# APPLYING THE LEVEL(S) INDICATOR LANGUAGE TO RESILIENT HOUSING

CARMEN DÍAZ-LÓPEZ[1], DARIEL LÓPEZ-LÓPEZ[1], ANTONIO SERRANO-JIMÉNEZ[2], ÁNGELA BARRIOS-PADURA[1], JULIA HIRUELO PÉREZ[1] & CARLOS ROSA-JIMÉNEZ[3]
[1]Universidad de Sevilla, Spain
[2]Universidad de Granada, Spain
[3]Universidad de Málaga, Spain

ABSTRACT

The construction sector represents an opportunity to promote urban culture change in favour of housing stock regeneration, encouraging urban interventions that extend the life of buildings in a sustainable and resilient way from the project's design phase. Level(s) is the European Union's new language for sustainability, circular economy, and resilience indicators. Specifically, Indicator 2.3 proposes a process that assists the design and renovation of housing in a state of obsolescence to explore its maximum resilience to climatic, functional, and socio-economic effects. The indicator is made up of objectives that allow the needs of any occupant to be met throughout the useful life while also proposing a study of the payback time of the investment. The objectives of this indicator focus on the most efficient use of space, greater longevity and operational performance of the building and the longer-term vision of the valuable life by allowing the change of use of the building. Thus, this research aims to identify a resilient housing retrofit methodology based on Level(s). The following specific objectives have been identified: (i) resilience assessment of the current state of the pilot cases using Level(s) to meet this objective; (ii) design of new resilient housing configurations and analysis of project opportunities and constraints using Level(s); and (iii) assessment of cost amortisation. The results of this research allow for the identification of a comprehensive, functional, flexible, accessible, resilient, and dynamic space refurbishment model that allows for the maximum number of configurations for the maximum number of tenants over time, considering cost reduction, time and payback.

*Keywords: Level(s), resilience, housing, retrofitting, payback, sustainability, flexibility, accessibility.*

## 1 INTRODUCTION

The growth of construction in urban areas significantly impacts the environment, economy, public health, and wellbeing of cities [1]. Buildings are responsible for 40% of energy consumption and 36% of greenhouse gas emissions in the European Union (EU) [2]. Approximately 15% of the EU population live in inadequate housing. Air quality, thermal discomfort, noise, dampness, increased mould, lack of hygienic equipment and overcrowding are some of the main threats to users' quality of life [3]–[5].

Such inadequate housing includes mental and physical health problems, poverty and associated socio-economic outcomes, especially for low-income families with children. People living in inadequate housing often cannot meet the costs of energy bills due to obsolete equipment and inefficient building envelopes. In Europe, energy poverty affects around 125 million people [6]. Inadequate housing is part of a vicious circle that increases the risk of poverty and social exclusion. Moreover, the communal spaces of existing buildings constructed in the 20th century constitute natural barriers from physical, psychological, energetic, technological, and other point of view. The consequences entail monetary and non-monetary costs for inhabitants, public authorities, and society.

The development of medicine has increased life expectancy globally. By 2050, 16% of the world's population is estimated to be over 65 years old. Population ageing establishes new challenges and impacts on all sectors of society, including architecture and urban planning and complementary services, in addition to proposing a challenge in terms of

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generational relationships, where the accumulated experience allows them to obtain positive results and generate a collaborative environment around them as a strategy of lower impact on users and public spending [7].

In this context, the construction sector represents an opportunity to promote a change of urban planning culture in favour of the regeneration and resilience of the pre-existing housing stock in the face of growth and urban sprawl of new constructions. It encourages urban interventions that prolong the life of buildings and sustainably rehabilitate them [8], taking into account active ageing from the project's design phase. This change of strategy will allow the sector to align with the commitments of the Urban Agenda 2030 [9], the European Green Deal [2] and the European New Bauhaus [10], and the principles of circular economy that have emerged as one of the central policies to establish more efficient strategies to conserve resources for longer [11].

In response to this challenge comes the Level(s) framework, a set of EU sustainability and circular economy indicators that address the performance of buildings throughout their life cycle [8]. Specifically, Level(s) Indicator 2.3. proposes a process that assists the design and renovation of housing in a state of obsolescence to explore its maximum resilience to climatic, functional and socio-economic effects. The indicator is made up of objectives that allow the needs of any occupant to be met throughout the useful life of the building while also proposing a study of the payback time for the investment. The objectives of this indicator focus on the most efficient use of space, increased longevity and operational performance of the building and the longer-term vision of the valuable life by allowing the change of use of the building [12], [13].

