

Entry

Social Housing Customization in Brazil

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Definition: Social housing customization in Brazil refers to the current processes of development and evolution of government-funded neighborhoods for the lowest-income population. The mass production of small housing units that do not satisfy family needs instigates a self-design and self-construction process post-occupancy to customize the units. Ultimately, these changes to the units bring unintended negative consequences for the families and the city. In this context, mass customization is seen as an alternative to address some of the problems related to unit design.

Keywords: housing production; low-cost; design quality; social housing; government programs; post-occupancy; healthy environments; mass customization



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1. Introduction

This paper shows how low-cost social housing neighborhoods are produced through government-funded programs and how these neighborhoods develop post-occupancy. Furthermore, the paper shows potential paths to maintain adequate environments in these neighborhoods as they evolve. It is based on the revision of literature including research papers, legislation, case reports and post-occupancy studies, as well as results from the authors' previous research. The paper starts with a historic overview to provide the necessary background for the understanding of the social housing processes currently in place. Following the historic background, the paper outlines, in Section 3, the current processes for the production of social housing neighborhoods for the lowest income range, highlighting the main stakeholders and their roles. Section 4 then shows the post-occupancy processes in neighborhoods of house units focusing on the changes the families make to their houses and the problems these changes bring to themselves and the city. In Section 5, the paper describes ways to address these unit changes while maintaining adequate environments as the neighborhoods evolve. In particular, Section 5 shows possibilities for mass customization to contribute to the processes in this context. Concluding remarks are outlined in Section 6.

2. History

The United Nations' Universal Declaration of Human Rights, approved in 1948, recognized housing as a human right and had vast repercussions on social housing initiatives worldwide. However, in Brazil, it resulted in political discourse rather than actions [1]. It was only after the military takeover in 1964 when the National Housing Bank (BNH) was created that large-scale social housing took off [2–4]. Social housing was primarily in the form of mass-produced apartment blocks resembling post-war housing blocks in Europe. However, BNH also subsidized lots with infrastructure and embryo units that were very small unfinished houses meant for further development by the owners. In some cases, only the bathroom was provided, as in the neighborhoods implemented through the Profilurb initiative [5]. These lots and embryo units were meant for people earning up to three times the minimum wage. This bank was the primary source of financing, not only for housing but also for infrastructure and sanitation, until it collapsed in 1986. BNH's

long-term legacy goes beyond housing and infrastructure. The idea that local governments are dependent on Federal initiatives is also a legacy from BNH [6]. This idea persists today, embedded in Brazilian legislation, as evidenced by the lack of local programs and recent laws such as [7,8].

Much of BNH's resources were directed at financing homeownership. Unlike in Europe or North America, homeownership subsidies in Brazil were granted to impoverished formal workers, but still excluded the most vulnerable population. This contributed to the extensive growth of slums (favelas). Attempting to deal with this exclusion, BNH implemented some specific initiatives to remove favelas, transferring the population to new apartment blocks. However, those initiatives ultimately failed as people moved back to the slums, illegally selling their apartments to higher-income families [6].

To start addressing the UN Committee's General Comment no.4 [9] on the right to adequate housing, and the outcome of the 1996 United Nations Conference on Human Settlements, subsequent social housing legislation in Brazil associated the building of new social housing neighborhoods with the provision of services and public transportation. Despite these efforts, the unstable economic and political circumstances of the late 1980s to early 2000s significantly limited the provision of social housing. This was especially significant for poorer municipalities and those less politically aligned with the federal government [1,6]. During this time, the federal government did not have a unified social housing policy or funding avenue. Therefore, states and municipalities had to be creative to implement local initiatives, which focused mainly on urbanizing precarious settlements [3,10]. The housing deficit grew significantly in South America between 1990 and 2000, increasing informal living arrangements [11].

In 1999 the Brazilian government authorized a new housing program based on the French leasing program. In Brazil, the program was called PAR (program of residential leasing) and had some significant differences from its French inspiration. The main difference was the option of ownership at the end of the 15-year lease agreement [1]. This program was initially aimed at families earning three to six times the minimum wage, but was later expanded to families earning up to three times the minimum wage. The cost of the lease was subsidized depending on the income of the family. In line with the international emphasis on housing ownership and internal pressure to overcome the financial deficit in this sector, in 2007 the government passed further legislation to allow early ownership [12].

