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Social housing improvement factors for upgrading processes

Elisa Atália Daniel Muianga ^a, Doris C.C.K. Kowaltowski ^b and Jelle S. J. Koolwijk ^c

^aTechnology Department, School of Architecture, Urbanism and Design, University of São Paulo, São Paulo, Brazil; ^bDepartment of Architecture and Building, School of Civil Engineering, Architecture and Urban Design, University of Campinas, Campinas, Brazil; ^cDepartment of Management in the Built Environment, Faculty of Architecture and the Built Environment, Delft University of Technology, Delft, The Netherlands

ABSTRACT

A large social housing (SH) stock exists around the world, and many developments need upgrading for various reasons. Upgrading demands careful planning and execution with specific improvement interventions that require clear, socially conscious, and technological as well as environmental objectives. In mandatory processes, top-down government improvement initiatives are mandated by directives, while users in non-mandatory processes instigate a bottom-up upgrading. In this context, people improve their living conditions and undertake self-built reforms, often at high costs due to a lack of planning and technical support. This study investigated upgrading interventions and improvement factors for SH. We discuss upgrading with a literature review to understand the operational improvements with user quality of life in mind. Results identify improvement interventions on topics of Energy and Resource Efficiency; Housing Quality and Comfort; Building Systems and Infrastructure; Health, Psychological and Social Wellbeing; Green and Open Spaces; Functional Design and Accessibility; Mobility and Services; Waste and Water Management. The study classified interventions by their complexity of execution. Frameworks for both mandatory and non-mandatory upgrading processes were created, and the impacts of SH upgrades are outlined. The contributions support decision-making roadmaps for upgrading processes to improve SH.

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Upgrading actions; social housing; built environment improvements; improvement interventions; transformations

Introduction

The term ‘Social Housing’ (SH) refers to projects implemented by governments or non-profit organizations to address housing deficits, supporting disadvantaged groups unable to acquire a home through the housing market (Monteiro et al., 2017). Many SH programmes, however, still rely on outdated social and technological concepts and struggle to keep pace with evolving demands (Ledent, 2017). Also, many SH projects meet only the minimal requirements of technical standards and the present-day challenges the building industry faces (Muianga et al., 2021).

A significant portion of the global SH stock has deteriorated over time, exceeding its original design life, no longer meeting the needs and expectations of society (Martin-Goñi et al., 2024). Maintenance, repair, and particularly upgrading actions are necessary not only to forestall obsolescence but to align housing with sustainable mandates, mitigate climate change, and respond to social dynamics (Buckley et al., 2016; Karvonen, 2013).

In this study, actions are conceptualized as processes intended to establish or enhance the essential conditions

and attributes that housing should support, including physical interventions and other efforts aimed at establishing or improving essential housing conditions. Upgrading aims to enhance residents’ living conditions and environmental sustainability, going beyond basic maintenance. Upgrading is often also referred to as refurbishment, retrofit, or renovation (Kowaltowski et al., 2024). This study supports both mandatory and non-mandatory upgrading processes of developed and developing regions.

In the case of mandatory processes, such as those established by the European Union (EU), and other developed countries adhering to the 2015 Paris Agreement of the COP21 climate conference, top-down initiatives confirm that natural renovation cycles are insufficient to meet the scale of repair and upgrading needs, particularly in aging housing stocks, where annual renovation demands far exceeds new construction with an expected growth in coming decades (Kurvinen et al., 2024; Sandberg et al., 2016). In non-mandatory processes, found chiefly in developing countries, a bottom-up approach prevails, and

upgrading occurs through dwellers' desires and projections. Interventions in this context are often insufficient to mitigate the negative impacts associated with below-standard housing conditions. Unplanned retrofits may even have adverse impacts on housing, reducing environmental comfort and compromising structural integrity (Kowaltowski et al., 2024).

Upgrading interventions should improve living conditions both within individual dwellings and at the neighbourhood scale, addressing user needs while responding to environmental challenges (Muianga et al., 2021). However, available upgrading measures, and their varying degrees of complexity, remain poorly understood, particularly from the perspective of homeowners. Clarity about upgrading actions is especially relevant as perceived complexity is repeatedly cited as a barrier to renovations (Mogensen & Gram-Hanssen, 2023). Factors contributing to this complexity include a lack of technical knowledge, insufficient awareness of the range and impact of possible measures, limited project management skills, and significant financial commitments (Asinyaka, 2023).

Research questions and objectives

While numerous studies have examined barriers to upgrading actions, they seldom focus on the nature of the measures themselves and their perceived complexity. Communication about available actions often remains shallow, and policy interventions lack the focus and precision needed to be truly effective (Bienert et al., 2023).

