

AVALIANDO A RESILIÊNCIA DO AMBIENTE CONSTRUÍDO NA HABITAÇÃO SOCIAL BRASILEIRA: DESAFIOS E REFLEXÕES

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RESUMO

No Brasil, o *déficit* habitacional é um dos desafios decorrentes da urbanização acelerada, sendo que o programa habitacional governamental “Minha Casa, Minha Vida” se destacou na oferta de milhões de moradias sociais no período de 2009 a 2019. No entanto, houve diversos problemas construtivos nessas moradias e uma baixa capacidade de resposta a impactos esperados ao longo do seu ciclo de vida, apontando sua baixa resiliência. Compreendendo a resiliência como força motriz no combate à vulnerabilidade, este artigo discute as bases teóricas do conceito de resiliência no ambiente construído, apresentando as definições adotadas na pesquisa institucional ora relatada e um sistema de matriz avaliativa de resiliência no ambiente construído da habitação de interesse social, apontando os principais achados no cenário brasileiro.

Palavras-chave: Avaliação pós-ocupação; Resiliência do ambiente construído; Habitação Social.

ASSESSING THE BUILT ENVIRONMENT RESILIENCE IN BRAZILIAN SOCIAL HOUSING: CHALLENGES AND REFLECTIONS

ABSTRACT

In Brazil, the housing deficit is one of the challenges arising from accelerated urbanization, with the government housing program “Minha Casa, Minha Vida” standing out in the offer of millions of social housing from 2009 to 2019. However, there have been several constructive problems in these homes and a low capacity to respond to impacts expected during their life cycle, pointing out its reduced resilience. Understanding resilience as a driving force in the fight against vulnerability, this article discusses the theoretical basis of the concept of resilience in the built environment, presenting the definitions adopted in the research presented and a resilience matrix evaluation system to assess resilience in the built environment of social housing, pointing out key findings in the Brazilian scenario.

Keywords: Post Occupancy Evaluation; Built Environment Resilience; Social Housing.

INTRODUCTION

Resilience, in architecture and urbanism, is often associated with built environments where natural disasters or the absence of natural resources are common. This paper focuses on built environment resilience of the Brazilian social housing, which frequently has to overcome socio-economic and also environmental difficulties. Potential threats emerge both in the form of disruptions (over short time horizons) slow moving, and diffuse challenges (over longer time spans, happening on everyday life).

As a response to Brazil’s accelerated urban growth scenario (UNITED NATIONS..., 2011), from 2009 to 2019, at least 4 million new housing units have been delivered by the government initiative

"*Programa Minha Casa, Minha Vida*" (PMCMV) – My Home, My Life – to low-income Brazilians in an attempt to reduce the national housing deficit (currently 6.5 million homes). Representing an investment of approximately US\$ 950 billion and providing much-needed housing for the population, the program raises questions with regard to built environment resilience. Some argue that it has failed to provide to the Brazilian people with the quality cities that they desire (ANGÉLIL, HEHL, 2014). Furthermore, the projects as conceived have demonstrated a low capacity to respond to the impacts and transformations expected during their life cycle. As a result, some recent research has pointed out the increase of the social, physical and environmental vulnerability of these housing developments (VILLA *et al.*, 2017; KOWALTOWSKI *et al.*, 2019).

Built environment resilience is defined as the capacity of the built environment to resist, adapt and transform to deal with different impacts and demands over time (PICKETT *et al.*, 2014; HASSLER, KOHLER, 2014; GARCIA & VALE, 2017). Is a fundamental aspect of raising the quality of social housing developments since it is directly connected to the concepts of sustainability, vulnerability and adaptive capacity. Furthermore, "resilience" is now a critical urban development objective, recognised as a driving force in combating the vulnerable state of urban centres caused by the rapid growth and other problems derived from inadequate urbanization (UNITED NATIONS, 2018).

This article derives from a research primarily developed in international partnership between an English and a Brazilian university¹. This research was duly submitted to ethical assessment and approved under the CAAE number 20239019.5.0000.5152. Currently, the research continues through the ongoing institutional research project entitled "[RESILIENT HOUSE] Design strategies for promoting resilience in social housing through post-occupancy evaluation methods," funded by the National Council for Scientific and Technological Development - CNPq (Research Productivity Scholarship - PQ No. 311624/2021-9), between 2022 and 2025.

Its intention is to present the theoretical basis on the concept of resilience in the built environment and the definitions adopted in the research, alongside a brief scenario of the resilience in the built environment of Brazilian social housing, pointing out key findings. Subsequently, it will present the definition of the resilience matrix evaluation system and some preliminary results derived from its usage. The methodology adopted in the research reported is structured as follows:

- (i) bibliographic research - review of the literature that critically conceptualizes resilience of the built environment;
- (ii) referential research - analysis of the results of the previous research, analysis of the elements that make up the systems of evaluation of the resilience in architecture and urbanism, and definition of the systems' resilience assessment matrix;
- (iii) conceptual research - from the findings of the bibliographic and referential research, the paper presents the concepts and theories, and defines a set of resilience assessment methods;
- (iv) empirical research - observational study and cross-sectional study based on comparative analysis of two different solutions (PMCMV flats v. semi-detached houses) in Uberlândia, MG, Brazil.

The main purpose is to provide, with the results, information for the agents involved in the production of social housing in Brazil in order to develop effective strategies to promote more resilient housing. More broadly, the partnership of the authors' institutions seeks to share knowledge in the areas of Post-Occupancy Evaluation, Building Performance Evaluation, sustainability, adaptability and resilience of buildings in order to advance an international understanding of localized solutions.

REVIEW: RESILIENCE IN THE BUILT ENVIRONMENT

In the face of uncertainty and environmental, socio-economic and political risk, the notion of resilience has attracted the attention of academics and decision makers across disciplines such as engineering, psychology and disasters (MATYAS, PELLING, 2014; VALE, 2014).

Holling's theory (1973), often cited as the origin of the theory of modern resilience (FOLKE, 2006; KLEIN *et al.*, 2003; MEEROW, NEWELL, 2015), applied the term in relation to the capacity of a system to absorb, and even benefit, from impacts that act upon it, without causing permanent damage to its structure and functionality. Before this, the term was used in physics, attributed to the resistance of materials to deformation under the effect of a force.

With more direct reference to the built environment, Hassler & Kohler (2014: 121) address the concept of resilience in the built environment in a temporal perspective, where threats in the resilient system can be both disruptive or diffuse. In addition, Garcia & Vale (2017: 53) will reinforce that resilience is focused on the process of adaptation and persistence, meaning that it functions as a thinking approach towards the built environment design.

This variety of conceptualizations of the term "resilience" leads to two reflections. On the one hand, there is a more positivist view that recognizes the benefits of conceptual freedom offered by the breadth of the term as a boundary object that can foster multidisciplinary scientific collaboration (MEEROW, NEWELL, 2016). On the other hand, a more critical view recognizes the scientific fragility of the imprecision of the term "resilience", which might be difficult to operationalize (MEEROW, NEWELL, 2016; VALE, 2014).

In order to mitigate the weakness pointed out above, a clear definition of the concept to be used in this research is fundamental. From those definitions, it is considered that the built environment resilience is a built environment capacity to resist, adapt and/or transform to deal with changes / impacts of different orders (climatic-natural, social-economic, physical architectonic and/or physical urbanistic) imposed over time (PICKETT *et al.*, 2014; HASSLER, KOHLER, 2014; GARCIA, VALE, 2017).

According to Garcia & Vale, (2017), we usually mean natural habitat for species other than human begins as opposed to an environment, whether rural or urban, constructed by people for people. In the specific case of this research, we define the built environment as the "man-made building and infrastructure stocks that constitute the physical, natural, economic, social and cultural capital" (HASSLER, KOHLER, 2014: 120), pertaining to social housing developments.

