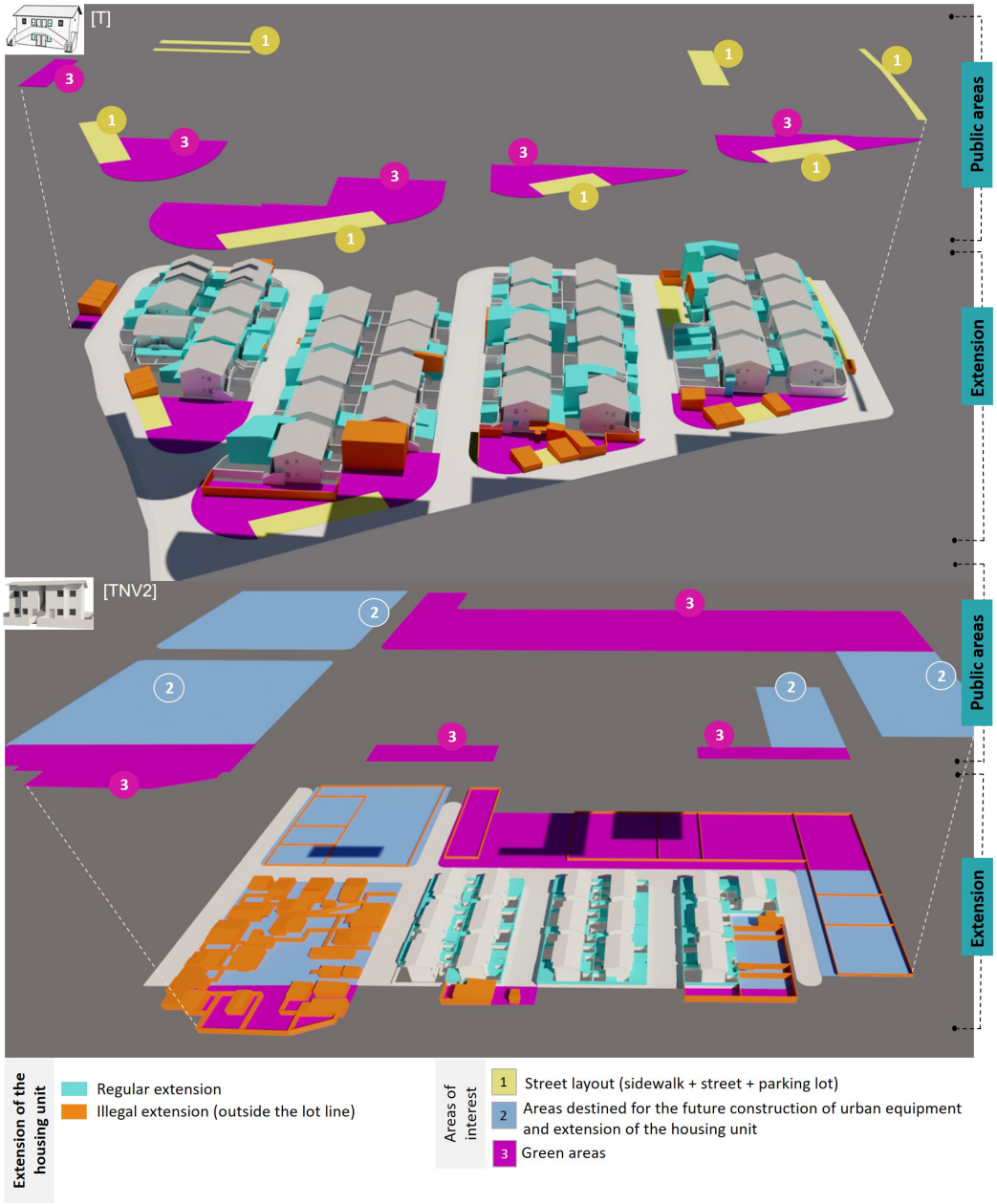

Figure 9. Intra-lot extension and public areas (duplex types)

Source: Own elaboration, 2023.

