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Incremental Pathways of Post-Disaster Housing Self-Recovery in Villa Verde, Chile

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Abstract: Housing reconstruction is considered the backbone of disaster recovery. The increasing losses in housing due to disasters challenge conventional top-down schemes and call for people-centred approaches to acknowledge their agency and self-recovery resources. This paper examines the pathways for housing self-recovery through resident-controlled incremental housing development. This paper focuses on the Villa Verde settlement built in the Chilean city of Constitución, which was severely impacted by the 2010 Chile Earthquake. Villa Verde, designed by the Chilean architecture studio Elemental, is one of the most notable incremental housing projects worldwide that encourage residents to extend their houses within a provided structural framework. This research aims to provide clarity in the much-needed understanding of disaster-affected people's agency to self-recover, noted by researchers as one of the crucial elements for improving the humanitarian response in the aftermath of disasters. Through capturing the evolution of incremental housing construction, this paper presents multiple complexities resulting from the variety of households' characteristics and needs in their process of post-disaster housing self-recovery. The resident-controlled process studied evidence that the people's capacities and dedication to self-recover challenged the established housing framework with extensions beyond the designers' parameters requiring further evaluation of the long-term implications of self-help constructions.

Keywords: Elemental; Villa Verde; incremental housing; self-recovery; adaptation

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1. Introduction

Disasters have tremendous impacts on housing. Housing accounts for up to 62% of economic losses due to disasters [1]. Global estimations indicate that more than 5 million houses were destroyed or collapsed due to natural hazards and conflicts between 2005 and 2018 [2]. Predictions of future disaster-related housing losses indicate that up to 167 million houses will be destroyed in the next two decades [3]. Housing damages are expected to be magnified by their unpredictable frequency and intensity, especially climate change-related events. Besides the significant economic impacts, housing loss due to disasters has profound and cascading effects on affected communities' dynamics [4] and generates traumatic changes in survivors' lifestyles and living conditions [5] that can take many years to recover. Therefore, re-establishing housing is considered the backbone of recovery impacting different dimensions of individual, household and community recovery [6,7]. Moreover, it cannot be ignored that for disaster-affected people the loss of their homes represents much more than the loss of a physical structure. Housing embodies the place where people carry out their daily activities, domestic functions, routines, homes also become workplaces and sources of income [6,8,9].

Despite the urgency in the timely provision of adequate housing following a disaster, studies have acknowledged the limitations of the humanitarian sector and government agencies [10]. The top-down constructor-driven reconstruction is one of the most criticised

but predominant approaches in post-disaster housing reconstruction. The limited or no space for affected communities' engagement and failure to acknowledge the diversity of people's needs and priorities questioned the top-down approach capacities to support recovery and build resilient communities [11,12]. Despite the discussions about the most appropriate housing reconstruction schemes, the reality of post-disaster housing recovery reveals that most of the affected people rebuild their houses using their own resources and capacities [13]. Recent estimations suggest that between 8 and 9 in 10 destroyed or damaged houses are repaired or rebuilt by the affected families with little or no outside support through 'self-recovery' [10].

Observing the characteristics of self-recovery, based on people's initiatives which might include or not external support from humanitarian agencies or governments [14], it is unavoidable to see how self-recovery emulates the resident-controlled incremental housing process, although in a post-disaster context. Incremental housing is a people's centred and controlled process of housing production responding to the inadequate and insufficient housing stock in the Global South, where it is estimated that 50–80% of people build incrementally [15]. According to Nohn and Goethert [16], incremental construction is the largest viable creator of new affordable housing as residents use the "pay as you go" principle to gradually build and improve their homes based on available capacities and resources at the time. Interestingly, Latin America is considered the "birthplace of ideas for legitimising self-help housing approaches" [17] through government policies promoting owner-driven housing development by providing "site and services", expandable "core houses" or subsequent subsidies for housing improvement or extensions [17] influenced by the seminal studies conducted by John Turner [18]. Different types of incremental housing schemes have been implemented in Latin America since the 1950s, and incremental housing programmes have been promoted in Chile since the 1990s [19]. The Chilean Pritzker-awarded architectural studio Elemental is one of the advocates of incremental housing, revisiting the idea of partially completed housing inspired by John Turner's claims that people should have the "freedom to build" [20]. Elemental proposed a structural framework for residents to gradually build extensions based on the Dutch architect John Habraken's proposal in his book "Supports" [21] to facilitate a support structure to be infilled by residents who control their construction. The Elemental-designed project of Quinta Monroy in 2005 became an iconic example of in situ replacement of informal housing within an incremental framework. Elemental's approach became a reference for social and participative housing discussion in Chile and internationally [22–24].

The 2010 Chile earthquake and tsunami devastated various coastal cities in central Chile. The city of Constitución was one of the most affected, with almost two-thirds of its housing stock damaged or destroyed [25]. In the aftermath of the 2010 Chile Earthquake, reconstruction plans for the city of Constitución focused on incremental housing schemes influenced by Elemental's partially built housing framework promoting active engagement of disaster-affected communities in the co-production of their homes [26]. The Villa Verde settlement developed in a government-corporation partnership was developed as a social housing project to resettle disaster-affected and social housing beneficiaries. The housing reconstruction projects in Constitución prioritised conventional top-down approaches. Conversely, Villa Verde embraced the lessons from Chilean incremental housing projects and the structural framework to be infilled by residents based on their personal needs and aspirations for post-disaster housing.

Developing appropriate post-disaster housing approaches and their long-term impacts on affected communities are some of the main concerns of humanitarian agencies, governments and stakeholders involved in post-disaster reconstruction. Experts point out the intricacies of the evolution of self-recovery and call for a longer-term perspective on the priorities for learning and enabling change in focus toward safe, durable and sustainable recovery [27].

This research aims to clarify the much-needed understanding of disaster-affected people's agency to self-recover, noted by researchers as one of the crucial elements for

improving the humanitarian response in the aftermath of disasters [12–14,27]. This research examines the pathways for shelter self-recovery through resident-controlled construction of post-disaster housing within Elemental's half-built incremental housing framework, including disaster-affected and unaffected households relocated in Villa Verde. By analysing the temporality of the housing extensions, this study observes the impact of changes in household makeup and financial conditions on the physical changes of the houses.

2. Research Design

2.1. Sample and Participants' Selection

The data for this paper was collected between July and August 2017. The complexities in understanding the process of incremental housing construction in Villa Verde require mixed-methods research combining a self-administered questionnaire survey and face-to-face semi-structured interviews. Participants selected included disaster-affected and non-affected families, as both were eligible to be beneficiaries of a house in Villa Verde. However, many interviewed families also expressed that they applied on both grounds.

The initial contact with the residents of Villa Verde was with the community leaders. At the moment of the fieldwork, there were two neighbours' associations. One of these associations' leaders requested help from us to design an extension of the communal centre after they knew our architectural background. We understood this as the first sign of residents' motivation to improve their neighbourhood and their houses. Later, during the interviews, we received some individual requests from the residents to help with their houses' extensions and renovations design.