Resilience thinking is thinking about the system in its complexity (TAINTER, TAYLOR, 2013). It is important to highlight that applying the idea of resilience to the built environment means making decisions about how things should change. Within this context, a wider question is: why is resilience important in the built environment? The main arguments are: on-going ordinary crises, strong recommendations from recent agendas and policies, and a lack of research focused on the resilience of the built environment (GARCIA, VALE, 2017). Today, leading institutions promote urban resilience in the world, such as the Stockholm Resilience Centerⁱⁱ, the Rockefeller Foundationⁱⁱⁱ and the ARUP^{iv}. However, many do not rely on the work of urban architects and planners, which, according to Garcia and Vale (2017), seems an oversight given the emphasis on the link between social and ecological systems.

In this regard, resilience can be understood as the contrary state to vulnerability (IPCC, 2014), where the precarious conditions of physical-territorial and social precariousness amplify the vulnerability that prevents a state of resilience of the urban systems (SMITH, KLEIN, HUQ, 2003). The approach adopted in this study recognizes a broader and more systemic view, where vulnerability refers to the sensitivity of the system in the face of specific threats, combined with the adaptive capacity of the population, of the exposed institutions and of the built environment, in other words, their conditions to utilize available resources to react to the events (BROOKS, 2003).

The adaptive capacity component is a concept closely related to both resilience and vulnerability (MAGUIRE, CARTWRIGHT, 2008), defined as: "the ability or capability of a system to modify or change its characteristics or behaviour to cope better with actual or anticipated stresses" (BROOKS, 2003, p.8), with actions to reduce vulnerabilities and increase resilience (SMIT, WANDEL, 2006).

CONTEXT: THE RESILIENCE OF BRAZILIAN SOCIAL HOUSING

In developing countries, a relatively low quality of construction and urbanism increases the vulnerability of millions of people who find it difficult to find adequate housing, which in turn is found in precarious conditions and locations (AMORE, SHIMBO, RUFINO, 2015). When governmental housing programmes try to address this deficit, the quality of defined standards typically leads to inadequate housing for residents. This requires them to make modifications to buildings which are not designed to accommodate such adaptations, and can lead to a waste of materials and the inefficient use of

resources (VILLA *et al.*, 2017). The lack of quality in the implementation of these houses, together with ineffective public policies, has made the social housing supply a problem that is perpetuated in Brazil.

The repetition of standardized models of social housing is observed throughout the Brazilian territory, which are disconnected from concerns related to local social, economic, cultural, climatic, and environmental characteristics. Some of the consequences, highlighted by research conducted by IPEA (INSTITUTO..., 2014), and by the Federal Court of Accounts (SENADO..., 2018), are dissatisfaction with the urban insertion and availability of urban equipment, as well as the dimensions, temperature, humidity, room distribution, and ventilation of housing units (KOWALTOWSKI *et al.* 2019; AMORE, SHIMBO and RUFINO, 2015).

After the National Housing Bank (BNH) ceased to exist in 1986, the federal government's housing policies underwent a discontinuity, and the responsibility for providing housing for low-income audiences became primarily that of states and municipalities. Only in 2003, there was an attempt to create a new national housing policy that emphasized the strategic role of local administrations, working together with other levels through the National System of Social Interest Housing (SNHIS). In response to the global economic crisis of 2008, the *Minha Casa, Minha Vida* (MCMV) was created in March 2009, which aimed to provide affordable housing for low-income families (CARDOSO, ARAGÃO and ARAÚJO, 2011; ROLNIK and ROYER, 2014).

The programme was a response to the Federal Government's effort to address the housing problem. However, it has suffered criticisms about its hiring process, guidelines, planning and execution for providing neither the quality nor the location expected for the houses (KOWALTOWSKI *et al.*, 2019, VILLA *et al.*, 2017; AMORE, SHIMBO, RUFINO, 2015; CARDOSO, MELLO, JAENISCH, 2015; BERR, FORMOSO, 2012; KOWALTOWSKI, GRANJA, 2011; MARICATO, 2009; HIRATA, 2009).

The MCMV was created to address the housing demand, by making it easier for the population to acquire and construct a house. Unfortunately, the profit-based process resulted in horizontal and vertical developments¹ located at peripheral areas of the city (because of the low price of land), disconnected from the urban realm and without any consolidated or pre-established infrastructure, which have considerable impact on the economic, social and urban infrastructures of Brazil (VILLA *et al.*, 2017; AMORE, SHIMBO, RUFINO, 2015; KOWALTOWSKI, GRANJA, 2011).

Various authors have indicated the low functionality of the housing, which, according to a minimum architectural programme, overlook the necessities of the family profiles of the residents. Presenting reduced and compartmented spaces, the rooms make the installation of basic furniture difficult, and also reduces privacy and the appropriation of the residents (LEITE, 2006; PALERMO, 2009; VILLA, SARAMAGO and GARCIA, 2015). Besides this, the choice of construction systems and finishes are quite limited, and there is an assumption that all domestic activities should be able to be performed in ground housing units with a minimum space (CEF, 2012) (see typologies on Figures 1-2). As pointed out by other studies on POE (VILLA *et al.*, 2013), such situations are aggravated by the difficulties encountered in remodelling of the housing unit over time, demonstrating the lack of flexibility required and the predicted need for enlargements.

In 2021, the MCMV was replaced by the *Casa Verde e Amarela* programme through the MP nº 996/2020, sanctioned by Law 14.118/21. This change resulted in budget cuts for low-income families. The *Casa Verde Amarela* program prioritizes the offering of loans with resources guaranteed by the FGTS², known as Group 2, aimed at carrying out improvements and land regularization (MINISTÉRIO DA ECONOMIA, 2020). This means that housing production and public housing policy have become privatized and inaccessible to vulnerable populations who do not have the possibility to take on a mortgage and/or approve loans from financial institutions. This situation highlights a failure in the social inclusion proclaimed, demonstrating the importance of research capable of supporting the promotion of resilience and the fight against vulnerabilities frequently observed in the sector.

¹ Houses and flats are commonly referred to as horizontal and vertical developments, respectively. According to PNAD (2013), houses are permanent private residences that occupy a building with one or more floors, situated on the same land and without shared spaces (such as vestibules, stairs, corridors, entrances, and other areas). On the other hand, flats are permanent private residences located in a multi-story building with more than one unit, and are served by shared spaces such as a foyer, stairs, corridor, entrance, and other facilities.

² FGTS stands for "*Fundo de Garantia por Tempo de Serviço*" in Portuguese, which translates to "Time of Service Guarantee Fund".