Consequently, this research aims to identify a resilient housing retrofit methodology based on Level(s). The following specific objectives have been identified to meet this objective: (i) resilience assessment of the current state of the pilot cases using Level(s); (ii) design of new resilient housing configurations and analysis of project opportunities and constraints using Level(s); and (iii) assessment of cost amortisation.

The results of this research allow for the identification of a comprehensive, functional, flexible, accessible, resilient and dynamic space refurbishment model that allows for the maximum number of configurations for the maximum number of tenants over time, considering cost reduction, time and payback.

## 2 MATERIALS AND METHOD

The following methodology has been identified to meet the objectives of this research: (i) resilience assessment of the current state of the study cases (SC) based on Level(s); (ii) design of new resilient housing configurations and analysis of project opportunities and constraints based on Level(s); and (iii) assessment of cost amortisation (Fig. 1). For the development of this research, two SCs have been identified in southern Spain.

The first study case (SC-1) is a dwelling in a building in the Barriada Juan XXIII in Seville, built between the 1950s and 1980s. It has undergone various socio-urban dynamics and has different degrees of marginalisation due to its origin as social housing. The dwelling analysed is in a residential building built in 1967. It is a double-aisled building with two ground floor flats, with a ground floor plus four floors. On the ground floor, there is a communal space with storage rooms, access to different services in the building and garden areas cared for by the residents themselves. The dwellings have a symmetrical configuration concerning the communication nucleus and have a good surface area of 68 $m^2$.

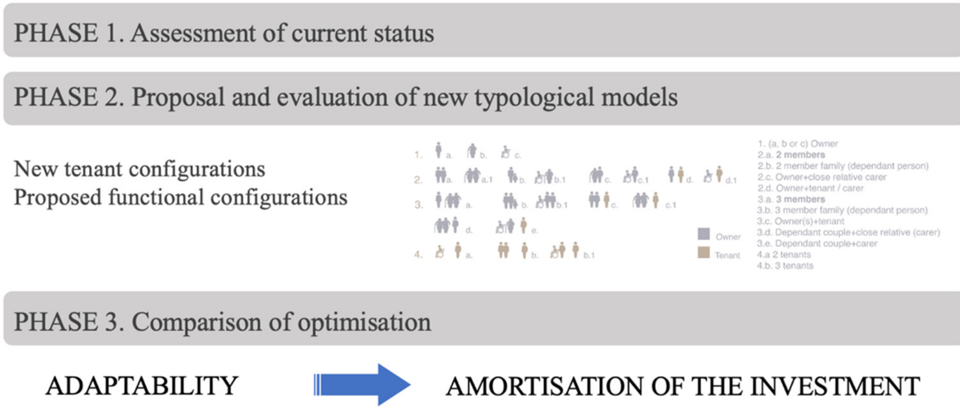


Figure 1: Materials and method.

The second case study (SC-2) is a dwelling located in a building in the Gamarra neighbourhood in Malaga. It is a residential and office building built in 1970. There is a common area; on the first floor, there are offices; and on the rest, there are dwellings. This building has 17 floors with a surface area of 97 m$^2$.

### 2.1 Resilience assessment of the current state of the pilot cases with Level(s)

The first phase of the methodology consists of the analysis of the current status of SC-1 and SC-2 using Indicator 2.3 of the Level(s) framework.

### 2.2 Design of new resilient housing configurations and analysis of project opportunities and constraints through Level(s)

The second phase of the methodology consists of the application of Indicator 2.3. First, a Base Proposal (BP) for the refurbishment of the dwelling is identified, with the capacity to be transformed into different spatial configurations to achieve the maximum extension of the useful life of the dwelling and to accommodate the maximum number of tenant types. Second, different configurations of the BP are determined. Thirdly, different models of temporary cohabitation are identified, divided according to the number of members and tenants.

The basic refurbishment model is based on the following principles: (i) accessibility, control of the width of accesses and passages inside the dwelling, as well as the adaptation of the bathroom to the passage of a wheelchair following European regulations; (ii) flexibility, use of mobile panels that allow maximising or reducing the space of the dwelling according to the needs of the tenants; (iii) independence, incorporation of a second bathroom and another entrance access to the dwelling that allows privatising part of it; and (iv) economy of means and materials: maximum resilience with minimum investment.