Following the financialization trend, in Brazil, the government established a new program in 2009, the MCMV (my house my life, translated from *Minha Casa Minha Vida*) program, which subsidized most of the cost for low-income families to buy homes in a financing process [8]. Its creation was an economic response to deal with the financial crisis that had started in 2007. It was meant to benefit large construction companies, and to boost the economy as much as provide housing for those in need. The MCMV program broke free from the social representation and sustainable urban development aspects of the existing Social Housing National System (SNHIS) [13]. This occurred due to concerns about agility in project approval and the interests of entrepreneurs in the construction industry [14–16]. The MCMV program was implemented based on similar programs previously implemented in other Latin American countries, such as Chile and Mexico [11]. The state's role in these programs is mainly to provide financial support for private companies to build housing for the poor. Even though the government establishes some rules, the companies have autonomy to choose the location, typology, and size of the development. As a result, these developments often remove populations from well-located informal settlements to distant and isolated, but formally owned, housing. Ultimately, this type of program has contributed to creating new problems of urban ghettos in the peripheries [11]. Such top-down schemes based on industrial geometries have been criticized for bringing more benefits to banks and construction companies while producing inhumane, monotonous neighborhoods [17].

Over the past decade, the MCMV program has produced significantly more housing units than any other social housing program in Brazil, having delivered more than one

million housing units for the lowest income range between 2009 and 2019 [18]. Furthermore, MCMV's processes and regulations became the model for local programs and a requirement for federally funded programs. Therefore, the processes and policies outlined in this article pertain mainly to the MCMV program. In late 2020, the federal government ended the MCMV program to implement the new Green and Yellow House program (translated from Casa Verde e Amarela), named in reference to the colors of the Brazilian flag, for which legislation was approved in early 2021 [7]. However, this new housing program has kept the MCMV processes for the production of new housing units. In addition, the new program also incorporates avenues for land regularization and improvement initiatives for existing housing. Nevertheless, evaluating the new program beyond theoretical speculation at this point would be premature.

3. Production of Housing Units: Stakeholders, Policies, and Operations

The enterprise sub-section of the MCMV is the main way housing can be financed. It has enabled markedly more housing than other sub-sections. From 2009 to 2019, the MCMV enterprise delivered 1,094,698 housing units for the lowest income range, while all the other urban housing avenues within the program delivered 183,904 units collectively [18]. Importantly, many processes in the MCMV for the lowest income range, including unit design, are similar to those of prior programs for the lowest income range. The units produced, the needs of the intended inhabitants, and the problems that emerge post-occupancy are also consistent with previous programs. Therefore, this section discusses the production of social housing units created under the enterprise sub-section of the MCMV program. However, some specific changes brought about by the Green and Yellow House program are noted.

Historically the lowest income range of social housing programs in Brazil has considered families earning up to three times the minimum wage. More recently the MCMV program changed the cap to BRL 1800, which is less than two times the minimum wage. Currently, the Green and Yellow House program considers families earning up to BRL 2000 [19]. For this population, the programs subsidize most of the costs to build new housing units. According to their individual income, families of the lowest income range pay a small monthly amount to acquire a home in developments built by private companies. Although the program has been successful to some extent in reducing the housing shortfall [20], it has also received much criticism. The role of local housing and planning authorities became limited in this program, with most of the decision power left to the financing bank, Caixa Econômica Federal (CEF), and private companies [21]. Consequently, the lowest income range, which accounts for 70% of the housing demand, only received around 30% of the resources [22].

There are four main stakeholders involved in the design, decisions, approval, and construction of new social housing units: the federal government, the municipal authorities, private developers, and the national bank responsible for financing, CEF. For the lowest income range of such programs, the families that will live in the units have no decision power and are only assigned to a unit once they are built. Several authors indicate that private companies are the main promoting agents in the production of new housing units. It is their role to take the initiative to propose new developments, making the local authorities dependent on the private companies' willingness to build [14,15,21]. These companies prefer cheaper land on the outskirts of cities to increase profits. Similarly, the standardization of designs re-using pre-approved unit designs in several developments has become common practice [21,23]. This standardization can be seen in the examples of newly built house units shown in Figure 1.