A classification of possible interventions and structured frameworks to support upgrading processes is needed. Upgrading measures require more precise definitions to distinguish between deep and shallow interventions, as these categories often remain vague concerning their complexity and necessary resources for execution (Saffari & Beagon, 2022). More importantly, this binary distinction does not adequately capture the often incremental nature of real-world renovation practices. Many retrofits unfold in stages, adapting over time to financial, technical, and behavioural constraints (Galvin & Sunikka-Blank, 2017; Maia et al., 2024).

There is also a lack of insight into how various upgrading measures relate to one another, particularly concerning specific renovation goals, such as energy efficiency or improved indoor comfort (Directive (EU), 2024; Martin-Goñi et al., 2024). This lack of clarity hampers integrated decision-making by stakeholders and limits the effectiveness of policy and communication strategies in upgrading processes.

In some regions, such as in the EU, Building Renovation Passports (BRPs) were developed to support upgrading processes (Fabbri et al., 2016). BRPs are intended to offer tailored roadmaps for energy upgrades, developed through on-site audits and consultation with building owners. Although they offer numerous potential benefits, including improved documentation, clearer guidance, and enhanced stakeholder coordination, they remain underutilized, despite the concept's existence for over 40 years (Buchholz & Lützkendorf, 2023). Also, the actions recommended in current BRPs often remain superficial, focusing mainly on generic energy-saving measures and CO₂ emission reductions, rather than addressing the broader, building-specific or user-centred improvements needed for long-term resilience and quality of life of users (Sesana et al., 2021).

Even with the roadmaps to support upgrading processes, such as the BRPs, mostly applied in the EU, their usefulness depends on the availability of a well-structured classification of interventions and their interrelationships (Fabbri et al., 2016). For housing improvement projects worldwide, sequencing actions, identifying a community spirit or conflicts, and communicating upgrading strategies are essential (Buchholz & Lützkendorf, 2023).

This study provides insights into the range and complexity of upgrading actions for SH, both for mandatory and non-mandatory housing improvement processes. Through a systematic identification and analysis of interventions, the research supports more effective upgrading strategies and offers communication tools that align with the needs, capacities, and concerns of households. We address these issues by answering three research questions:

- What types of improvement actions are applied in SH upgrading processes?
- How can these actions be classified according to their complexity?
- How can understanding complexity support more effective mandatory and non-mandatory upgrading process strategies?

Our contribution includes a classification of upgrading actions by complexity, supporting more targeted communication, and policy-making for mandatory and non-mandatory renovation processes. Understanding how specific measures contribute to outcomes such as building energy efficiency, environmental comfort, health, and the psychological wellbeing of users can inform more integrated and effective design strategies. Structured frameworks of upgrading processes may

help decision-making, optimize resources and enhance stakeholder engagement by making the benefits of actions more tangible. With our research, we also aim to incorporate broader wellbeing and adaptive capacity considerations into upgrading classifications and roadmaps.

Background

The literature presents upgrading as improving a building beyond maintenance. Upgrading includes adjustments, additions, reuse adaptations, improvements, replacements, repairs, renewal, refurbishment, interventions, regeneration, renovation, redevelopment, retrofit, rehabilitation, restoration, and preservation (Ortiz et al., 2020).

Worldwide, many SH developments are more than 50 years old. In Europe, a large building stock was constructed soon after WW2 in a quick process at low costs, and with minimum comfort standards (Martin-Goñi et al., 2024). These constructions fail to meet the expectations of modern society and the 2015 Paris Agreement. The European Directive (2024) plans to renovate a quarter of its buildings by 2033, and the transformation of the building stock into zero-emission constructions is foreseen by 2050. A mandatory process for upgrading SH is in place not only in Europe but also in Canada and Japan, and is under review in the US. New regulations, technical standards and building construction innovations were created (Martin-Goñi et al., 2024). Government-sponsored initiatives to improve housing conditions have also been introduced, through technical assistance and financial support for self-constructed upgrading in developing countries (Sombrio et al., 2025).

However, in many countries, mandates that target the complete decarbonization of a building stock by 2050 are being questioned by governments as being unrealistic and too costly (Maduta et al., 2023). Especially in developing countries, public policies are still more concerned with new constructions than the introduction of improvements to the existing SH building stock, as the housing deficit remains the main challenge (Kowaltowski et al., 2024). Also in these countries, SH constructions are predominantly standardized, based on non-participatory design processes and most initiatives of upgrading address precarious sanitation conditions only, targeting slums (Kamaruzzaman et al., 2018; Preciado-Pérez & Fotios, 2017). Renovations of SH depend on large financial resources, a trained workforce, efficient planning and design choices. Upgrading processes need the support of the many stakeholders involved, and Fabbri et al. (2016) demonstrate

that building owners and potential investors face barriers to improving the energy performance of their buildings. Also, one of the most often quoted barriers to upgrading is ‘the lack of knowledge about what to do, where to start, and which measures to implement in which order’ (Fabbri et al., 2016, p. 4).