Community leaders introduced some participants individually and during a community meeting with residents in middle July 2017. Other participants were randomly selected based on their availability. In total, 40 residents agreed to undertake the questionnaire and among them 31 residents agreed to be interviewed. The detailed contents of the tools used for data collection are described below:

(1) A closed question quantitative questionnaire seeking (a) general household information, (b) previous housing conditions, (c) initial housing conditions after moving to Villa Verde, and (d) current housing conditions.

(2) A qualitative semi-structured interview aiming to expand the knowledge of housing modifications not captured in the questionnaire. The interview included (a) timelines for incremental additions, (b) difficulties encountered when undertaking incremental improvements, (c) plans for future improvements, and (d) changes to the broader neighbourhood. This information was graphically captured through diagrams based on the methodology by the Special Interest Group in Urban Settlement, Massachusetts Institute of Technology [28–30].

(3) Mapping of settlement conditions using architectural research tactics, including architectural drawings, photographic surveying, and physical trace analysis [31–33].

(4) Secondary data from government reports, books, and academic papers.

2.2. Data Analysis

The information analysis is based on the premise that the complexities and multi-dimensional approach needed to analyse the interactions between people and the built environment require diverse research strategies [34,35]. This paper primarily considers the qualitative component analysed at household level using data collected through (2) and (3) specified in the previous section and uses the quantitative component as supporting data at settlement level.

This paper analyses ten families (see Figure 1) and includes their narratives related to their housing modification over time. The reason for combining the narratives with four-year timelines overlapping changes in household size, financial situation and housing extensions/modifications responds to two concerns:

(1) The spontaneous nature of the incremental construction can only be captured by understanding the specific circumstances and context in which the changes that otherwise would be misrepresented or omitted in quantitative studies [36].

(2) The clear patterns observed in these ten selected households provide a realistic image of the process of incremental housing at the household level.



Figure 1. Settlement and housing layout of Villa Verde. Source: Authors, based on Aravena & Iacobelli [37].

2.3. Scope and Limitations of the Study

This paper focuses on a specific project and covers a small sample size relevant to understanding household conditions changes. The scale of the analysis is limited to each household and the changes made in their housing. Therefore, this paper does not attempt to generalise the challenges faced by all the residents in Villa Verde or other housing projects designed by Elemental.

3. The Housing Project at Villa Verde

3.1. Context and Planning

The housing complex in Villa Verde is part of the "Plan for Arauco Forestry Workers" promoted by the forestry company Arauco as an initiative to provide definitive houses for their workers in Chile's southern region Maule in 2009. Villa Verde was conceived

as a private-public funded housing project in 2009, and Elemental was commissioned to develop an incremental housing project [37].

The earthquake and tsunami that hit the southern regions of Chile in 2010 changed the project's context. The city of Constitución was one of the most affected cities by the disaster, where the tsunami flooded 61% of the city's urban area [25]. Constitución's reconstruction and the allocation of disaster-affected families in permanent housing became the priority of the post-disaster recovery planning managed with a public-private partnership responsible for delivering the Master Plan for Sustainable Reconstruction (PRES Constitución—in Spanish) involving Government Agencies, the company Arauco and international consultants including ARUP and Elemental. The PRES Constitución presented Elemental's incremental housing designs to replace the city's destroyed housing stock [38]. However, only two incremental housing projects designed by Elemental were built in the city, Villa Verde, and its second stage under construction in 2017. The disaster changed the beneficiaries of the houses in Villa Verde, which combined Arauco workers and disaster-affected people, for this reason Villa Verde is considered a post-disaster housing and received further government subsidies for its construction through the Housing Solidarity Fund programme (FSV—in Spanish).

The Housing Solidarity Fund targets the most vulnerable first and two quintiles, meaning the country's 40% poorest. Under the Housing Solidarity Fund conditions, housing beneficiaries must co-fund the housing projects [39]. In Villa Verde, beneficiaries made a single payment of 400,000 Chilean Pesos, approximately 590 USD, and received their houses' formal ownership although subjected to some conditions. Subsidies' conditions prevented beneficiaries from renting the houses out within five years and selling the property in the following ten years from the turnover date.

Beneficiaries are also requested to follow the Chilean regulations for a joint property since Villa Verde is a residential condominium essential for constructing extensions and housing modifications. Elemental's claimed that they prioritised community participation through the beneficiaries' involvement in the planning stage of Villa Verde. The consultations' outcomes with the beneficiaries were the housing designs, including the specific housing extensions allowed to be built by themselves [37]. In the turnover ceremony, each household received a "Habitability Manual" that included directions for housing maintenance and the specifications of the extensions approved by the city council in the housing building permit. As Villa Verde falls under a condominium property scheme and following the Chilean regulations, housing modifications not specified in the building permit required the neighbours' collective endorsement and formalisation following the local city council procedures [40]. The Housing Solidarity Fund program also allows for further government subsidies such as the Housing and Neighbourhood improvement program [41], although it is limited to works within the formally approved designs. Furthermore, the Housing and Neighbourhood improvement program specifies that only collective applications are received for housing improvements [41]. The regulation limits applications to neighbours' associations or community associations established within the settlement, for instance, in Villa Verde, there is a seniors' neighbours association that exists in parallel to the two neighbours' associations.

3.2. Design

Villa Verde is located in a high hill area approximately 2.5 km from the city centre and next to consolidated residential subdivisions (Figure 1). Villa Verde is made up of rows of 484 two-story houses organised in clusters sharing one common courtyard. There are two typologies of houses, Types A and B (87% and 13%, respectively) (Figure 1). Elemental's designs show that the Type A half-house was built to 57 m^2 and is possibly expanded to 85 m^2. The 62 Type B houses, initially built at 55 m^2, are expandable to 69 m^2. For this study, only house Type A is considered.

The housing design (Type A) considers a wooden structure covered by a gable roof in which half of the house is infilled and the other half is left empty for the residents to build

extensions (Figure 1). A kitchen, small dining area, and a bathroom were built on the lower floor while the living room was expected to be built by the residents. On the upper floor two bedrooms were built and other two were considered for residents to extend. Prefabricated panels covered the houses' wooden structure as the finishing of walls, cement floors, and lacking finishing. Kitchens came with just a sink without cabinets or working tables. The Habitability Manual discourages residents from building in the backyard or in the frontal garden arguing that habitability conditions such as natural lighting and ventilation would be compromised.

3.3. Beneficiaries' Selection and Housing Allocation

Following the 2010 disaster, 244 disaster-affected families were included as beneficiaries alongside 240 Arauco households and in many cases some households qualified on both grounds. Beneficiaries had the opportunity to show a preference for the type of house and its location in the settlement. Priority was given to beneficiaries based on their contribution during community meetings and workshops with Elemental and Arauco.