Legislation surrounding social housing developments is vast and involves different levels of government. The regulation around how funds can be used for social housing is mainly federal, governed by federal law complemented by standards set by the federal executive power. However, all levels of government have some say regarding where and how things can be built, sometimes with diverging focuses. Given the design of the MCMV

program in which the construction companies can propose the developments and location, the federal government must establish some minimum standards for the proposal of new developments. Such standards are very broad to encompass all municipalities' urban planning and building codes. However, this broad regulation is often used to circumvent the more restrictive local legislation. The developers pressure the municipalities to approve new developments that comply only with the federal regulation. Often, this pressure is successful in changing the local regulation for all future developments. Such changes include moving urban perimeters, reducing requirements of green and public spaces, and reducing unit requirements [21,22,24]. These changes in local legislation highlight that the power of choice of location and typology lies with the construction companies [24]. Furthermore, federal legislation prioritizes funding for cities that implement policies like tax exemptions for social housing construction and expedited approval processes [8]. Often, these local policies further diminish the local authority's decision power.



Figure 1. Examples of newly built developments of house units: (a) Residencial Veneza in the state of Maranhão—development of detached units built in 2014; (b) Residencial Pinheiros in the state of Paraná—development of row-houses built in 2015; (c) Residencial Dona Sílvia in the state of Minas Gerais—development of detached units built in 2014. Photos by Ministério do Planejamento [25].

In this context, it is not the role of the municipal authorities to design or propose new developments. The municipality can, however, decide where the development will be by donating the land. While this does happen, in most cases, the developers prefer to acquire the land. Acquiring the land gives the developer a financial advantage to start construction on the development. The developer receives the amount designated for land purchase upfront, but can often negotiate with the previous owner to pay in instalments, leaving a significant amount to start construction. The local authorities approve the final design of the development; however, they cannot deny approval if the project is within the legislation [14,26]. This hinders the municipality's ability to suggest changes and require higher design quality.

The other major role of the municipal authorities is identifying and promoting social actions with the families. The local authority registers the families on an ongoing basis according to the federal criteria for eligibility. It is the process that both the city and the federal government use to determine the demand for social housing in the city. Once a new development is in construction, the municipal authorities rank the eligible families according to national and local criteria to determine the list of families to be sent to CEF for further consideration to receive a unit in that development. It is also the role of the municipal authorities to lead the social work actions with the population of the new development [27,28].

Current legislation guarantees that a minimum of 2.5% of the total amount of federal funds given to any social housing project must be used for social work with the families. However, these funds are often mismanaged, used for other purposes, or not used. When the funds are used according to the legislation, the social work can begin before the families move into the new development, with actions to prepare them to live in the new house and neighborhood. The social work continues for about one year after occupancy. The

social work team that works within a given development (a private company) is usually hired specifically to work on that project. The municipal housing social work department oversees and manages this team [28]. One of the services provided by the social work team is providing workshops on skills that will allow the family to generate income, such as fixing mobile phones, makeup, and nail styling. However, such actions reinforce the social stratification of the populations of these neighborhoods. No real effort is made to effectively train them to obtain a higher income, which could lead them out of a low-income situation. Another important action is having on-call days. On these days the families can bring up any issues they are having, and the social work team mobilizes the municipal network to find a solution. Some of the issues the families bring up include finding schools to enroll children, scheduling health exams, etc.

The bank CEF is the primary agent responsible for financial operations. In this regard, there are two main streams of action that are under CEF's responsibility: first, the management of funds for the construction of the development, and second, the financing process for the acquisition of the housing units by the families. Regarding the management of funds for construction, it is the role of this bank to verify if the developers can complete projects under the program. Hence, before proposing the specific project, the construction company must provide a series of documents to CEF to prove their experience, legal standing, and technical and financial capacity [8]. Once this process is completed, the company is enabled to produce a certain number of housing units with a pre-established typology [14]. Later in the process, CEF is responsible for approving the specific project in relation to the requested funding. This approval refers to budget aspects and the compliance of the project to the program's regulation. After the approval of the project, CEF also manages this funding, releasing monthly funds based on inspections and the company's monthly construction completion report. For the lowest income range, CEF acquires all the housing units on behalf of the existing fund used to finance the construction.