Figure 1 – MCMV similar Housing Developments in different climatic regions
HORIZONTAL DEVELOPMENTS IN SÃO GONÇALO DO AMARANTE - RN AND MARABÁ - PA (2013)

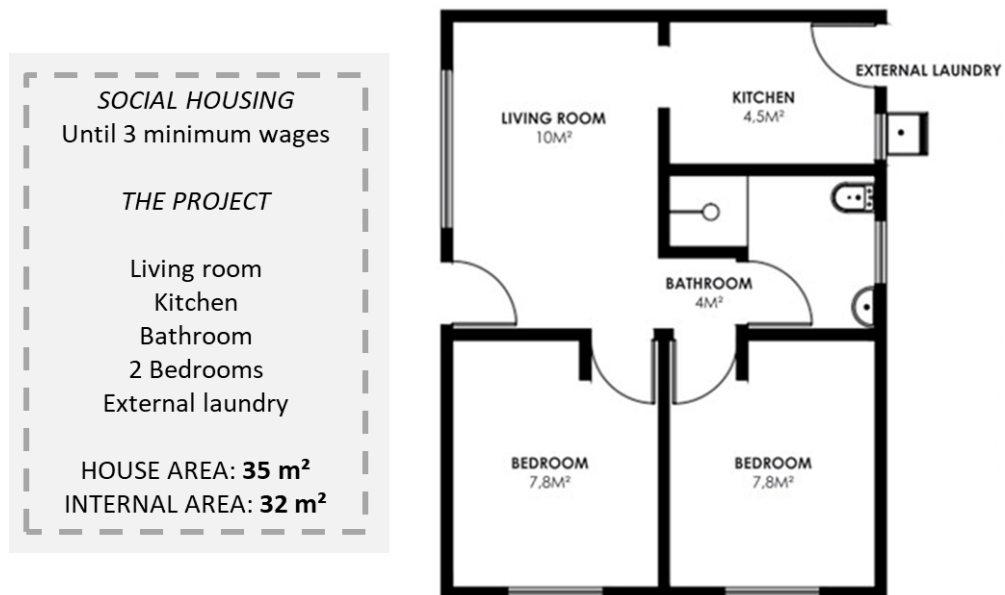


VERTICAL DEVELOPMENTS IN BELO HORIZONTE – MG AND CAMPINAS – SP (2013)



Source – AMORE, SHIMBO & RUFINO, 2015.

Figure 2 – Horizontal house unit typology example in Brazil



Source – <http://www.caixa.gov.br/> (Adapted).

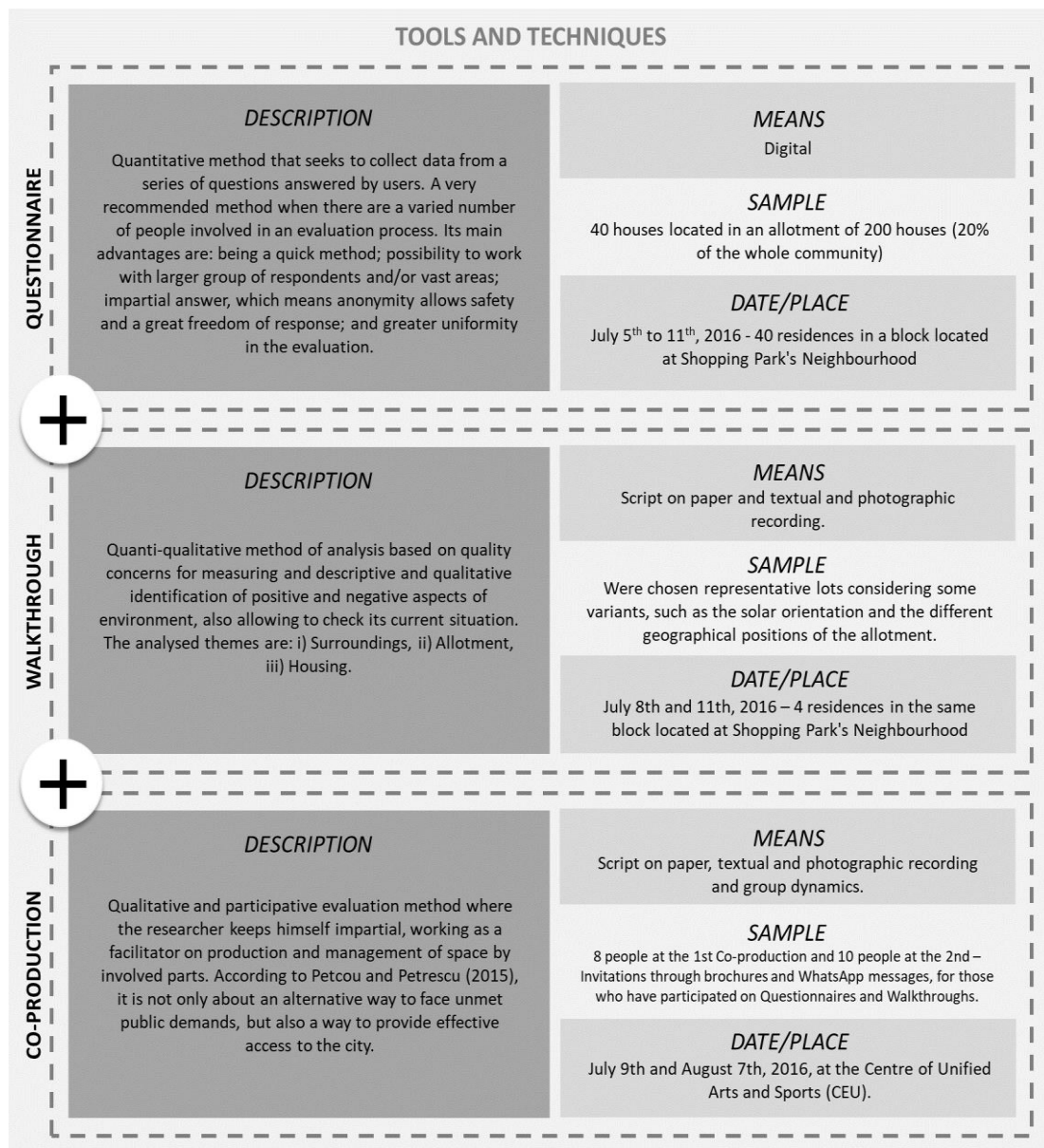
Results from the preview research

The research named [RESAPO_Stage 1] Method of analysis of the Resilience and Adaptability in Social Housing Complexes through Post Occupancy Evaluation and Co-production^v, developed in 2016-2017, reviewed a Brazilian social neighbourhood named "Shopping Park", located in the city of Uberlândia, in the state of Minas Gerais. In this research, advanced Post-Occupancy Evaluation and Co-

production techniques have been applied, with the aim to develop initial knowledge about the resilience in social housing developments (Figure 3). The research informed improvements of the Shopping Park neighbourhood, and future projects of the same type, in order to increase the resilience of families in social housing programmes and minimise social and environmental impacts commonly found in this sort of development in the future. Stages 2 and 3 of this research aimed, through co-production activities, to increase the resilience in the houses studied and evaluated previously (VILLA, ORNSTEIN and VASCONCELLOS 2022; GARREFA *et al.*, 2021).

The several transformations which Brazilian society has gone through led to the emergence of other forms of domestic leisure, transformations in the notions of privacy and individuality, and also the growth of homeworking. As these social houses do not attend to the new functions of domestic space, remodelling and changes to low-cost housing are very frequent (almost obligatory), with a very large number of house interventions (VILLA *et al.*, 2022b). The inadequacy of the houses, evidenced by the case study, also occurs due to the lack of enough space to accommodate even the basic traditional demands, creating undesirable “competition” between furniture, appliances and internal circulation.