4. Incrementality and Resilience in Villa Verde

The timeframes and continuity of incremental housing production are not homogeneous and respond to the changing conditions and needs resulting from the process of human habitation [42,43]. Furthermore, in Villa Verde, homeowners had three years between house planning and turnover to prepare for building extensions. Additionally, there are cases the housing adaptations would happen before the beginning of inhabitation, evidencing the process's complexity. The data collected show the different homeowners' pace for completing and improving their houses following diverse motivations in each stage. In this research, ten participant households (see Figure 1) were considered for the analysis and included the categorisation of residents into five groups:

- Steady performers
- Started then stalled
- Late starters
- Late occupants
- Low-density model performers

These classification criteria are based on the construction timeframes of extensions and examine the motivations and triggers and how the incremental construction became a continuous or intermittent process or even ignored for some time. The housing growth process is analysed based on the variations from late September 2013 when the homeowners received the houses, to July August 2017, when the data for this paper was collected. This analysis considers three components for the analysis of resident-controlled housing adaptations or extensions: (1) household size, (2) household income, and (3) physical changes in the initial house.

4.1. Steady Performers

This group of residents is analysed to know whether households that progressively performed changes in their houses represent the ideal of sustainability. In the two cases in Figure 2, residents regularly built extensions to the original house and completed more complex house additions.

House 01 (see Figures 1 and 2) household is a nuclear family of four members, and the father is working for Arauco. The family moved in immediately after they received their house and started to modify their home within the first year. The family decided first to build bedrooms in the upper floor extensions to accommodate the family comfortably. Later they built a grocery store on the ground floor, changing the use of living space, prioritising the family's need for extra income. This triggered the change in the space uses moving the kitchen to the back of the house and the dining and living room in front with independent access. The family income remained regular until 2016, when there was an increment, and they decided to cover the backyard because of the wind and the dust that mess up the

laundry. The family expressed their satisfaction and pride about their house improvements because they financed with their savings. The residents mentioned their interest in keep modifying the house, specifically enlarging the living room by moving the toilet to the backyard. They also expressed their desire to expand the house vertically if this will be allowed in the future.

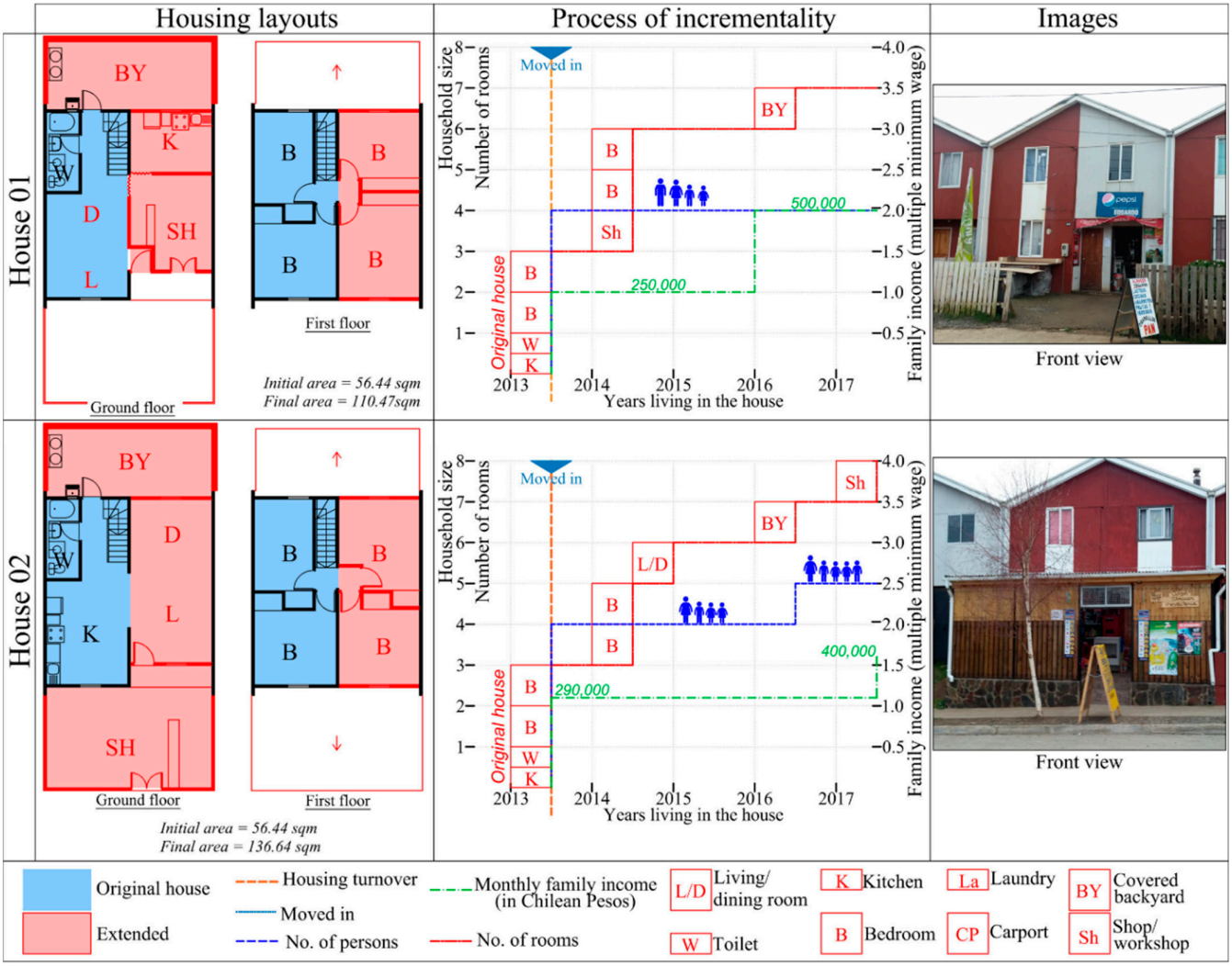


Figure 2. Housing extensions steadily built by residents. Source: Authors (2020).

Figure 2 also presents the process of change performed in house 02 (See Figure 1 to locate the house in the settlement) whose occupants are a single-parent family affected by the disaster. The mother is the head of the family with a daughter and a son, both adults and a grandson. The son and the daughter had various jobs in the city, and now the daughter runs a grocery shop in their home. The family moved into the new house immediately after they received it. Six months after the family moved in, they built bedrooms on the upper floor. Subsequently, the family built the living room and the dining room on the ground floor as specified by the house designers. All the extensions were built with the family savings as there was no increase in the monthly family income of 290,000 Chilean Pesos (approximately 482 US dollars), which is slightly higher than the monthly minimum wage in Chile (as of 2017). After three years of living in Villa Verde, the family decided to cover the backyard because it flooded during heavy rain. In the last year, the daughter's partner moved into the house and encouraged the family to open a grocery store financing its construction. Thus, the family income has increased, and the daughter can spend more

time with her son. The family hired a carpenter to build the extensions; they feel their needs are covered and do not have plans to build more.

According to the cases shown above, residents who regularly build extensions were motivated by diverse factors such as the urgent need to accommodate the family members or the pressure to have an income source. The main reason to cover the backyard is to protect the family and the house from rain, wind and dust. Although the families' incomes are relatively low, they are willing to invest in improving their living conditions reflected in the housing extensions.

4.2. Started then Stalled

This group of residents promptly started to extend their houses, although they paused the housing growth process at one point. Understanding the residents' behaviour would explain the non-evident reasons behind the interruption or slowdown of building housing adaptations or extensions.