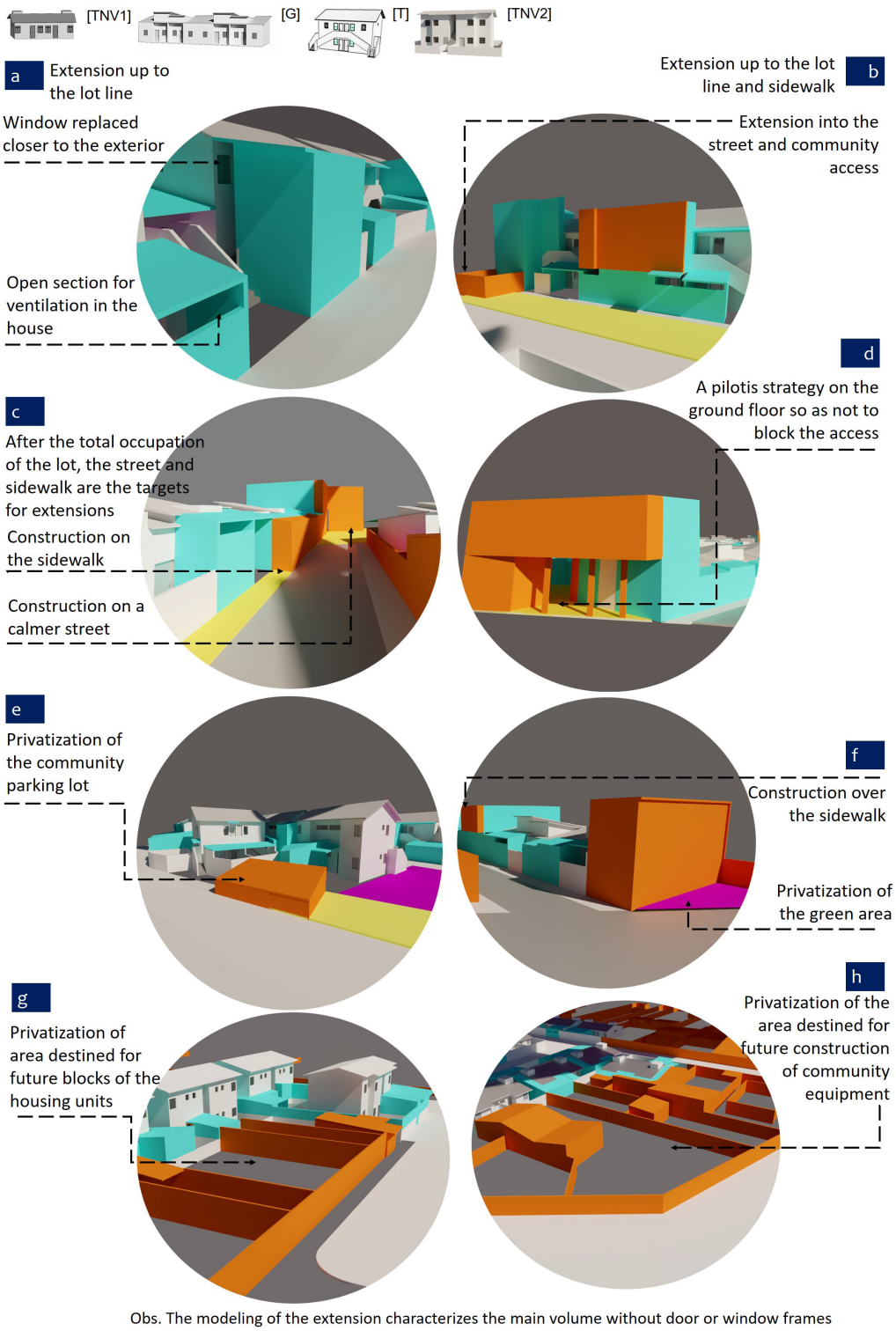

Figure 10. Illegal appropriations

Source: Own elaboration, 2023.

4.10 Sale/rent of the unit

One of the consequences of failing to adapt to "formality" is the sale of the housing unit during the first years of use ("The guy (*a benefitted resident*) sold it for 15.000,00 BRL (3,091.00 US dollar). He sold it because it had a stairway"). Cases in which the residents are not the original beneficiaries were associated with the units bought or rented (obtained through reports by residents during the interview or open questions) ("I'm not interested in renovating because I don't own the house. I rent it."). With the data obtained, it is possible to quantify the percentage of selling and renting: 19.0% of the housing units of the sample were already not occupied by the original beneficiaries. The most significant percentages were identified in the TNV1 (32.1% of the TNV1 sample) and TNV2 (31.0% of the TNV2 sample), G (18.2% of the G sample) and T (7.6% of the T sample). Currently the percentages of G and T may be even more expressive, because a longer period of use (investigated in 2017) of the housing unit would be computed, such as the cases of TNV1 and TNV2 (investigated in 2022).