Motives for SH upgrading, whether mandatory or non-mandatory (voluntary), are decay, structural, infrastructure and functional obsolescence (Kowaltowski et al., 2024). Buildings are not eternal, and structures need to be continuously looked after and maintained, especially given greater construction complexity and fragility. Hazardous construction techniques and materials require interventions, and neighbourhood renewal can benefit communities (Hackitt, 2018; Karvonen, 2013). The reduction of demolitions and the resulting material savings should be considered (Martin-Goñi et al., 2024). Savings on social, environmental and economic scales are important motivations for retrofitting SH (Muianga et al., 2021).

Social impacts, health issues of a population, energy efficiency and climate change intensify the need for upgrading programs (Peters & Halleran, 2021). For SH users, fuel poverty and the reduction in running costs are incentives (Kowaltowski et al., 2024).

New social norms and values impact the introduction of aesthetic and functional improvements. Retrofits may have a goal to adapt to changing life situations through flexible housing layouts. The existing SH stock rarely offers such layouts and upgrading should attempt to accommodate changes in lifestyle. For homeowners, psychological and status reasons may play a part in planning renovation projects (DellaValle et al., 2018). ‘Keeping up with the Joneses’ and ideas disseminated by the media stimulate upgrading (Helms, 2012). Health-related problems such as mould, damp and condensation issues are frequent incentives to refurbish for socially minded governments and housing associations. Furthermore, demographic changes increase attention given to the needs of the elderly through accessibility interventions (Thomsen & van der Flier, 2011). Enhancing the built environment through thoughtful upgrading actions may strengthen both individual and community resilience by improving physical health, enabling social interaction, and fostering a greater sense of belonging, especially crucial in the face of environmental or social stressors (Rashidfarokhi & Danivska, 2023).

Energy savings, environmental responsibility and a demand for well-performing buildings are the main incentives to attend to climate change mandates (Konstantinou et al., 2020; Van de Moortel & Allacker, 2023). The reduction of the carbon footprint of housing

can benefit the environment, the economy, and social welfare (Cauvain et al., 2018). Related construction actions address insulation, triple glazing, building automation and new heating installations in most developed countries (Bienert et al., 2023). Retrofitting the existing SH stock involves reducing energy consumption of buildings with lower carbon emissions, demanding significant investments.

Assessing the ecological performance of retrofit measures is essential since climate change and its effects are a threat to natural ecosystems and human wellbeing (De Mel et al., 2023). Actions should address the balance between embodied carbon and operational savings. A carbon payback period would be calculated as a key performance indicator for decision-making. Furthermore, switching to low-carbon and bio-based solutions has the potential to reduce up to 50% of the CO₂ emissions in retrofit constructions with additional health benefits (Bienert et al., 2023).

Non-mandatory upgrading programmes are more common in developing countries, and improving SH and environmental conditions depend mainly on the owners' financial resources for interventions (Kowaltowski et al., 2024). Transformations made by self-builders are primarily driven by the low construction standards of typical SH projects, characterized by inadequate layouts and insufficient dwelling sizes that fail to meet individual family needs (Tipple, 2000; Villa et al., 2022). Most SH developments around the world also fail to consider energy efficiency. However, most transformations by users/owners rarely address the issues of sustainability.

Upgrading feasibility studies presents opportunities to identify improvement actions for different contexts, especially for shallow invasive and non-invasive processes (Karvonen, 2013). Actions with a higher potential for implementation, especially in terms of their economic and technical feasibility, should be detailed. A gradual upgrading process that promotes feasible initiatives may offer opportunities for continuous improvements of SH.

A structured overview of interventions could empower housing agents and construction companies to explain added-value measures to users, support consistent decision-making, and reduce reliance on the cheapest short-term options. Advisory roles of these various agents would be enhanced and project outcomes would be aligned with long-term policy goals for energy performance and positive environmental impacts. Forward-looking tools capable of generating projections on the feasibility, performance, and costs of various renovation options should also be available to provide building owners with early insights into expected

outcomes, help reduce uncertainties in investment decisions, and support better coordination of multiple technologies or interventions (Murto et al., 2019). This coordination is especially relevant for phased retrofits, where fragmented services and technical ambiguities place a heavy interpretive burden on end-users (Murto et al., 2019).