House 03 (Figure 3) belongs to a worker from a subcontractor of Arauco who moved in alone six months after he received the house. He only expanded in the house's upper floor with a carpenter's help, although it remains incomplete. In 2014, the owner received an unexpected income resulting from a former job's unemployment compensation that helped him finance the few extensions he built. Later he made few improvements, like installing ceramic tiles in the kitchen' flooring on the ground floor. The house remains unfinished because of the owner's lack of motivation until recently when the number of family members increased and became a nuclear family with two children. The owner is considering building extensions on the ground floor and finishings in the bedroom built upstairs.

The family living in house 04 (Figure 3) has initially four members, both parents and two children. The family was affected by the disaster and immediately moved into the new house after receiving it. In the following months, they expanded the house followed Elemental's design. However, the family changed the internal spaces' distribution motivated by privacy, which is the central family's priority. The family built a living room where initially the kitchen was located and moved the kitchen to the rear of the living room part of the extended half of the house on the ground floor. The two bedrooms built upstairs followed the designers' plans. There have not been considerable differences in the family size, the grandmother temporarily moved in to live with the family for six months in 2015. There was a slight increment in the household income as the father started working as a builder in a neighbouring housing project. The family selected the house at the end of the settlement because it is well concerned about privacy (Figure 1). However, since a new development is currently under construction, the family decided to build a front fence for safety reasons and define their property's limit. All the construction works have been done by themselves through self-construction and using the family savings. Although the family halted the house's construction, they expressed their intentions to pave the front garden and the backyard.

Residents interrupted the home extension construction when they considered that the house satisfied their needs. However, families might feel motivated to build new extensions or improvements when new needs emerge, whereas these might not be performed immediately. The second case presents motivations for change driven by the family's need for privacy and comfortable living spaces. Therefore, once residents satisfy their urgent needs, they might stop housing growth and focus on improvements of already-built spaces inside or outside their houses.

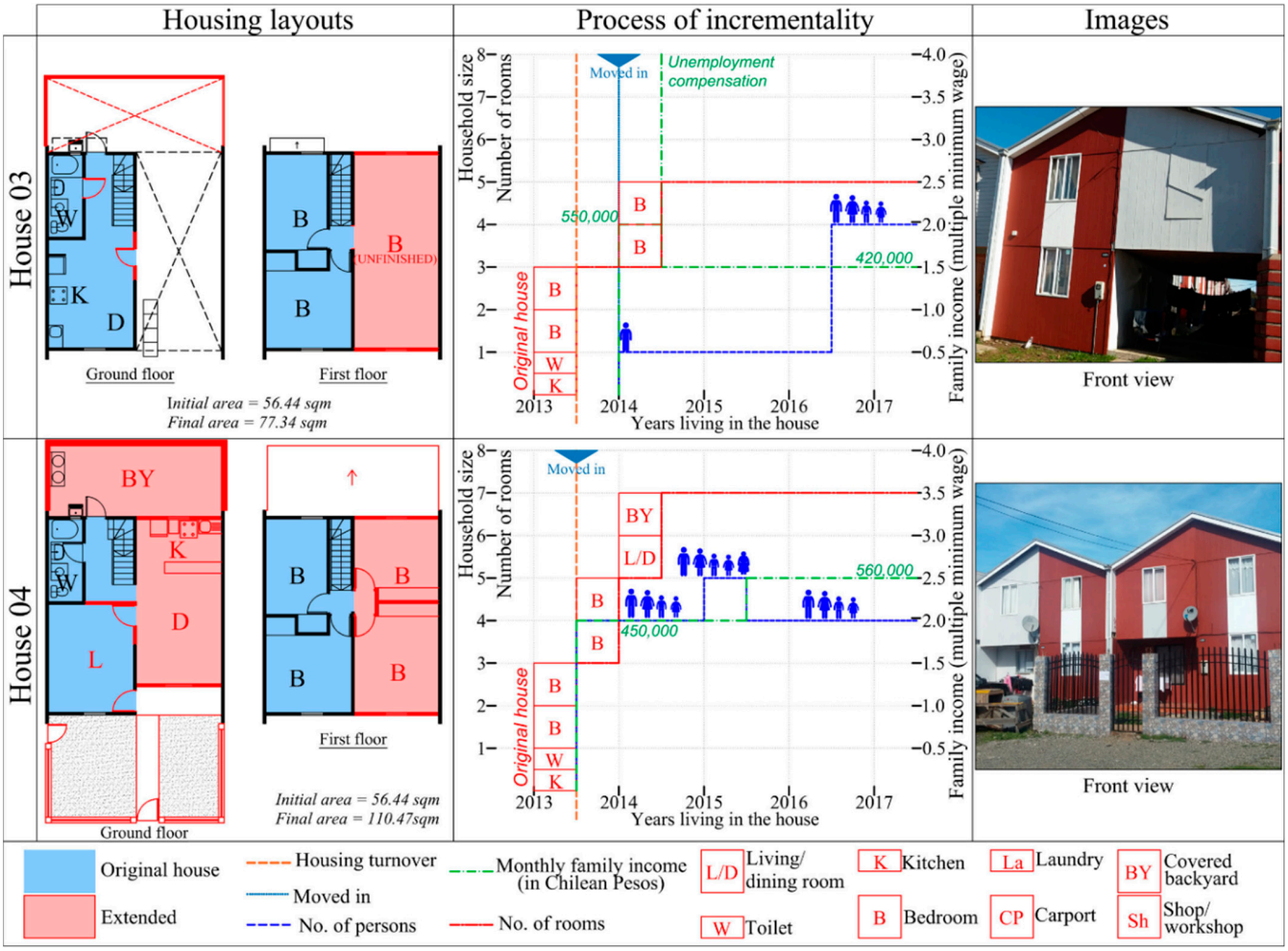


Figure 3. Residents that started and postponed the housing improvement. Source: Authors (2020).

4.3. Late Starters

Another group of residents delayed the construction of extensions, which despite the differences in the family size and type, at one point, they suddenly decided to start building. In the examples shown in Figure 4, residents experienced a long time of passiveness and decided not to extend their houses.

The family residing in house 05 (Figure 4) is an extended family, and its members increased since the homeowner, a retired lady, moved in alone in 2013. In early 2014, the homeowner's sister moved into the house, while their income remained slightly lower than the minimum wage. Almost three years later, the homeowners' daughter moved into the house with a consequent slight increase in the family income due to her occasional work. Finally, almost after four years of occupancy, the family decided to extend the house. The family decided to build an extra room with easy access for the daughter and her son when he was born. The family expressed their discontent for having most of their house unmodified and expect to build extensions on the ground floor in the short term. Their plans include building a dining and living room on the ground floor and one bedroom upstairs. Despite their incomplete house, the owner expressed her satisfaction with the house, especially the settlement location, accessible from the city centre about 20 to 30 min by foot. Although she also feels limited by the few options on what and how to build specified by Elemental.