When construction of the new development is about 50% completed, CEF receives a list of the selected families from the city to determine their eligibility to finance a housing unit [29]. The list the city provides includes more families than housing units in the development since not all families will remain eligible after CEF's analysis. CEF requests financial information from the families and the documentation that proves their stated financial situation. It is CEF's responsibility to cross-check the financial information provided by the family, including tax and banking information [8]. Establishing a family's eligibility can be difficult given the frequent informal work arrangements of the candidate families. Once the family is approved, CEF determines the amount of the subsidy and charges the monthly payments for the duration of the ten-year contract. The families are only assigned to a specific housing unit when the construction of the development is almost finished, and sometimes after it is finished.

The federal government is responsible for providing most of the funds and outlining, through regulation, the minimum standards required to access the funds. These include requirements in terms of the program's organization, the roles of stakeholders, and the final product itself in urban, architectural, and technical terms. Currently, the product of any housing program that uses federal funding is required to comply with the minimum standards established in this regulation [30]. The federal government also establishes the national demand and goals, deciding how much funding will be allocated for each region, state, and even municipality. However, because the program requires the initiative of private developers, the release of funds for certain regions often does not meet the established goal. Thus, some cities or regions receive extra funding, while others receive much less than the goal [14,15].

For the design of house units, the federal regulation indicates that the housing units must include a living room and kitchen, two bedrooms, a bathroom, and a laundry area. For houses, the minimum area is 36 m² if the laundry area is outside or 38 m² if the laundry area is inside the house [30]. Since private developers have increased decision power in unit design, they usually have a single unit design that is repeated throughout the

development, and even in several different sites, without considering the diverse needs of end-users [21,23,31,32]. It is expected that families will expand their houses after occupancy. However, only recently has this expectation been acknowledged in the regulation of the program. Even so, it is far from being a solution. The legislation includes only one line about allowing the growth of the units, which translates into English as: the housing unit shall be designed to enable its future expansion without loss to the lighting conditions and natural ventilation of the existing rooms [30]. As a result of the lack of guidance, this line of the regulation is often not followed or enforced. Furthermore, when it is followed, the resulting design usually only allows the addition of one room in a specific location [26].

Each stakeholder has the main aspects of their role defined in legislation. However, how they carry out that role can vary significantly from one city to another, and even from one project to another within the same city. Much of the provision of social housing depends on the individual subjective judgements of the many actors involved in the process, and on the political will of government officials and institutions. Thus, this process is susceptible to the capacities, operational standards, and will of those who carry it out.

4. Post-Occupancy Processes and Design Problems

The way a social housing program is implemented can negatively impact the target population. Housing developments for the lowest-income population are usually isolated from commercial areas where most jobs and services are found, thus also increasing the cost of transportation for the families [21,22,24,32]. These segregated neighborhoods are vulnerable, often becoming ghettos of violence and drug trafficking dominated by militias, especially in large cities [11,21]. Such segregation also diminishes the retention rate, with many units illegally sold while families move back to better located informal arrangements [21]. Furthermore, the standardization in unit design, incorporating only the minimum required by the program, results in units that do not satisfy the needs of the many different families that depend on such programs.

Several studies have shown the variety of families that live in these housing units. The units may have only one occupant, more than five family members, or, in many cases, more than one family in the same unit. These studies highlight that the standardization of the housing product is inadequate, considering the diversity of families who live in these developments [4,32,33]. Standardization issues were also present in previous housing programs. They are a consequence of a minimalistic mass-production approach and the lack of interest in the demand during the production process. Families are only selected and assigned to units at the end of the process [31,32,34]. In this context, the families start making changes and expanding their units to satisfy their needs and build spaces for activities to complement their income. Such activities include small shops and services for the local population. Other factors that also contribute to the families' perceived need to make changes to their units include: the lack of safety and privacy, the need to personalize and define the family's territory, the desire for higher quality in surface materials such as floors and walls, and changes in family circumstance (family size, economic, educational, among others) [35–37].

National and local authorities know that the families will make changes and expand their house units. However, the units are not designed and built to facilitate changes, making it difficult and more expensive for families to do so [21]. Moreover, the homeowners design and illegally build most of the changes themselves. This practice often results in inadequate situations, such as the inappropriate discharge of rainwater, encroachment onto the public space, lack of ventilation and natural lighting, among others [31,35,37]. As well as the families, the problems with self-designed and built expansions also affect the municipality and broader society by diminishing the public authorities' capacity to provide safe and healthy environments and services. For example, there have been several reports of flooding inside the houses because the families had built over the water drainage system, which consequently blocked the access for maintenance [26]. Other examples can be seen in Figures 2 and 3. These figures show two different neighborhoods in the city of Pelotas

in the south of Brazil, which were built more than thirty years apart. Figure 2 shows an older neighborhood, which originally consisted of duplex units. Currently, access to most of the public lighting and distribution is difficult because the electrical network posts are now inside people's houses or locked gardens. In some areas, the posts had to be moved onto the carriageway. Despite being much more recent, the neighborhood of single-story row-houses in Figure 3 shows the same process of encroachment into the public space in many of the houses.