Figure 3 – Tools and techniques: evaluation at Shopping Park neighbourhood, Uberlândia, MG, 2016

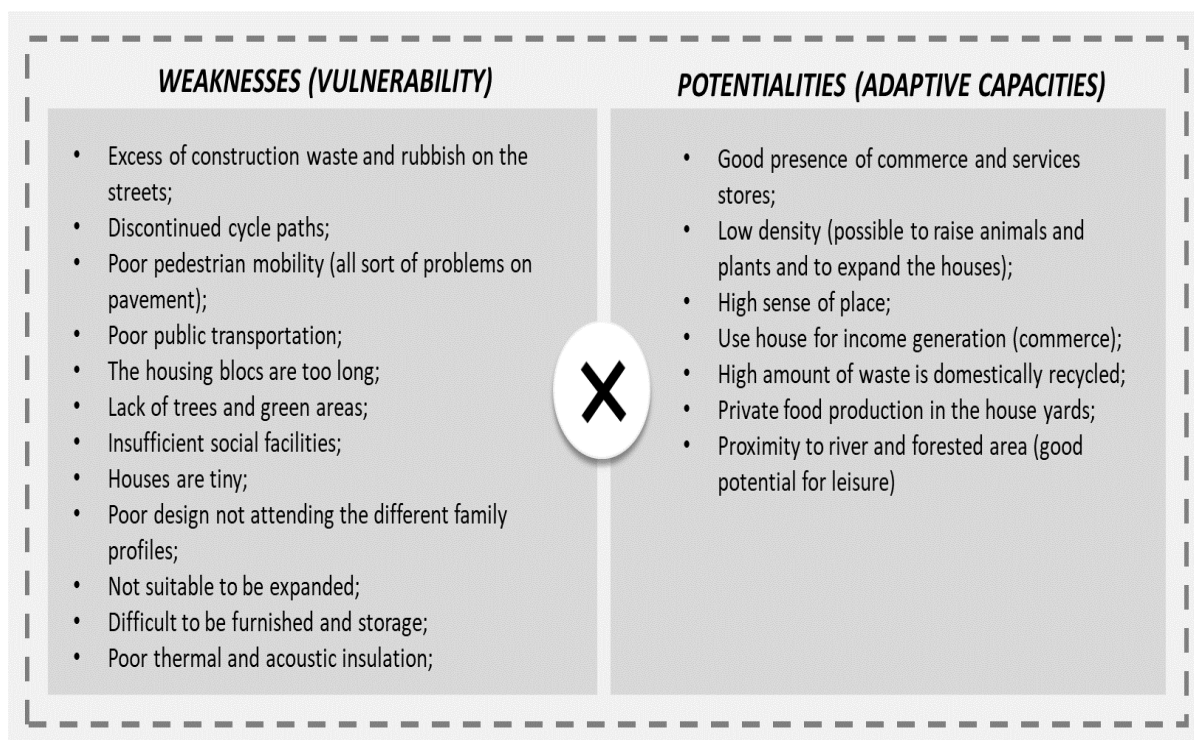


Source – Adapted from VILLA *et al.*, 2017.

The main results from RESAPO_Stage 1 reinforce the arguments shown previously, since the houses sampled present innumerable constructive, functional and environmental problems. High levels of dissatisfaction were observed in relation to the repetition of typologies, as well as inability of such typologies to attend to different family profiles.

The tools and techniques applied revealed that the residents' dissatisfaction is not restricted to the houses. It extends to the way these houses are inserted in the city and the relationship with the urban space and its facilities. These factors result in the weakening – socially, economically and environmentally – of the community. The residing population becomes more vulnerable to various forms of impacts: climatic natural order, physical-architectonic order, physical-urbanistic order and socio-economic order.

Figure 4 – Main weaknesses and potentialities perceived during the first 5 years of use the evaluated houses, found in the research RESAPO_Stage 1



Source – VILLA *et al.*, 2017.

From these concepts, we identified the main impacts, shocks and tensions in the system studied (Figure 4). The information was identified in previous research RESAPO_Stage 1 in a specific case study located in the city of Uberlândia. These impacts were selected according to the order and type they came from. The impacts analyzed are those related to the scenario 1, which is referred to when the residents have just received their houses through the PMCMV with the problems previously mentioned (item 3). Unpredicted impacts, considered as scenario 2, are those that frequently occur during use first 5 years of use, and may be of external origin (climate) and internal (social, spatial) origin. It should be noted that this information is only for reference since its precise and complete identification is one of the objectives of this research (see Frame 1).

Frame 1 – Impacts, shocks and stresses identified in the system based on RESAPO_Stage 1

| | SCENARIO 1 (HOUSE DELIVERED ³) Imposed changes to users (characteristics inherent to the houses delivered) | SCENARIO 2 (5 YEARS OF USE) Unpredicted changes to users (characteristics inherent to the use) |
|------------------------------|---|--|
| CLIMATIC-NATURAL ORDER | <ul style="list-style-type: none"> Inadequate allocation of blocks, perpendicularly to contour lines, causes fast water runoff A implantation in a high declivity area without the construction of retaining walls Lack of green areas and street vegetation – no shadow and water infiltration | <ul style="list-style-type: none"> Lack of resources Increase of waste generation (due to refurbishments) Stronger rains plus waterproofing of lots – risk of floods Stronger wind Stronger temperature – high rates of radiation absorption Long dry seasons Exposure to noise Risk of landslides |
| PHYSICAL-ARCHITECTONIC ORDER | <ul style="list-style-type: none"> Design does not match the needs of different family profiles Poor quality and performance of construction materials and services infrastructures Reduced, compartmentalised and monofunctional spaces Lack of privacy among residents due to rooms' accesses converge towards the same point – the toilet Difficulty to enlarge due to inflexibility of masonry and closed design that does not predict/accommodate enlargements Lack of privacy/security relating to the neighbourhood due to the absence of external walls and position of windows and doors Semi-detaching without acoustic insulation causes privacy problems among neighbours Furniture does not fit properly, obstructing circulations | <ul style="list-style-type: none"> Risk of structural collapse after refurbishments without technical assistance Health problems due to the lack of insulation and ventilation inside rooms after enlargements Risk of domestic accidents High rate of robbery and drug trafficking |
| PHYSICAL-URBANISTIC ORDER | <ul style="list-style-type: none"> Lack of facilities for leisure, culture, education, health, security, garbage collection Low density linked to the large extent of blocks leading to aesthetic monotony Unconsolidated and badly distributed commercial, institutional and service activities Need of large displacements to achieve basic services and employment opportunities, within or outside the district limits Public transport does not match with the population demand required There are many green areas without planning, or landscape and architectural projects | <ul style="list-style-type: none"> Deposition of waste at green areas without use, impairing its use Inappropriate disposal of waste attracting undesirable animals Irregular occupations consolidated in the areas of permanent preservation Contamination of soil, river and springs due to sewage that is released directly |
| SOCIOECONOMIC ORDER | <ul style="list-style-type: none"> Low monthly incomes (0-3 minimum wages) Lack of local opportunities of job Low educational level Insufficient educational facilities Lack of engagement High costs involved on making refurbishments | <ul style="list-style-type: none"> Change of family profile Unemployment Need of extra income generation indoors Psychological diseases Drugs consumption in public areas Violence |

Source – VILLA *et al.*, 2017.

³ The assessment of scenario 1, which involves the delivery of the development to the residents, was conducted through the analysis of the following documents: A) Technical documentation of the development, such as plans, memorials, construction specifications, and other related materials, which were obtained from the Municipality of Uberlândia; B) The outcomes of the PTTS (Social Technical Work Project), developed by the Municipality of Uberlândia; and C) An examination of the residents' recollections, based on questionnaires and structured interviews, as documented by Villa *et al.* (2017).

DEVELOPMENT OF A SYSTEM RESILIENCE ASSESSMENT MATRIX: HOW TO ASSESS RESILIENCE IN THE BUILT ENVIRONMENT?

Assessing the resilience of the built environment is not an easy task. Garcia and Vale (2017), indicate that “...there is no existing methodology for measuring resilience in the built environment, particularly when it comes to measuring things that matters for designers, like the size or shape of a block or a neighbourhood. Attempts to do this have looked at how well cities and urban areas could cope with disasters” (GARCIA, VALE, 2017: 159). We recognize, of course, the relevance of these works, however this will generate responses to particular natural hazards, but it does not account for ordinary changes in a city, like heritage loss, urban growth or the impact of cities on local ecosystems that in turn can increase the vulnerability of the built environment. On the other hand, scholars in ecology have been developing their own ways of assessing changes to know more about resilience but there is a yet no unified approach. In view of the problems identified above, this study proposes a matrix of assessment of the resilience in the built environment.