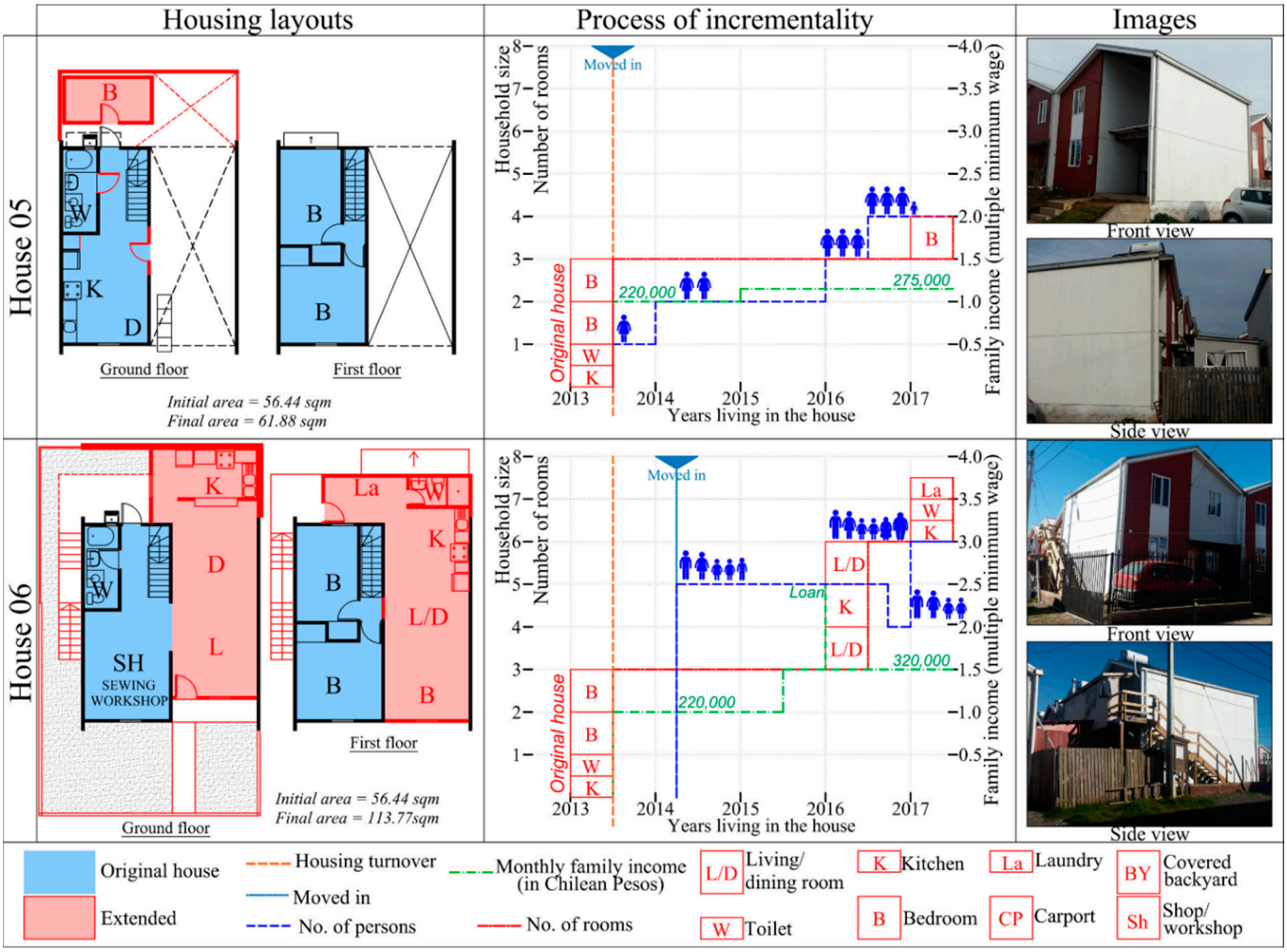


Figure 4. Delayed housing improvements. Source: Authors (2020).

The family living in house 06 (Figure 4) has five members with both parents and three children. The family former home was severely affected by the disaster and was awarded a house in Villa Verde. The family father is a full-time employee, and the mother is a dressmaker. The family delayed their occupancy, which moved in the first quarter of 2014, approximately six months after the housing turnover. The house remained unmodified until mid-2016, more than two years after the family moved in. The reasons to extend the home were related to the need to satisfy the family's space needs and provide them with a comfortable living environment that was finally possible thanks to a bank loan applied by the family. The family also changed the uses of the spaces. The backyard was covered and the kitchen was moved there. In this way, the house's frontal part could be converted into a sewing workshop for the family's mother to establish a home business. All these works were done through self-construction with relatives' support. Later, a second event triggered unexpected renovations and extension of the house. In January 2017, there were wildfires in the forest areas in the region, and the parents' house of the family father, located in a rural area near the city of Constitución, resulted heavily damaged. Suddenly, the family needed to modify the house again. They built a separate entrance to the upper floor, a space for laundry and toilet, and renovated two bedrooms' space to make a multipurpose space for a studio apartment. In the future, the family wants to make internal renovations and applied for government subsidies through the Home and Neighbourhood Improvement Program, but the outcome is delayed.

In the previous examples, at first, residents remained passively living in the original house. In both cases, the residents' expressed their unconformity for not extending their house earlier and compared their homes with their neighbours' wishing to actively improve their living conditions and have comfortable spaces for their families. Although there were financial constraints, the sudden change in the family size motivated a rapid change and expansion of the houses. Both homeowners expressed their will to continue improving their homes in the future.

4.4. Late Occupants

The fourth group identified is the residents that delayed their moving into the houses. In fact, in the survey conducted in Villa Verde, 84 percent of the households interviewed delayed occupying their houses. The 68 percent did it because they wanted to build the extensions before moving in, and 16 percent lacked the motivation to extend. Thus, most of the residents that occupied the houses late felt that they needed to build first

The family residing in house 07 (Figure 5) moved to Villa Verde one year after receiving their house. The parents expressed that it was difficult to live in an incomplete house with the whole family. The housing extensions included the construction of the living room and two bedrooms on the upper floor. Additionally, the change of use of one of the original bedrooms and converted it into a toilet. The priority was to have a comfortable living environment for the four family members when they moved into the house. Later, the family covered the backyard to protect the house from heavy rain and wind. In the next year, the daughter moved out and later the son. Although in 2015, there was a particular income from the father's unemployment insurance, he did not invest in renovating or improving their home. Recently, residents built a low fence to define their lot and paved the house entrance and worked on their frontal garden. Nowadays, the parents are a retired couple who does not have plans for building further housing extensions.

The family residing in house 08 (Figure 5) was granted a house in Villa Verde because they lost their home due to the disaster. The family moved in Villa Verde house in 2015, about one and a half years after receiving their house, because they wanted to build the extensions first. The household is a nuclear family type with both parents and three sons. The initial extensions included completing the other half of the house, such as the living room on the lower floor and bedrooms upstairs. The kitchen was also renovated to make space for a small eatery. The family covered the carport to protect their cars because the father works in transport. The family feels proud and satisfied with the house as it results from their efforts and is highly motivated to continue with housing renovations and extensions.