Figure 2. Example of significant transformation and expansions encroaching into public space in the Guabiroba development. Photos by the authors.



Figure 3. Examples of expansions encroaching onto the public space in the Anglo development: (a) advancing onto the neighborhood's green area, and (b) advancing over the sidewalk. Photos by NAUrb-UFPEL [38].

Health problems are also among the most significant negative consequences that can emerge from self-designed expansions. The lack of ventilation and natural light often creates problems of humidity inside the unit, aggravating health problems such as respiratory and skin conditions [31,33,36,39,40]. This lack of ventilation, often associated with overcrowded units, has also been an aggravating factor in the spread of COVID-19 in such neighborhoods [39]. Another concern stemming from such expansions is the significant amount of serious accidents occurring due to the use of areas on top of ceiling slabs and inappropriately proportioned staircases [40].

The families make many kinds of changes to their units, such as changes to surface materials, adding objects of significance or painting the façade to personalize and show territoriality, and adding high walls and bars on windows to increase the appearance of safety [35–37]. However, the most relevant kinds of changes that the families make, and that are often associated with negative consequences, are expansions. Expansions usually occur because the dimensions of the initial unit and its spaces are inadequate to their functions and the needs of the users [36,37]. These changes include expanding existing rooms, such as the kitchen and living room, adding rooms such as bedrooms and bathrooms, and adding a room for business [31,33,35–37]. These modifications affect the spatial aspects of the unit, with significantly diverse design solutions depending on the needs of each family. This variety also appears when considering the same kind of change within the same development. Even in cases wherein an expansion plan is provided, it is often not followed [41]. It is also relevant to note that most changes are made soon after the families move in [33,36]. However, although slower, this process continues through time, as illustrated by the greater amount of such changes in older neighborhoods [4].

Although these processes of self-construction and their consequences are well known both in social housing neighborhoods and informal settlements, it was only in 2008 that the government approved legislation to provide professional assistance to low-income families. The federal law Lei No 11.888, from 2008, establishes that low-income families should have free technical assistance in the design and construction of housing [42]. This law indicates that the services for such assistance should be provided by professionals from the areas of architecture, urban planning, and engineering. Among the several objectives of this legislation are: optimizing and qualifying the use of the built space and its surroundings, and formalizing the process of building, renovating or expanding housing before the municipal public authority and other public bodies [42]. The law allows professionals from four different sectors to act through partnerships with the public executive power: public servants, NGOs, autonomous professionals, and professionals enrolled in university residency or outreach initiatives [42,43]. Thus, this law shows great potential to “channel the forces of self-building” [17] (p. 547) by providing some guidance and legal validation in a self-construction context [17]. However, municipalities and other entities have been struggling with the lack of resources to provide such assistance. As a result, there are still very few cases of actions carried out under this law. More recently, some entities, especially CAU (architecture and urbanism professional council), have been mobilized in facilitating and disseminating the enforcement of this law and providing funding for such actions. However, funding for technical assistance is usually destined to informal settlements, since the families in formally established social housing neighborhoods are considered as already adequately housed [26]. This further demonstrates that the construction of social housing units, post-occupancy processes, and the management of informal settlements are all seen as completely unrelated by national and local authorities.

5. Possibilities and Challenges for Design Improvement through Mass Customization

As seen in the previous sections, many of the problems related to unit design are a consequence of ignoring the needs of the many different families in the production process. The small size of the units, contemplating only the minimum required by legislation in standard designs, leads to the immediate transformation of the neighborhoods in a self-design process, often with significant negative consequences for the families and city. The literature shows some paths of investigation and actions to address this problem.