The reasons for either selling or renting out the housing unit were: (i) dissatisfaction with the architectural type, especially in relation to the upper floor units, due to the difficulty of building extensions and the need to use the stairs; (ii) exchanging for housing in another community (closer to relatives); (iii) renting out the housing unit to increase income; (iv) difficulties in adaptation – the interviewee considers the community dangerous and did not establish ties with the neighbors; (v) selling the housing unit to return to the conditions of the informal settlement and to become a candidate for a housing unit in a new enrollment scheme for social housing.

5. Conclusions

Providing the vulnerable population living in informal settlements with improvements goes beyond the mere provision of formal housing. Therefore, this study has analyzed how families from informal settlements adapt to the conditions of formal housing. The process of adapting to formality are especially compromised because: the architectural types are inappropriate for the family's needs, the housing units are of a poor quality, there are conflicts among neighbors, and common areas are invaded.

In terms of the family's needs, increasing the living area of the housing unit often leads to the occupation of the setback or clearance. These areas are crucial for the permeability of the housing unit, allowing sunlight and natural ventilation into the unit. The generation of income is also a significant concern. The high number of unemployed residents in the area forces families to make adaptations to their units so as to engage in income generating activities.

The occupation and fragmentation of the common areas results in environmental degradation, with a detrimental effect on the health, quality of life, and the neighborhood relations of the populations involved.

The study also identified different levels of economic vulnerability associated with the capacity to change the spatiality of the housing unit. The impossibility of the most vulnerable group to carry out housing improvements intensifies the precariousness, in such a manner that similar conditions are recreated of the informal settlement.

Social conflicts arise as a result to the serial units and of the fragmentation of the territory, caused by the division of private lots and the unauthorized occupation of public areas. Faced with the challenges of adapting to the housing units, one of the consequences is to sell or rent out.

The time lapses for the field survey in the four architectural types investigated was a limitation of this research. For future studies, we suggest a research team conducting assessments simultaneously or within shorter timeframes.

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Gianna Monteiro Farias Simões

Assistant professor in the Department of Science and Technology at the Universidade Federal Rural do Semi-Árido (UFERSA). Postdoctoral researcher in the Postgraduate Program in Architecture, Technology and City at the Faculty of Civil Engineering, Architecture and Urbanism/Universidade Estadual de Campinas (FECFAU/Unicamp) (2024-current). Post-doctoral research, in 2023, in the Postgraduate Program in Architecture and Urbanism at the Universidade Federal da Paraíba (PPGAU-UFPB). Research in partnership with the University of Cambridge (2019-20), the University of Edinburgh (2023-current) and the Federal University of Santa Catarina (UFSC) (2023-current). A PhD (2022) and master's degree (2018) in Architecture and Urbanism from PPGAU at UFPB. First degree in Architecture and Urban Planning from the same institution (2015).

Email: gianna_farias@hotmail.com

ORCID: 0000-0002-7961-9468

Authorship contribution: Conceptualization; Data Curation; Formal Analysis; Funding Acquisition; Investigation; Methodology; Software; Writing – First Draft.

Solange Maria Leder

Full professor on the Undergraduate and Postgraduate programs in Architecture and Urbanism and Civil and Environmental Engineering at the Universidade Federal da Paraíba (UFPB). Coordinator of the Postgraduate Program in Civil and Environmental

Engineering (2018-21) and the undergraduate course in Architecture and Urbanism (2010-12), at the same institution. Postdoctoral research at the National Research Council (2013-14), Canada. PhD in Civil Engineering (2007), master's degree in Production Engineering (1999) and a first degree in Architecture and Urban Planning from the Universidade Federal de Santa Catarina (UFSC) (1991).

Email: solangeleder@yahoo.com.br
ORCID: 0000-0003-3784-4461
Authorship contribution: Supervision; Validation; Writing – Review and Editing.

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