The cases presented show the residents' concerns about building housing extensions to provide comfortable living environments for the family before moving in. The residents are proud of the works performed in their homes and feel attached to them. Families are motivated to renovate some existing spaces and build more extensions in the future.

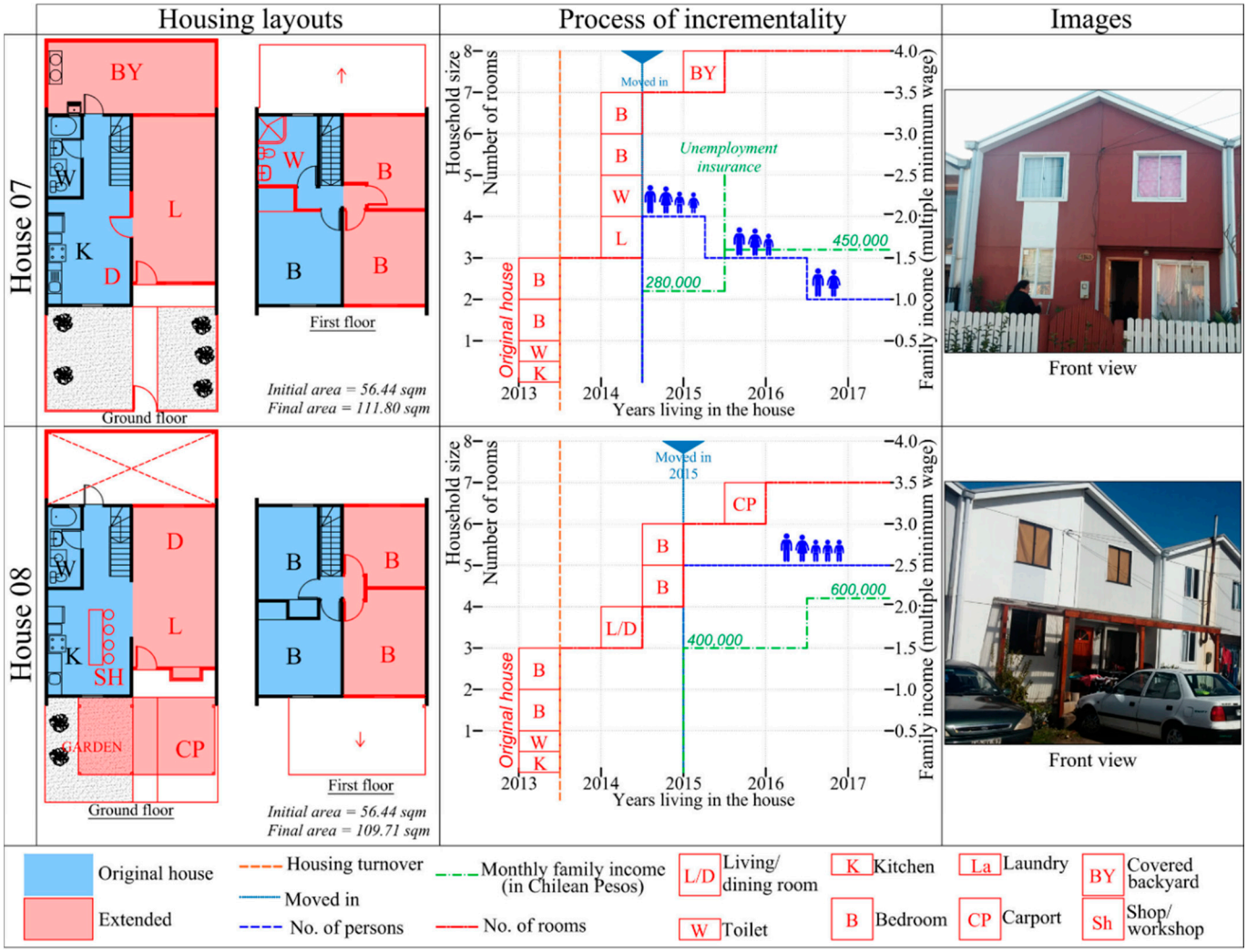


Figure 5. Late occupants and progressive housing construction. Source: Authors (2020).

4.5. Low-Density Model Performers

The last group analysed are the small-sized households that performed multiple extensions and improvements, although the initial house would have been enough to enjoy comfortable habitable spaces. Both households were affected by the disaster. Due to the household size, building housing extensions might are not directly related to the urgency to provide a quality of life to the residents.

The owner of house 09 (Figure 6) is a senior woman who moved in with her adult daughter, who moved in during the first year. The homeowner receives a modest income from her retirement pension and additional casual income from baking pastries. They delayed the construction of housing extensions for almost two years. The homeowner's daughter financed most of the housing improvements to provide a comfortable living environment for her mother. A carpenter who is a neighbour in Villa Verde built the extensions and renovations. Most of the construction works were done simultaneously. The internal renovations include reducing the living room to build a bedroom for the mother anticipating her future reduced mobility due to her advanced age. The bedrooms on the upper floor were built to accommodate the homeowner's daughter and son during their visits. The backyard was partly covered and used as storage. The owner feels that the house improvements satisfy her needs. However, she is coordinating with the Villa Verde senior's association to apply for government subsidies to renovate the kitchen and toilet.