Building more adaptable initial units is an option that has been extensively researched. More adaptable housing units are designed to make it easier for the occupants to change their homes to suit new circumstances [44]. Some studies have developed guidelines for the design of adaptable housing units specifically for this social housing context [35,37]. However, such guidelines are seldom adopted by developers. Some of the aspects of such adaptability strategies that are not attractive to developers include the higher costs of construction, and the greater effort required in the design stage. These aspects reduce

profits for the developer. This dynamic is evidenced in the few cases that have used such guidelines in their design. An example is the pilot project in Parauapebas, which incorporated housing units that facilitate change along with other urban quality guidelines. In this case, it was possible because the company Vale guaranteed funding and higher profit margins if the developer followed the guidelines, given that the process required more time and involved a larger number of stakeholders [45]. The added effort in the design stage and the higher costs of building housing units following adaptability guidelines could explain why such guidelines have not been incorporated in the social housing programs' legislation.

Initiatives that operate under the technical assistance law [42] have great potential to improve the quality of environments not only in informal settlements, but also in the development over time of formal social housing neighborhoods. However, there have been few technical assistance actions since the inception of this law in 2008. The costs for a professional to work individually with each family to design their home are high, further limiting the reach of the social assistance law as regards individual renovations. Some groups promote actions to teach the families some design and construction skills, such as the currently active *Arquitetura na Periferia* organization [46]. Such actions empower the families to self-design and self-build with more quality, while reaching more families with each action. Mass customization, seen as "the mass production of individually customized goods and services" [47] (p. 48), is another approach that shows potential for reaching a large number of families without needing to increase the funding to the same degree.

In a more practical definition, mass customization is seen as "a system that uses information technology, flexible processes, and organizational structures to deliver a wide range of products and services that meet specific needs of individual customers (often defined by a series of options), at a cost near that of mass-produced items", [48] (p. 2). Organizing social housing programs for the lowest income range to provide units designed to satisfy the needs of each family, without needing to increase funding, could significantly increase the quality of environments both within the units and for the neighborhood. However, there are many challenges to the adoption of mass customization in this context.

A significant challenge is engaging the stakeholders with the idea of mass customization for the lowest income range of the social housing programs. Several studies and industry examples explore the concept of mass customization for social housing programs in Brazil. However, such studies and examples are usually limited to the higher income ranges of the social housing programs. The higher income ranges of the programs have a company–customer relationship like that of any other product: the customer chooses the product they want to buy and how much they are willing to pay for it. The lowest income range does not have this market-oriented logic. Only a few studies explore mass customization in social housing programs for the lowest income range, such as [23,26,34,49,50]. These studies consider the benefits that mass customization could bring and some directions for its implementation.

Although these studies agree that it would be beneficial for the families to have a housing unit customized to their needs, mass customization has not yet been applied in any development for the lowest income range. One of the reasons for this is that many of the motives that lead companies to mass customize—such as attracting more customers with customized products, gaining their fidelity, or taking advantage of their willingness to pay a premium—are not available for the lowest income range [26]. In the case of the lowest income range, the families are chosen and assigned to a unit by the local authorities, and the cost per unit is regulated by the program. Thus, despite the benefit it could bring to the families, the developers are not interested in mass customizing the initial unit for the lowest income range [26]. Therefore, the mass customization initiative and management for the lowest income range cannot depend on the developers. They should be in the hands of a stakeholder who has more to gain from unit customization and that also has management capabilities, such as the local authorities. However, currently, the stakeholder with the decision power over the design of the initial housing units is the developer.

Parallel to this are challenges related to the programs' budget and the regulation of the initial housing units. Some studies indicate potential paths to mass customize the initial unit in this context [23,34]. However, legislation currently regulates the number and type of rooms that each unit must have, as well as the types of materials that must be used, which leaves little room for customization [26]. Although the regulation does not set the sizes for the individual rooms, it establishes the furniture that each room must fit and the minimum size of this furniture [30]. All these parameters are expressed in the regulation as the minimum required, thus the housing units could include more rooms or larger rooms, for example. Nonetheless, the program's regulation also favors proposals that have the lowest cost per unit, thus benefiting the largest number of families [51]. It does not include any incentive for incrementing quality in design or being more considerate of user needs. This encourages developers to produce the smallest possible units, accommodating only the minimum required by regulation. City workers from the social housing sector and researchers have strongly criticized this minimalistic approach of the regulation [24,49,52]. However, changing this approach would require significantly higher funding to benefit the same number of families. Therefore, this existing dynamic is a challenge for the implementation of the mass customization of the initial units.