The starting points for the development of the matrix were:

- (i) the conceptual definitions adopted in the study (Frame 2);
- (ii) the clear definition of the object of the study (Frame 3);
- (iii) the results of previous research; and
- (iv) analysis of the elements that make up the systems of evaluation of the urban resilience (Frame 4/Figure 5).

According to Garcia & Vale (2017), the *decision* system will identify what has to be kept, improved or enhanced. As suggested above, you need to know where you are starting from, which implies measuring something, and you need to know where you are going, which implies modelling future possibilities. Thus, resilience implies engaging with a problem in a deep and quantitative way that moves beyond ticking a predetermined checklist. From this recommendation, the methodology of this study is based on the technologically advanced methods for assessing process (post-occupancy evaluation) and use of parametric modelling resources for comparative analysis and visualization of results.

Frame 2 – The conceptual framework of the study

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| RESILIENCE: Built Environment Resilience (BER) is a built environment capacity to resist, adapt and/or transform to deal with changes or impacts imposed over time (GARCIA; VALE, 2018; RODIN, 2015; PICKETT et al., 2014). |
| BUILT ENVIRONMENT: The built environment includes man-made building and infrastructure stocks that constitute the physical, natural, economic, social and cultural capital. In the specific case of this research, we define the built environment as the social housing developments. |
| SYSTEM: This research assumes that the built environment (social housing developments) is a system composed of different elements: natural environment, buildings, infrastructures, residents, managers and social agents. |
| SOCIAL HOUSING DEVELOPMENTS: Social Housing Developments delivered in Uberlândia (Brazil) with up to 5 years of use – comparative analysis between two different solutions (PMCMV flats x semi-detached houses). |
| VULNERABILITY: The vulnerability in social housing refers to their stage of sensitivity/susceptibility to certain threats, mainly deriving from characteristics inherent to the project delivered and the situation of the building at the time of the incidence of these threats, which compromise their ability to resist, adapt and transform (VILLA et al., 2017; LEMOS, 2014). |
| ADAPTIVE CAPACITIES: Adaptive capacities are positive responses to the impacts experienced. These are adjustments in the behaviour and characteristics of a system to better deal with external tensions, which may result in actions to reduce vulnerability and increase resilience (BROOKS, 2003; SMIT; WANDEL, 2006). |
| IMPACTS/DEMANDS: The term impact refers to the set of acute shocks and / or chronic stresses that threaten the lives, livelihoods, health, ecosystems, economies, cultures, services and infrastructure of an exposed society and built environment, generating negative effects proportional to the system’s state of vulnerability at any given time (ARUP; THE ROCKEFELLER..., 2015; GARCIA; VALE, 2018; ELIAS-TROSTMANN et al., 2020; LEMOS, 2014). |

Source – VILLA et al. (2022b).

Frame 3 – Definitions of the object of the study

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| <p><i>WHAT IS THE OBJECT OF STUDY?</i> The study object of the research are two social housing developments delivered by the program “<i>Minha Casa, Minha Vida</i>” in the city of Uberlândia (Brazil) with an average of 5 years of use and characterised by different typologies (flats and semi-detached houses).</p> |
| <p><i>WHAT CHARACTERISES THE SYSTEM OF THE STUDY?</i> This research presupposes that the built environment (development of social housing) is a system composed of (i) natural climatic order; (ii) physical-architectural order; (iii) physical-urban order (iv) socio-economic order.</p> |
| <p><i>WHAT WILL BE EVALUATED?</i> It is intended to evaluate the resilience of the built environment based on the identification of the main impacts, vulnerabilities and adaptive capacity perceived in the system. We will also evaluate desirable qualities for resilience in the built environment: environmental comfort, environmental adequacy resistance, flexibility, accessibility, well-being and engagement.</p> |
| <p><i>WHAT ARE THE ASSESSMENT SCENARIOS?</i> Two scenarios will be evaluated: (i) SCENARIO 1 – when the house was delivered by the programme, and (ii) SCENARIO 2 – when the house reaches more or less 5 years of use).</p> |
| <p><i>WHICH TOOLS WILL BE USED FOR EVALUATION?</i> The research will use multi-method of qualitative and quantitative nature, depending on each evaluated attribute. It is intended to use as a base, technologically advanced tools, developed in previous research [RESAPO_stage 1], which questionnaires and walkthroughs. Such instruments use digital data platforms to facilitate the collection and analysis of results. See more information at https://systemapodigital.wixsite.com/english.</p> |

Source – VILLA *et al.* (2022b).

Methods for assessing and visualization of results

Generally, there are three types of feedback from Building Performance Evaluations (BPE):

- (i) Review of project performance – this covers the brief, design, project management, programming and co-ordination, cost control, build quality, etc;
- (ii) Feedback during the first year or so after completion – this can help to fine-tune inform the client and the design and building team, and ease transition into full and effective operation;
- (iii) Assessment of the complete product and its performance in use.

Post-Occupancy Evaluation (POE) is normally understood to fall in the third category, although it can sometimes be included in any or all three. Buildings are also a mixture of physical (“hard”) and behavioural (“soft”) systems. According to Mallory-Hill, *et al.* (2012), in the second half of the twentieth century the traditional POE (with focus in the users) has become a Building Performance Evaluation, amplifying the focuses on the relationship between design and technical performance of buildings in relation to human behaviour, needs and desires (STEVENSON, 2019; STEVENSON, LEAMAN, 2010).

According to Roaf (2004), POE is about real-world outcomes and their consequences (“ends”) rather than design prescriptions (“means”). It aids learning from experience to improve the next generation of buildings. The relevance of POE in achieving high quality in an architectural project has already been identified in many studies in civil construction, both in Brazil (ELALI, VELOSO, 2006; VILLA & ORNSTEIN, 2013; VOORDT, WEGEN, 2013), and in the international sphere (MALLORY-HILL,; PREISER, WATSON, 2012; PREISER, NASAR, 2008; PREISER, HARDY, SCHRAMM, 2018; STEVENSON, BABORSKA-NAROZNY, 2018; LEAMAN, STEVENSON, BORDASS, 2010; PREISER, VISCHER 2005; ROAF, 2004).

Being resilient – resilience qualities desired

According Garcia & Vale (2017), a resilience measurement is needed and it is necessary to create a theoretical framework, a theoretical built environment made out of the pieces we can measure, or to pick the variables that are assumed to be the most important, and this of course depends on whose assumptions we use.

Today there are a number of leading institutions that promote urban resilience in the world and have developed methods for resilience assessment. However, these institutions focus their work on aspects related to urban planning and urban management, with an emphasis on the connection between social and ecological systems. None of them address the problems most closely linked to the scale of the housing itself, focusing on the resilience of the built environment.

In this sense, the methodology of evaluation of urban resilience that most closely matches our objectives is the tool system “City Resilience Index (CRI)”. The tool system provides a holistic, practical and evidence-based definition of urban resilience. The CRI shows the relevance of the study of resilience to the expansion of the quality of our cities. The CRI measures relative performance over time rather than a comparison between cities and provides a common basis of measurement and assessment to better facilitate dialogue and knowledge-sharing between cities (ROCKEFELLER FOUNDATION, 2015). The structure and categorization proposed by the CRI served as a reference for the development of the matrix that will be described below.

The evaluation matrix (Frame 4/Figure 6) was structured based on the main impacts perceived in social housing, especially in the Brazilian case. These impacts were identified mainly from evaluative research (item 3). Attributes and indicators of resilience have been defined in line with perceived impacts. They are derived from the analysis of factors identified as important, to allow the built environment (social housing) and its residents to recover from impacts. Together they form the “immune system” of the environment.