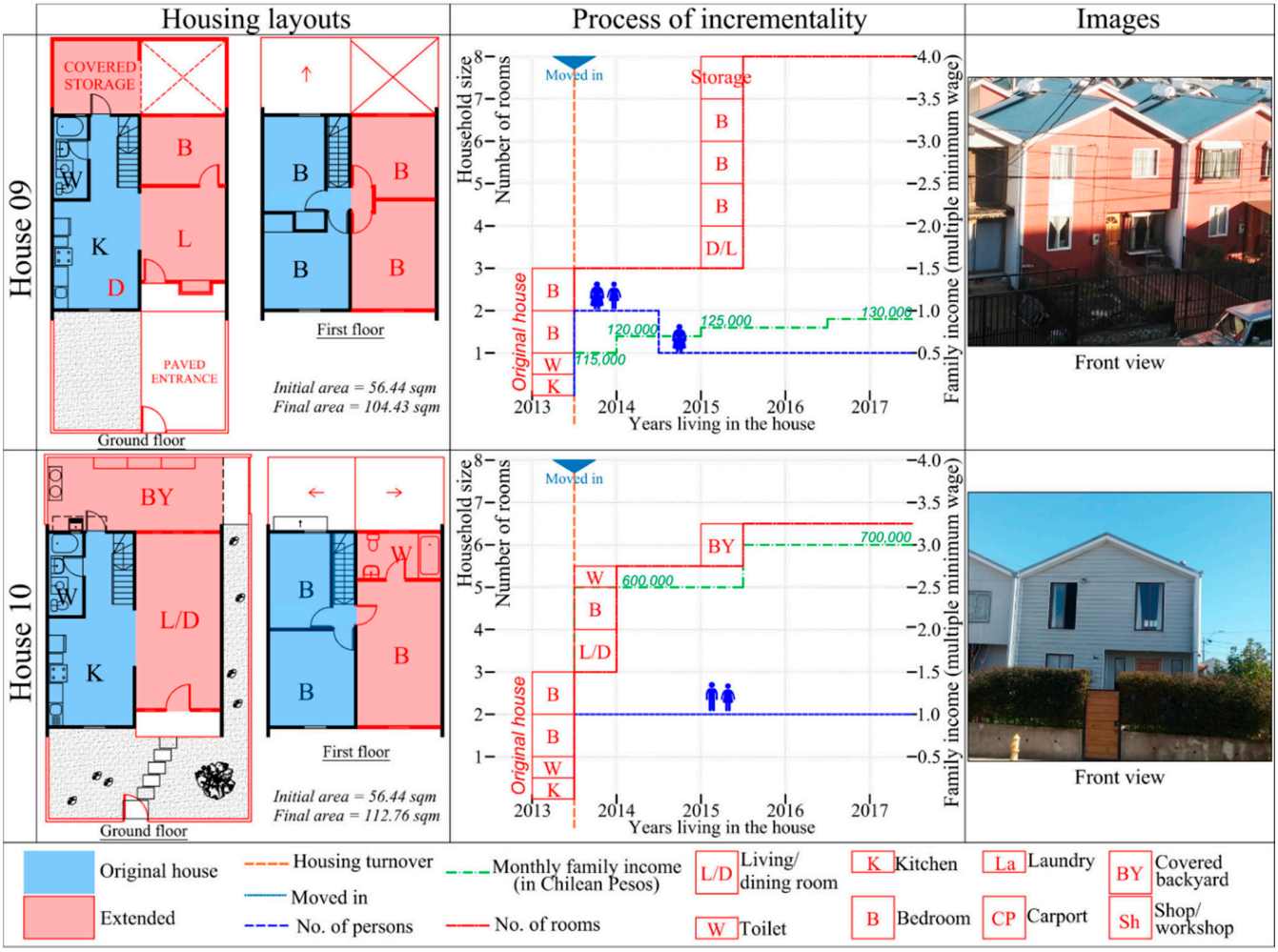


Figure 6. Small size households as model incremental builders. Source: Authors (2020).

The family residing in house 10 (Figure 6) is a childless couple with a higher family income as both work full time, the wife as a hairdresser and the husband as a taxi driver. They were affected by the 2010 earthquake and tsunami and received the house as disaster victims. The wife got actively involved in the planning of the houses and later was a community leader. Thus, she got the priority for selecting her house's location in Villa Verde. The initial improvements in the house were the planned extensions built just after they moved in. They used their family savings before they received the house. One of the initial improvements included constructing a toilet for the master room on the upper floor and the other two bedrooms have flexible uses. The family also expanded the limits of their lot to the house's side, which they coordinated with the neighbours. Later they covered the backyard to use it as laundry space, storage, and a small-scale hydroponics urban farm as the residents practice a "healthier lifestyle". The family built a fence and worked in the frontal and side garden. Their plans for future housing improvement include protective structures against rain like a covered entrance.

In previous cases, residents were initially motivated to satisfy their space needs. However, later other motivations emerged based on the residents' lifestyles and special needs.

5. Discussion: A Resident-Controlled Process

The analysis of the progress in the construction of housing extensions between disaster-affected and non-affected households (see Figure 7 and Table 1) suggest that both groups were in similar conditions at the time they moved into their houses in Villa Verde. Residents used the three-year gap between the disaster and the housing turnover to prepare emotion-

ally and financially to build extensions. Thus, the information suggests that residents have similar capacities to modify when the circumstances motivate them to build. For instance, when they have sufficient financial resources or when they feel pressured by family needs.

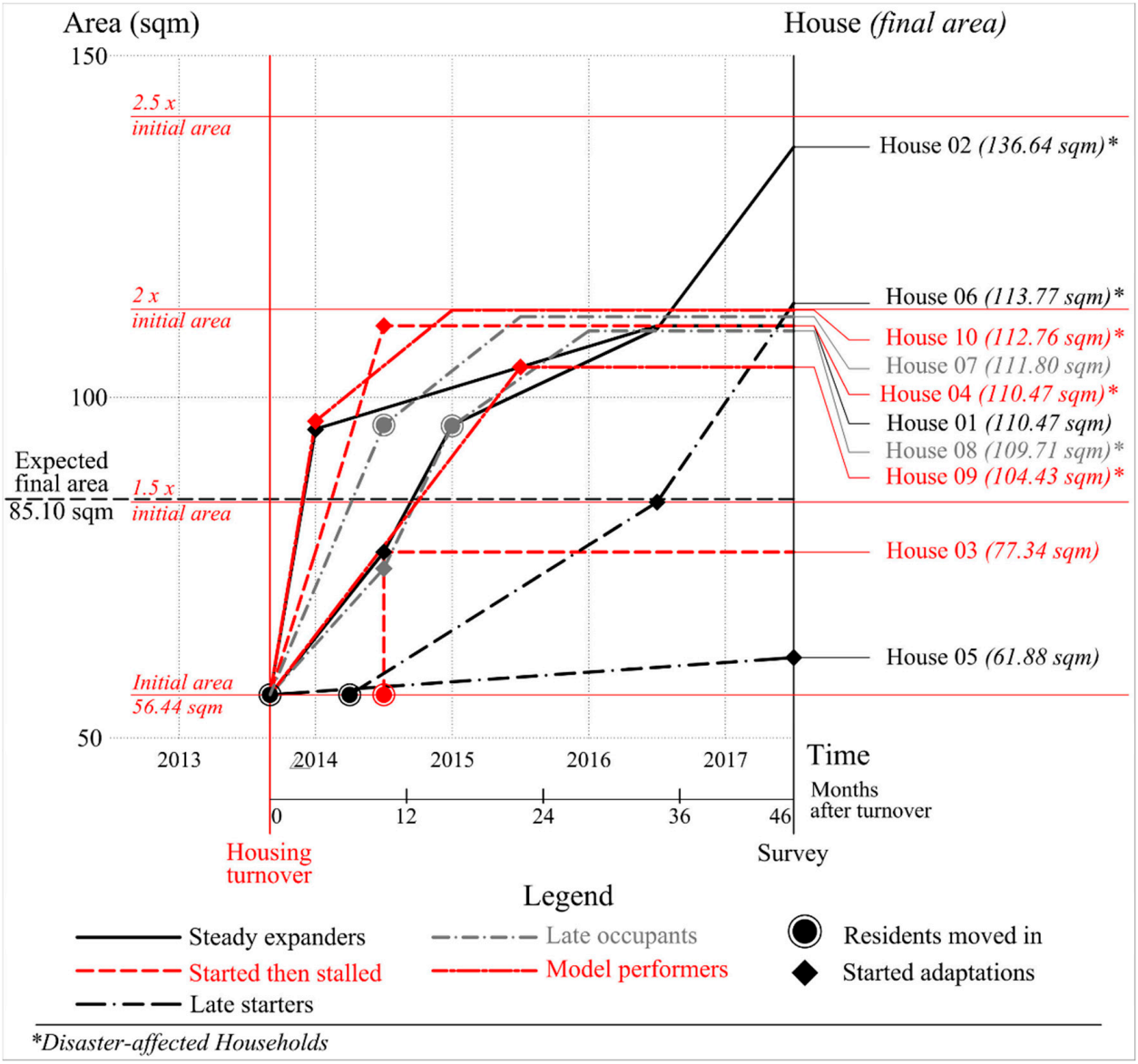


Figure 7. Temporality and progress of housing modifications in Villa Verde. Source: Authors (2020).