Some challenges could be overcome by considering the post-occupancy processes as an integral part of the housing provision instead of a separate problem. Most studies and cases of mass customization in housing consider the customization of the initial unit, without taking into account the post-occupancy processes. Therefore, they consider that manufacturing must be finished once the family moves in. However, for individually owned houses, the manufacturing process continues long after the family moves in. A shift in perception to match the reality of the users, in which manufacturing continues after occupancy, broadens the scope in which the mass customization agent can operate. This broader scope allows the inclusion of more actors in the value chain of the mass-customized product. Thus, the developer who builds the initial units can be seen as one of the suppliers, while the local authorities, who have closer contact with the families, especially post-occupancy, become the main mass customization agent, and manage the differentiation of the units [49]. Furthermore, considering post-occupancy processes as part of the manufacturing process allows changes to the units over time, as the needs of the family change. Therefore, as concluded in a previous study, it would be more feasible and sustainable over time to apply a mass customization strategy with post-occupancy differentiation of the housing units [26]. Such an approach could also open doors to structure the mass customization processes considering the technical assistance law. Thus, different modes of funding could be considered for the differentiation of the units in a retrofit approach based on mass customization. Furthermore, organizing processes with a mass customization approach could facilitate technical assistance with the individual renovation of units that reaches a large number of families, differently from the current craft processes, in which a specific and different process is put in place for each renovation.

Importantly, expansions affect the spatial aspects of the units, including the size, number, and types of rooms in the house. Therefore, a mass customization strategy in this context must consider dimensional or geometric customization [26]. The lack of confidence, knowledge and will of the users to engage in the design of their own homes has been identified as the main reason for geometric customization not being more widely adopted in housing developments [53–55]. In this social housing context, such cultural limitation is not present since the families have shown they are willing to design their own homes. Thus, a significant challenge in this context is how to guide the families into designing adequate solutions that do not result in negative consequences.

Mass customization toolkits are widely used to match the needs of the user, with custom possibilities available for the product in mass customization strategies. The use of such a configurator, a co-design system, could be useful to engage the families, post-occupancy, in deciding how to expand their units [26]. For housing, digital configurators can include spatial aspects, allowing geometric or dimensional customization [56–58]. For

this social housing context, the co-design system would only validate solutions within the parameters determined by the local authorities, thus avoiding problematic situations with the designs [49]. Most importantly, this system would serve as an educational tool, providing a medium through which the families can interact with, visualize, and receive feedback on their solutions before starting construction. Thus, it would not only allow the users to gain better insight into their preferences [59], but would also allow users to gain a better understanding of the design solutions. Such a system could also take advantage of other forms of interaction that are useful in increasing the users' perception of space in social housing design processes, such as physical models, virtual reality and augmented reality [50,60–62].

Mass customization for this context is not seen as a business strategy that brings profit to the agent that provides it. Instead, it is seen as a strategy to optimize the use of resources to improve environments in the city, bringing benefits, through the customized product, not only to the families, but also to other stakeholders and broader society [49]. Thus, mass customization is not seen as a solution separate from other approaches for the improvement of environments and design quality. It is seen as an approach that complements other approaches, such as increased unit adaptability and providing technical assistance.

6. Conclusions

The goal of providing adequate housing for those in need is far from being achieved under the current structure of social housing programs in Brazil. This structure leaves significant decision power in the hands of private companies and benefits quantity regardless of quality. Additionally, it limits the design input of other stakeholders to checking for compliance to minimalistic parameters. Most importantly, it excludes the users from any decision. This process results in segregated neighborhoods, and housing units that do not satisfy the needs of users, as evidenced by extensive renovations post-occupancy. Current research shows that it would be beneficial to apply mass customization in the lowest income range of social housing programs [23,26,34,49]. The literature shows there are feasible avenues and sufficient technologies to apply the concept. It demonstrates the potential of mass customization to significantly improve living environments in these neighborhoods, and to maintain this quality as the neighborhoods evolve. Moreover, this is feasible without significant budget increases. The discussions and studies of mass customization, alongside studies of housing adaptability and architectural technical assistance, should lead to new social housing programs that effectively satisfy the needs of the families and ensure the continued quality of the environments as the neighborhoods evolve.

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