Frame 4 – System resilience assessment matrix

| <i>IMPACT</i> | <i>RESILIENCE ATTRIBUTE</i> | <i>RESILIENCE INDICATOR</i> |
|---|-----------------------------|---|
| <ul style="list-style-type: none"> • Strong rains • Floods • Long periods of drought • Heat waves • Cold waves • Strong winds • Acoustic problems • Ergonomic problems • Low performance of building materials worsening after refurbishments | ENVIRONMENTAL COMFORT | THERMAL COMFORT VISUAL COMFORT ACOUSTIC COMFORT ANTROPOMETRIC COMFORT |
| <ul style="list-style-type: none"> • Alterations in water and energy supply • High water and energy costs • Lack of vegetation and permeable areas • Low performance of building materials • Presence of waste in green areas | ENVIRONMENTAL ADEQUACY | AIR WATER ENERGY SOIL WASTE MATERIALS/SYSTEMS |
| <ul style="list-style-type: none"> • Variety of family profiles • Demands for work at home • Different ways of life • Need for house extensions • Lack of privacy of family members • Need for storage | FLEXIBILITY | ADAPTABILITY MULTIFUNCTIONALITY VARIABILITY CONVERTIBILITY |
| <ul style="list-style-type: none"> • Lack of adequate collective transportation • Lack of universal design • Weak urban insertion • Lack of infrastructure • Lack of schools and cultural facilities | ACCESSIBILITY | MOBILITY UNIVERSAL DESIGN ACCESS TO SOCIAL FACILITIES ACCESS TO INFRASTRUCTURE |
| <ul style="list-style-type: none"> • Lack of space for flourishing • Lack of space for interaction between residents • No privacy between residents and neighbours • Poor facilities to perform physical activities • Need for access to healthy food • No connectivity with the city • Lack of green spaces • Lack of schools and health care facilities • Feeling of belonging –“The own home dream” • No identity with the neighbourhood | WELL-BEING | TAKE NOTICE GIVE KEEP LEARNING BE ACTIVE |
| <ul style="list-style-type: none"> • Poor communication network • Weak interaction between neighbours • Low active participation in local social entities • Low active participation in public activities • No awareness of local production • Insecurity • Violence | ENGAGEMENT | TAKE PART SHARE COMMUNICATION MOTIVATION SAFETY |

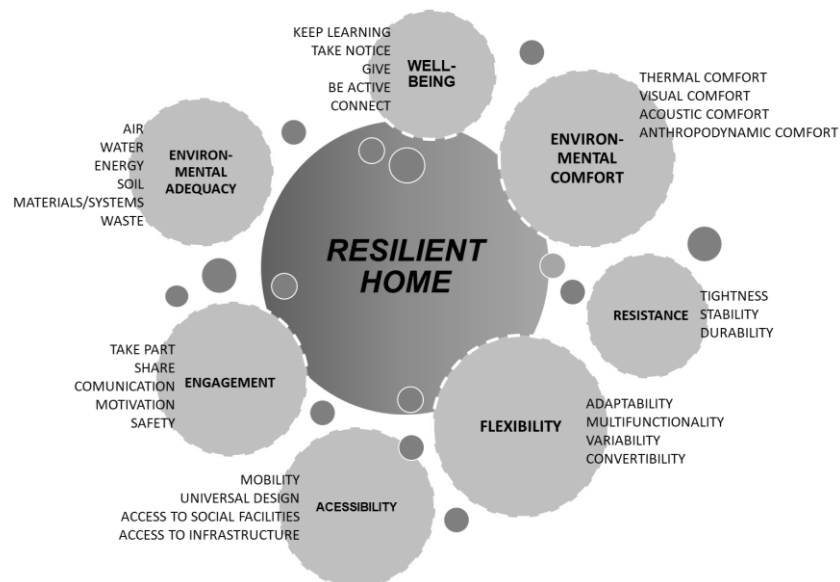
Source – VILLA *et al.* (2022b).

Although the definition of attributes and indicators of resilience start from the main impacts perceived in the environment, they present a generic approach. This makes the evaluation model generic and applicable in different contexts. In this way, this study intends to be applied in different contexts during the years 2018 to 2020, especially in Brazil and the United Kingdom. This application in different case studies intended to support an objective refinement of the matrix, its attributes and indicators. It was the intention to investigate, through a comparative analysis, the possibility of assigning indices or weights to the indicators, depending on the context in which it was applied.

Figure 5 visually summarizes the system resilience assessment matrix. Finally, the aim of this study is to advance in the area of resilience of the built environment of social housing in different ways:

- (i) with the development of an evaluation matrix, as well as its instruments, applicable in different contexts;
- (ii) the establishment of databases with comparative bases; and
- (iii) the development of design guides for more resilient homes (intended for designers).

Figure 5 – System resilience assessment matrix: attributes and indicators of resilience



Source – VILLA *et al.* (2022b).

APPLICATION OF THE MATRIX IN CASE STUDY: ASSESSING ENGAGEMENT AND ENVIRONMENTAL COMFORT IN SOCIAL HOUSING

Methodological Procedures

Currently, there are masters and doctoral researchers affiliated to the [MORA] Housing Research group^{vi} investigating the attributes of resilience and their indicators enunciated for the reality of Brazilian social housing (ARAUJO and VILLA, 2020; VASCONCELLOS, 2019; VILLA *et al.*, 2019; BORTOLI, 2018). Within the scope of the group, and as a methodological development of the proposed matrix, POE instruments were developed to assess the resilience for each of the attributes and their indicators. These instruments were designed with the purpose of generating information capable of orienting reforms aiming at the amplification of resilience in social housing. They are: the impact questionnaire and the resilience ruler.

The impact questionnaire was structured in order to measure the level of inconvenience caused by impacts on the houses. These impacts, in turn, are derived from major causes, which threaten lives and housing, generating negative effects more or less felt by residents of social housing. Once these impacts and the level of inconvenience caused by their effects (if there is too much, too little or if there is none) are known, there are indications about the vulnerabilities in question in the case study, pointing out priorities for action for the research group (VILLA *et al.*, 2022a).