Looking at the timeframes and the progress of housing extensions as indicator of self-recovery, this paper observes a variable increase in the floor area from minimum to more than double the initial house designed by Elemental, as seen in Figure 7. Remarkably, the designers' expected final area of 85.10 sqm was rapidly achieved by 7 out of 10 households within the first year after receiving their houses with disaster-affected households among the better performing residents. Furthermore, the major construction works were performed within the first 15 months. Moreover, 6 out of the 10 households studied added between 50 to 100 percent to the initial house area, and two households more than doubled the initial house area. Figure 7 also shows the various paces of the housing modifications that have been identified in the five groups of residents. However, there is no clear evidence to link the housing modification's pace and the quantity of area added to the houses.A closer look at the periods of active construction presented in Table 1 shows no clear pattern in activity level among the five groups of households within the four-year timeframe

despite the different housing construction paces. However, there were slightly less active periods in the group of residents that paused the constructions and those who moved in later. Conversely, looking at the area built during active periods (semesters), we observe that the less active households and the most active added similar areas to the original house.

Table 1. Progress of housing adaptations and areas.

Group	House No.	Periods of Active Construction *	Final Area **	Area Added **	Area Built during Active Semesters **	Beyond Designers' Framework	Future Extensions/Renovations	Built Internal Renovations	Applied for Subsidies †
Steady performers	House 1	2	110.47	54.03	27.02	x	x	x	
	House 2※	4	136.64	80.20	20.05	x			
Started then stalled	House 3	1	77.34	20.90	20.90		x		
	House 4※	2	110.47	54.03	27.02	x	x	x	
Late starters	House 5	1	61.88	5.44	5.44		x		
	House 6※	2	113.77	57.33	28.67	x	x	x	x
Late occupants	House 7	2	111.8	55.36	27.68	x			
	House 8※	3	109.71	53.27	17.76	x	x	x	
Low-density model performers	House 9※	2	104.43	47.99	24.00	x	x	x	x
	House 10※	4	112.76	56.32	14.08	x	x	x	

Notes: ※ Disaster-affected households. * Measured in semesters based on interviewees' preferences to define timeframes. ** In square meters. † Subsidies must be collective and only in areas previously approved in the building permit.

This study also shows that the construction pace has no impact on where the residents-built extensions as residents in all the groups built beyond the designers' framework. Furthermore, all except two expressed their motivation to keep building in the future, and most of them already have plans of what they want to build. Even though most of the discussion in this paper was related to the housing extensions and self-recovery, residents also invested in improving the spaces already built. We observe that six households built internal renovations, including changing the houses' original layout or replacing specific elements like renovating the kitchens and toilets or adding finishing to the houses.

This study also observes that few households applied for government-funded subsidies for internal renovations due to the Housing and Neighbourhood program conditions, limiting the eligibility to collective applicants. In Villa Verde, one successful collective application was submitted by the seniors' neighbours association and the second was in preparation by one of the neighbours' associations and targeted the poorer households and the large families. However, they often complained about the limited control over the government-funded renovations that contractors performed.

Residents built extensions at different paces and following various motivations. Despite the differences, this study observed that Villa Verde houses' incremental construction is sustainable in time and is affected by the family conditions changes. For instance, residents prepared for building their houses before moving in, and investing in construction was their priority. Homeowners' urgency to accommodate family members motivated the construction of extensions. Residents modified their houses due to changes in household conditions and size, which sometimes triggered unexpected extensions and renovations. However, the houses' changes were also motivated to change their financial or family conditions. For instance, the construction of grocery shops and home-based businesses affected the families' financial situation, which might motivate residents to build more extensions or renovate the already-built spaces. As we observed during the interviews with residents, building and improving their houses is part of their daily lives as they expressed their pride in the extensions performed and are highly motivated to keep building.

This study has presented the outcomes of facilitating housing frameworks for resident-controlled incremental construction and self-recovery to empower disaster-affected people to take care of their own recovery. Twigg [44] highlights building back safer as paramount in the self-recovery discourse that focuses on avoiding the recreation of unsafe designs and building practices. For instance, the seismic performance of the Quinta Monroy project, also designed by Elemental, was tested during the 2014 Iquique Earthquake. The positive outcomes resulted from the residents' willingness to use only lightweight materials, which

the designers encouraged in their technical manuals for building extensions [22]. However, the impacts of the complexity in the types of extensions built beyond the designers' technical specifications in Villa Verde remain unclear. Therefore, it is necessary to evaluate the long-term implications of the Elemental's incremental housing model in the residents' safety and quality of their living conditions which will define opportunities for improvement and replicability in other contexts.

6. Conclusions

This study presented different patterns for housing adaptations analysed almost four years after Villa Verde's houses were given to the families. Capturing the evolution of incremental housing construction evidenced complexities resulting from the variety of households' characteristics and needs in their post-disaster housing self-recovery.

Unlikely strictly following Elemental's plans for extensions, residents presented different alternatives and reasons beyond the designer's manual regardless of their disaster-affected or unaffected household condition. Residents started building at different times and at different paces based on regularly emerging needs or sudden family income and size changes. The complexity of unpredictable, driven factors for housing adaptations is shown in some families' need to create an income source. In other cases, it is to accommodate the diversities of family compositions or simply adapt their home to suit their emerging spatial requirements. Therefore, the unpredictability of the changing households' conditions and behaviours defines the unexpected changes in the houses that often-covered areas beyond the designer's parameters. Houses in Villa Verde were designed to be changed, although the design allowed only specific future extensions trying to anticipate unpredictable needs. This paper evidenced that despite "pre-packaged" alternatives for housing adaptations, providing a "framework" that supports the housing extensions may challenge the conventional designers' ideals leading to what Leupen (2006) calls "designing for the unknown".

Aravena and Elemental tried to provide a platform for resident-controlled housing development, and the Chilean regulations also acknowledge and support incremental housing. Remarkably, vulnerable residents accessed government funding for housing renovations, although these were limited to internal spaces and controlled by contractors. However, for most of the housing extensions, designers and the government failed to try to limit a continuous and unpredictable process whose implications on appropriate living conditions and structural stability remain uncertain. In this context, designers and policymakers need to understand that housing is a mean to provide residents the freedom to be and exercise their rights and take responsibility for the needed decisions to fulfil specific aspirations. Therefore, once residents were given the freedom to modify their houses for an unpredictable time and in unexpected ways that show a "freedom of the unknown". This study evidenced residents' capacities and dedication to self-recover by controlling the incremental housing construction process. Accordingly, long-term analysis of post-disaster incremental housing is crucial to minimise the creation of further risks, which requires community engagement in creating safer living environments.

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