### 2.3 Assessment of cost amortisation

Finally, the costs and benefits derived from the refurbishment of the SC dwellings are quantified, identifying the costs of works and material of the BPs and the benefits of renting the different configurations.

## 3 RESULTS AND DISCUSIONS

The following sections present and discuss the results obtained from applying the methodology.

### 3.1 Resilience assessment of the current state of the pilot cases with Level(s).

In the following section, SC-1 and SC-2 are analysed using Level(s) Indicator 2.3. Regarding SC-1 (Fig. 2(a) and Table 1), the layout plan of the dwelling, located on the third level, has a northeast–southwest orientation, keeping the south façade completely opaque. The dwelling is small with a kitchen–dining room, living room, bathroom, toilet, laundry room and three bedrooms. According to the information provided by the users, it has undergone substantial modifications. There are severe deficiencies in the space's flexibility due to the building's structural rigidity and accessibility problems in the communication core and inside the dwellings, in addition to the impossibility of introducing substantial improvements in the building's installations due to lack of space, with shallow ceilings and minimal usable surface area. Given these limitations imposed by the use, the type of tenant and their way of living, a comprehensive refurbishment is proposed that responds to the current and future demands of the residents of this social neighbourhood.

Concerning CS-2 (Fig. 2(b) and Table 1), the distribution plan of the dwelling, located on the eighth floor, has a southeast orientation, with a very marked division of each of the spaces. The dwelling is generously sized with a kitchen–dining room, living room, two bathrooms, a laundry room and three bedrooms. According to data provided by the users, it has undergone minimal modifications over time. The house has a very marked division of each of the spaces. There are functional problems; the dining room is a considerable distance from the kitchen, which in many cases means that it is not used for this purpose but for other functions. Long distances that represent the space need to be better used. The house has excellent spatial potential thanks to its ample dimensions, two independent entrances and two balconies.

### 3.2 Design of new resilient housing configurations and analysis of project opportunities and constraints based on Level(s)

This section presents, for each SC, the BP and its possible configurations. In both SC, the BP seeks to economise the intervention as much as possible to make the space more flexible and maximise it. Spaces such as the living room, study and bedrooms become dynamic areas with greater flexibility of use. Each of the three configurations has different rental possibilities depending on the type of owner and tenant. In all configurations, the home can be used solely for residential use by a family unit; it can be used as a residence and workspace for the owner or tenant.

#### 3.2.1 Resilient SC-1 configurations

Regarding SC-1, as shown in Fig. 1, the preliminary proposal seeks to economise the intervention as much as possible to make the space more flexible and maximise its use. Spaces such as the living room, study and bedrooms become more changeable spaces with greater flexibility of use.

**Configuration 1 (Fig. 3(a)).** Two independent rooms, with use as a bedroom or study with movable partitions. This layout can accommodate three or four users. The common uses of the dwelling and the main bedroom are accessible. The possible users can be:

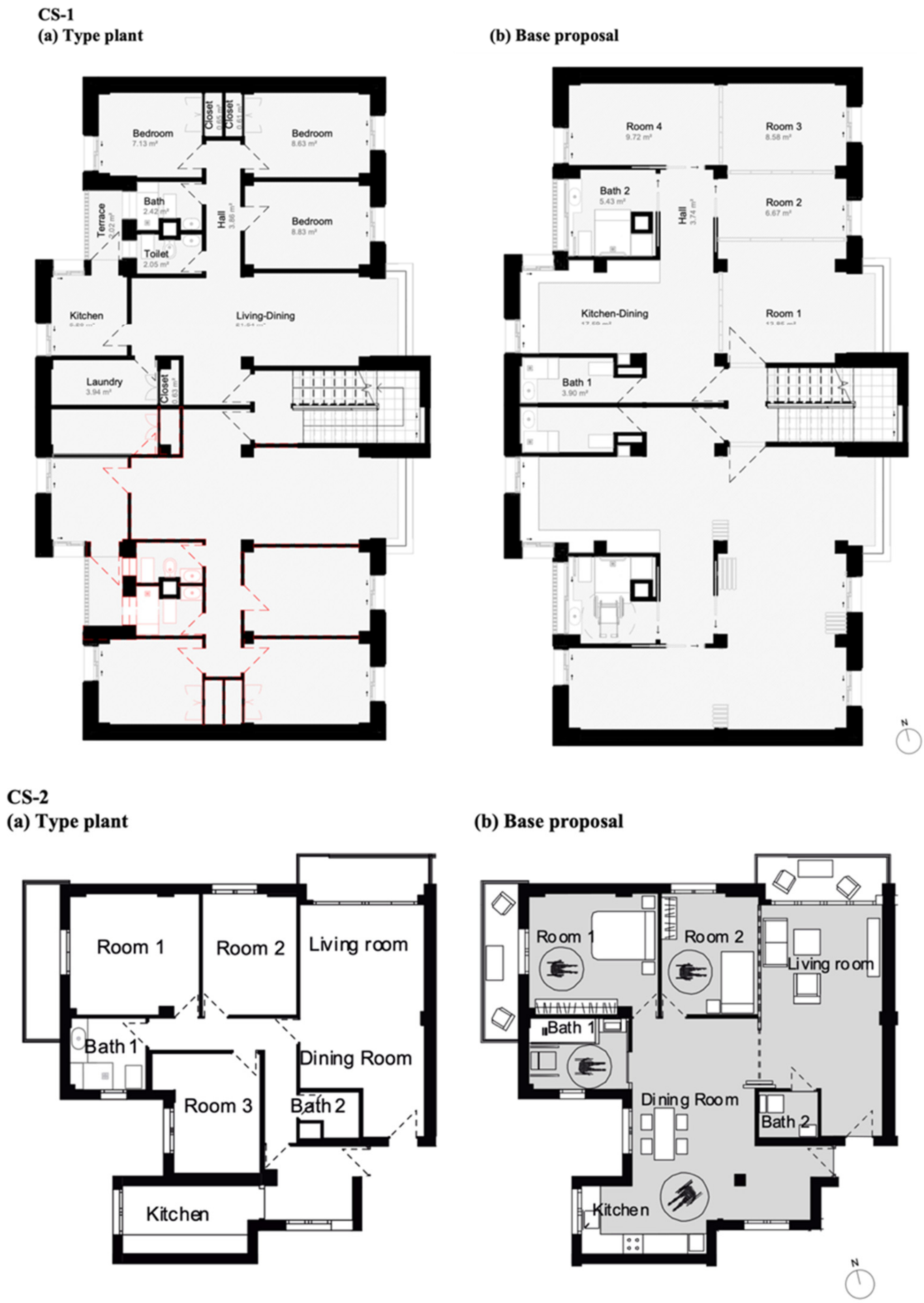


Figure 2: CS-1. (a) Type plant; and (b) Base proposal; CS-2. (a) Type plant; and (b) Base proposal.

Table 1: Residential building checklist of adaptability design concepts.

| Adaptability design concept | Specific design aspect to address | How the design aspect can contribute to adaptability | | |
|---|---|---|---|---|
| | | Original (SC-1, SC-2) | Basic Proposal (SC-1, SC-2) | Weighted score (SC-1, SC-2) |
| 1. Changes to the internal space distribution | 1.1 Wall systems that support layout changes | The internal wall design is fixed, and it does not allow the transformation of the space. | Use of movable panels to make the use of space more flexible. | 13.5 |
| | 1.2 Greater ceiling heights for surface routes | As there is no suspended ceiling, it is not possible to introduce air-conditioning ducts or extend the space. | No changes have been made, as there is no possibility of higher ceiling heights. | 0 |
| 2. Changes to the buildings servicing | 2.1 Ease of access to the building services | Access to the building's services is on the ground floor. | No changes were made. | – |
| | 2.2 Ease of adaptation of the distribution networks and connectors | The structure of the building does not facilitate the adaptation of distribution networks. | To make each studio independent, the distribution networks and connectors of a new downspout have been adapted to add a second bathroom. | 0 |
| 3. Change to the use of units or floors | 3.1 The potential for a segregated home working spaces | It is possible to make independent a space with adequate dimensions, light and services within the home. | The configuration of new movable panels, a new bathroom, and an alternative entrance to the flat makes it possible to privatise a part of the flat as a studio, office, etc., and to create a new living area. | 9 |
| | 3.2 The potential for ground floor conversion to a contained unit | It is possible to make independent a space with adequate dimensions, light and services on the ground floor. | No changes were made. | 9 |
| 4. Changes in access requirements | 4.1 Ease of access to each residential unit | A complete modification of the vertical communication core would be necessary according to regulations. | The width of the new entrance door to the house was modified (1 m width). | 9 |
| | 4.2 Access to and manoeuvrability within rooms | A complete restoration of the communication core and dwellings would be necessary to facilitate wheelchair access and manoeuvrability. | To allow wheelchair mobility in all rooms, the passage widths throughout the house have been modified. | 9 |
| Total weighted score 49.5 | | | | 49.5 |

- Families forming a family unit of one to three members. Two independent rooms can be used as bedrooms or studios.
- Family(ies) caring for a dependent person. In this case, the dependent person and their carer have a close relationship and share common uses while maintaining the independence of their bedrooms and bathrooms.