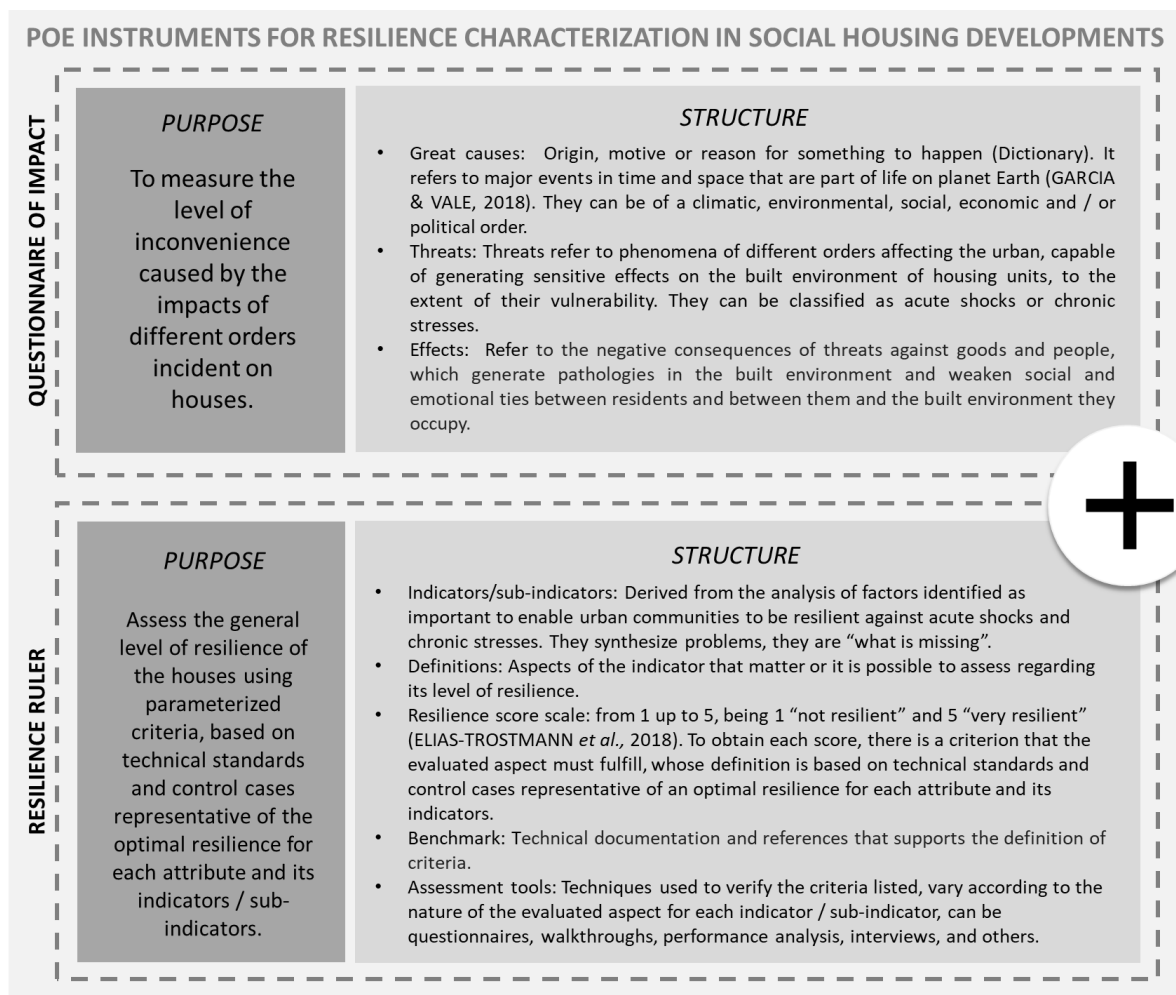
It is also necessary to analyse the general performance of each attribute of resilience in view of an ideal configuration situation. It is necessary to list “control cases”, representative of the optimal

resilience for each attribute and its analysed indicators/sub-indicators, which will provide analysis criteria and technical parameters to analyse the case study, and, based on this, state whether it is more or less resilient for each aspect analysed (VILLA *et al.*, 2022b)..

In this context, the research group developed the POE instrument designated as resilience ruler, which aims to answer the question “How far are the current conditions of a configuration capable of bringing resilience (the referred ideal configuration)?”. This rule applies to each of the proposed evaluation matrix attributes and their indicators/sub-indicators, through a standardized scoring system on a scale of 1 to 5, 1 for “not resilient” and 5 for “very resilient. Figure 6 summarizes explanations about each of the instruments and their structures.

The output data from these instruments provide a general overview of the resilience in the case study, for each indicator, allowing to check with precision what must be done to enable the achievement of a more resilient configuration, considering the socioeconomic and cultural reality of social housing residents in Brazil. After all, it is important to note that the study presented intends to advance in the area of research on resilience in the built environment of social housing, especially developing guidelines for users to carry out more resilient interventions on their homes.

Figure 6 – POE instruments for resilience characterization in social housing developments



Source – VILLA *et al.* (2022b).

Example of results of the application of the matrix for the attributes engagement and environmental comfort

Pilot studies developed by Bortoli (2018) and Vasconcellos (2019), already concluded, allowed to observe the potential of these instruments in obtaining information to support actions aimed at amplifying resilience. Both were developed in a case study located in the southern sector of the city of

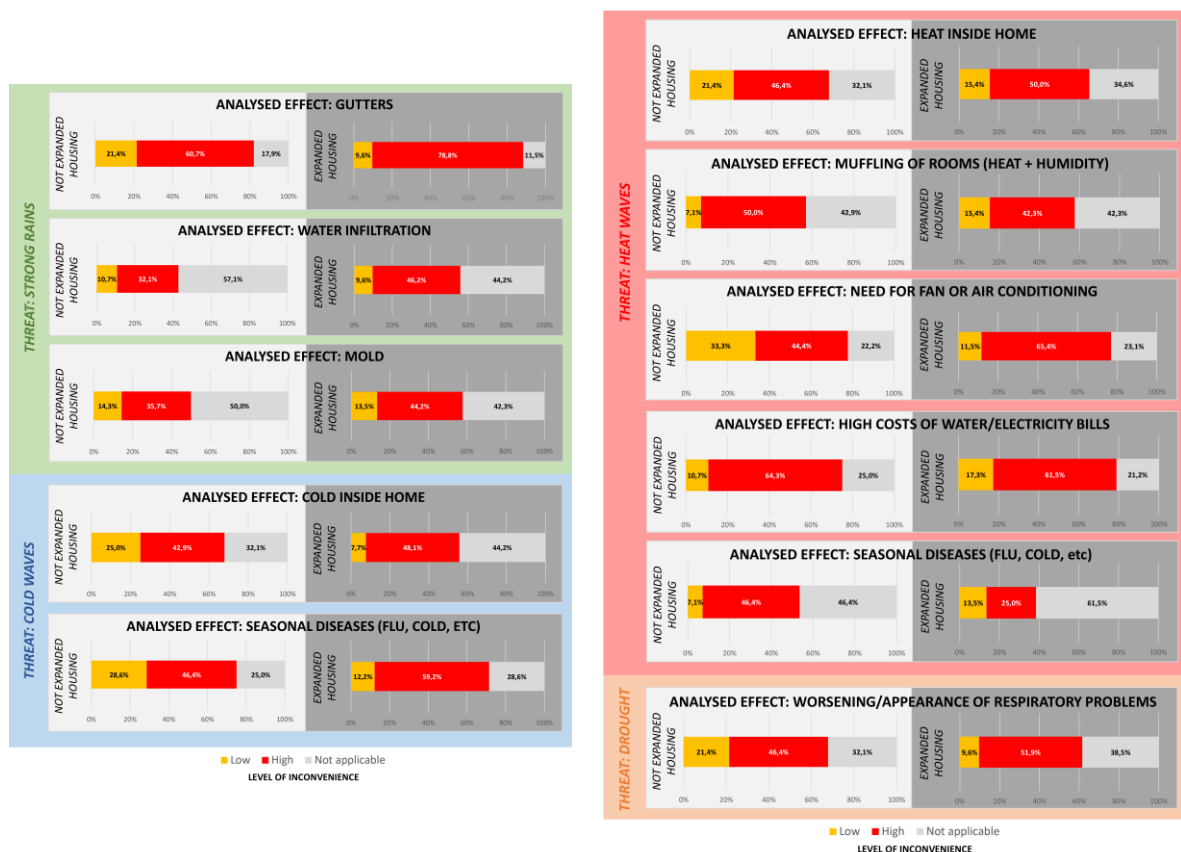
Uberlândia (state of Minas Gerais, Brazil), the social housing development of single-storey residential units named Residencial Sucesso Brasil.

To apply the impact questionnaire, a population of 367 housing units, a sample universe of 161 units were considered, a 95% confidence level and a sampling error of 5.79%, considered tolerable for quantitative and qualitative research in the area of applied social sciences.

It was observed that 65% of the questioned residents underwent extensions, and that, among these, 61% are still dissatisfied with the reduced dimensions of the rooms in the house, pointing to a tendency to carry out further extensions. Among these reforms, only 35% counted on the help of paid professionals, usually bricklayers, servants or masters of works. In 65% of the cases, it was family members, friends and even the resident himself, who voluntarily carried out the expansion works, demonstrating the commitment of this community to improve their living conditions.

However, it was observed that the performance of extensions to deal with the small dimensions of the houses had little or no impact on the feeling of environmental comfort inside them. Considering the sampling error of 5.79%, it was observed that the level of inconvenience with the feeling of heat inside the home is equivalent in extended and non-extended homes, repeating for the other impacts related to the environmental comfort attribute – as seen at Graphs at Figures 7 and 8.

Figures 7 and 8 – Results for environmental comfort attribute at Shopping Park neighbourhood, Uberlândia, MG, 2020

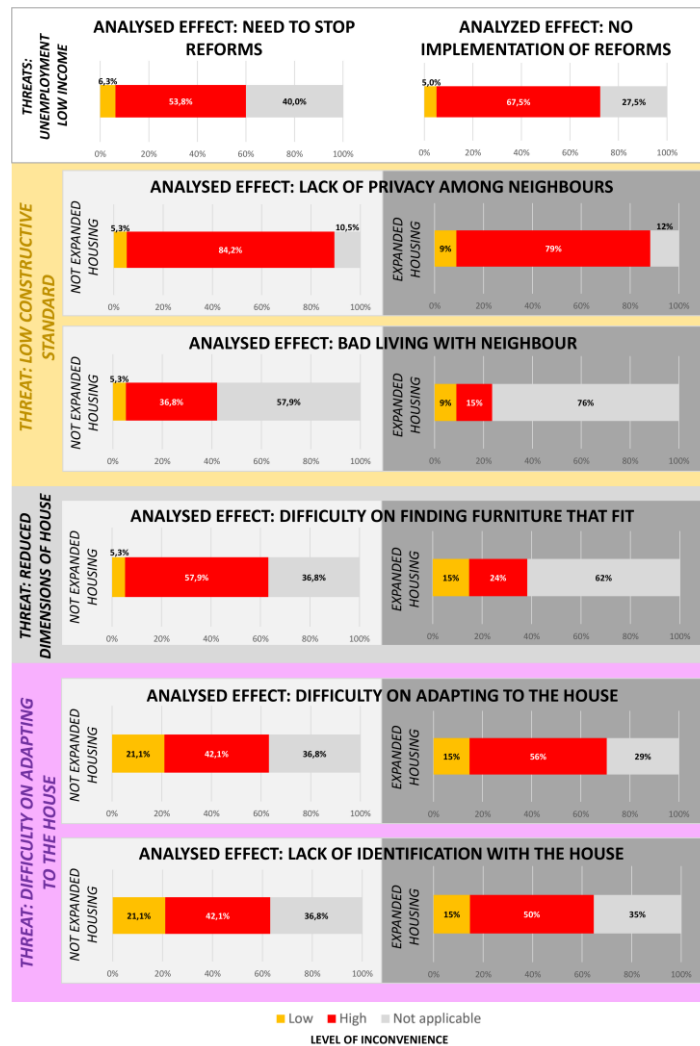


Source – VILLA et al. (2022b); BORTOLI (2018).

An essential factor for obtaining resilience is the engagement of people, which is effective in proportion to the strength of social and community ties and depends on the manifestation of certain personal dispositions, directly linked to the conditions of the inhabited environment (STOLLMAN, 2016; STEVENSON, PETRESCU, 2016) - see engagement indicators in Frame 4. In this sense, characteristics of the houses that compromise the effectiveness of this attribute were identified, such as the fact that 67.5% of the residents showed discomfort because they could not carry out necessary

reforms in time, while 52.5% felt uncomfortable because they had to interrupt an ongoing renovation, both due to lack of money. The lack of privacy between neighbours (which causes discomfort in 87.5% of the cases) and problems with living with neighbours (in 27.5%) due to the construction characteristics of the unit (twinning through the walls of the rooms, insufficient sound insulation), also stand out. Added to this is the fact that 39% are uncomfortable due to the difficulty to fit furniture in the house, due to its reduced dimensions, resulting in a difficulty in adapting and identifying with the housing unit, that bothers more than 65% of the interviewees, even after making extensions - see data in Figure 9.

Figure 9 – Results for engagement attribute at Shopping Park neighbourhood, Uberlândia, MG, 2020



Source – VILLA *et al.* (2022b); BORTOLI (2018).

Figure 10 – System resilience assessment matrix: attributes and indicators of resilience at Shopping Park neighbourhood, Uberlândia, MG, 2019.

| ENGAGEMENT | | | | |
|------------|-------|--------------|------------|--------|
| TAKE PART | SHARE | COMUNICACION | MOTIVATION | SAFETY |
| 3.4 | 3.0 | 3.2 | 2.8 | 2.5 |

Source – VASCONCELLOS (2019).

All of this information highlights the reduced resilience potential of this population, as an ability to resist, adapt and transform to deal with changes/impacts related to environmental comfort and engagement attributes. This finding finds support in the final result of applying the resilience ruler for the engagement attribute and each of its indicators, which resulted in an average resilience score of 2.98 (Figure 10). The individualised scores for each indicator in the resilience ruler have the potential to show 1. Where is the case study lacking resilience? 2. What is missing to improve resilience in this case study?; and, finally, 3. How to increase resilience in the case study? - the last two based on the criteria defined from the control cases, defining analysis parameters and scores.

FINAL CONSIDERATIONS

This paper intended to establish the theoretical basis on the concept of resilience in the built environment and the definitions adopted in the research presented. A brief scenario about the resilience in the built environment of Brazilian social housing was presented, pointing out key findings.

The presentation of new methodology and definition of the resilience matrix evaluation system received prominence. Resilience is a quality that Brazilian social housing must possess in order to optimize resources for its production and subsequent maintenance. The resilient built environment is able to resist, adapt and transform in the face of change that occurs naturally over the life of buildings.

The generic attributes and indicators of resilience here proposed have been defined in line with perceived impacts observed in Brazilian social housing. They are derived from the analysis of factors identified as important to allow the built environment (social housing) and its residents to recover from impacts.

In recent years, a large number of Brazilian families have acquired the possibility of obtaining their own home through the PMCMV. Along with the “dream of homeownership,” however, are associated serious material and constructive problems that undermine HIS’s resilience and thus its ability to resist, adapt and transform itself to cope with the impacts of change, as highlighted on topic 5.2, which highlights the validity of the present study.

Therefore, the study presented intended to advance in the area of knowledge in different ways:

- a) proposing definition of the concept of resilience in the built environment and methodology for investigating its attributes, supported by literature review and previous POE results undertaken by the group;
- b) establishing itself as a starting point in the definition of POE methodological procedures for observing and promoting the attributes of resilience in social housing developments;
- c) addressing the issue of social housing in Brazil associated with the prescriptions of urban agendas of international relevance, which place resilience as a motor in combating the vulnerability of large urban centers; and
- d) contemplating a knowledge gap arising from the lack of research on the international scene focused on the analysis of resilience in the context of the built environment in social housing, capable of effectively contributing to the achievement of the objectives set by the international urban agendas.
- e) highlighting the importance of the role of the architect and urban planner in the development of strategies for the technical guidance of interventions in social housing, aiming at resilience and guaranteeing complete user satisfaction with the final result of the reform and the efficient administration of the financial resources involved, which are especially dear to this audience.

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ⁱⁱ <http://www.stockholmresilience.org/>. Accessed 10 January 2018.

ⁱⁱⁱ <https://www.rockefellerfoundation.org/>. Accessed 10 January 2018.

^{iv} <https://www.arup.com/>. Accessed 10 January 2018.

^v “[RESAPO Stage 1] Method of analysis of the Resilience and Adaptability in Social Housing Complexes through Post Occupancy Evaluation and Co-production”, developed by the MORA housing research group from FAUeD, Federal University of Uberl ndia/UFU and the People, Environment and Performance research group from The University of Sheffield School of Architecture. This research was financed by Santander Research Mobility Awards (January, 2016 – October, 2016). https://morahabitacao.files.wordpress.com/2015/07/full-final-report-june_2017.pdf. Accessed 20 February 2018.

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