Figure 3: New configurations of (a) SC-1; and (b) SC-2.

**Configuration 2 (Fig. 3(b)).** Two independent rooms used as a bedroom, study or office with movable partitions. This layout can accommodate three or four people. The common uses of the dwelling are located in the northwest orientation, making it flexible whether or not the living room can be privatised. The main bedroom and the study are accessible, freeing the passage between the kitchen–dining room and the living room. Possible users over time could be:

- 1–2 member family unit with a studio or office.
- Family unit of one to two members with the possibility of renting part of the dwelling. The studio of 14 $m^2$ and has a separate bathroom.

**Configuration 3 (Fig. 3(c)**). Two independent rooms with movable partitions can be used as a bedroom, study or office. This layout allows for two or three users, maximising the private space of each room by removing the living room and reducing the shared space to the kitchen–dining area. The possible users could be:

- One user who carries out their trade within the dwelling.
- One user who rents a part of their home, a studio with an independent bathroom.

3.2.2 Resilient configurations of SC-2

**Configuration 1 (Fig. 3(d)).** Two rooms and a separate living area with movable partition walls. This layout can accommodate three or four users. Possible users could be:

- Families forming a family unit of between two and four members.
- Family(ies) caring for a dependent person. In this case, the dependent and carer have a close relationship and share common uses.

**Configuration 2 (Fig. 3(e)).** Two rooms and a separate area for office use with movable partitions with the possibility of renting one of the areas. Potential users may be:

- Families forming a family unit of one to three members. In addition to an office for one or two workers.
- Family(ies) caring for a dependent person. In this case, the dependent person and his/her carer have a close relationship and share common uses in addition to an office for one or two workers.
- Rental of part of the dwelling, 12.80 $m^2$.

**Configuration 3 (Fig. 3(f)).** The third proposal offers the possibility of renting a studio apartment independent of the main dwelling. The closing of one part of the panels and the opening at another point allows the creation of two independent dwellings. The possible users over time could be:

- Families forming a family unit of one or two members. In addition to a studio with possibilities for one or two members.
- Family(ies) caring for a dependent person. In this case, the dependent person and his/her carer have a close relationship and share common uses in addition to a studio with possibilities for one or two members.
- Rental of part of the dwelling, 23.60 $m^2$.

### 3.3 Evaluation of cost amortisation

Finally, the costs and benefits derived from the refurbishment of the SC dwellings are quantified, identifying the costs of works and material of the BPs and the benefits of renting the different configurations. The results are shown in Table 2.

Table 2: Results of evaluation of cost amortisation.

| | SC-1 | | | SC-2 | | |
|---|---|---|---|---|---|---|
| | C1 | C2 | C1 | C1 | C2 | C3 |
| $m^2$ available | – | 14 $m^2$ | 21.20 $m^2$ | – | 13.40 $m^2$ | 24 $m^2$ |
| Rental price per $m^2$ | | 21 € | 21 € | | 22 € | 22 € |
| Estimated rental price | – | 294 € | 445 € | – | 295 € | 528 € |
| Economic cost of refurbishment | 15,456 € | 15,456 € | 15,456 € | 18,165 € | 18,165 € | 18,165 € |
| Amortisation time (years) | – | 4–5 | 2.5–3.5 | – | 5–6 | 2.5–3.5 |

## 4 CONCLUSIONS

This research has identified a resilient housing rehabilitation methodology based on Level(s). The resilience of the current state of the pilot cases has been assessed using Level(s) and new resilient housing configurations have been designed and project opportunities and constraints have been analysed using Level(s).

The assessment of cost amortisation shows both functional and economic cost-effective models. The results of this research allow the identification of a complete, functional, flexible, accessible, resilient and dynamic space retrofit model that allows for the maximum number of configurations for the maximum number of tenants over time, taking into account cost reduction, time and payback.

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