Actions need to be accepted by the various stakeholders of an upgrading process. Housing authorities, tenants, occupant-owners and landlords may be involved, as are construction companies and design professionals. They have varying goals, roles and authorities over an upgrading process. Hidden agendas may exist (Gruis et al., 2011). Housing associations and public institutions that finance such projects will try to limit upgrading to the minimum mandated requirements. Contractors assess upgradings as risk projects due to unknown factors of existing constructions and individual desires of end-users. All agents should be given a voice.

Although participatory processes are recommended and are part of many mandatory processes, agents with authority over the upgrading scope and costs will avoid user involvement in the planning process to prevent the raising of demands (Kæseler et al., 2019). Various aspirations may hamper the sharing of power, and specific stakeholders' interests may be concealed behind smokescreens (Gustavsson & Elander, 2016). However, recent research shows that in decision-making group settings, with homeowner and resident associations, individuals are more willing to adapt their personal preferences to reach a collective agreement. Proposals concerning comfort, cost, and disruptions are perceived as fair through well-organized participatory decision-making (Tiellemans et al., 2022).

However, willingness to compromise has limits. If group members perceive proposals disproportionately to favour certain outcomes at the expense of others, consensus breaks down. Thus, promoting upgrading strategies that offer balanced benefits, rather than high-gain, high-cost outcomes, increases the likelihood of shared acceptance. In this regard, a structured classification of upgrading measures not only supports technical sequencing, as emphasized by Buchholz and Lützkendorf (2023), but can also play a crucial role in stakeholder negotiation processes, enabling more transparent communication of trade-offs, fostering perceptions of fairness, and improving the likelihood of group consensus in participatory upgrading initiatives. Furthermore, tailoring interventions to specific clusters of households and building characteristics enhances this process by ensuring that proposed measures are relevant and acceptable to the unique needs and preferences of

diverse stakeholders, thereby facilitating more effective and equitable decision-making (Ebrahimigharehbaghi et al., 2022).

Users can be renters or owners in SH developments with different socioeconomic and cultural levels. Tenants are usually the weakest stakeholders in an upgrading process to voice their desires and anxieties. They may fear the gentrification of housing projects with raised rents. They may also have concerns about the construction process including the loss of privacy, security, and the inconveniences of dust, noise and temporary removal to other quarters. Collaborative practices are essential, and intervention actions should be understood by all agents of an upgrading process with communication barriers broken to mitigate mistrust (van Geenhuizen, 2018).

Research procedures

To contribute knowledge on the type of improvements necessary for the existing SH stock in both developed and developing countries, we analyzed the literature on upgrading actions. We followed a structured process for a literature review. Actions were identified and classified according to the improvements they addressed. They were then classified according to the complexity of interventions and their priority through a frequency ranking of improvements. The research procedure is shown in Figure 1.

Systematic literature review

A systematic literature review (SLR) was developed through a protocolled process (Kitchenham et al., 2011). Databases used were Scopus, Web of Science, Science Direct, and SciELO to identify studies on upgrading. SciELO is a key open-access database for academic journals from Latin America, Portugal, Spain, and South Africa, widely used for disseminating research in Portuguese and Spanish, with some content also available in English. The SciELO database was included to broaden the review.

Table 1. Procedure for literature analysis.

Words variations		
Upgrading	Social housing	
Refurbishment	Mass housing	
Improve	Affordable housing	
Intervention	Low-income housing	
Renewal, renovation	Public housing	
Retrofit	Substandard housing	
Rehabilitation		
Strings		Database
String 1: (Upgrad* OR Refurb* OR Improv* OR Intervent* OR Renovat* OR Renewal* OR Retrofit OR Rehabilit*) AND ("Social hous*" OR "Mass hous*" OR "Affordable hous*" OR "Low income hous*" OR "Public hous*" OR "Substandard hous*")		Scopus Web of science
String 2: (Upgrading OR Refurbishment OR Improvement OR Intervention OR Renovation OR Renewal OR Retrofit OR Rehabilitation) AND ("Social housing" OR "Mass housing" OR "Affordable housing" OR "Low-income housing" OR "Public housing" OR "Substandard housing")		Scielo
String 3: (Refurbishment OR Improvement OR Renovation OR Renewal OR Retrofit) AND ("Social housing" OR "Low-income housing")		Science direct
Exclusion and inclusion criteria		
Papers that cover physical design configuration layout attributes design functionality and new ways of living		Inclusion
Papers that cover built environment, surroundings, unit, outdoor, indoor, and neighbourhood		
Not SH papers and not cover upgrading issues		Exclusion

Source: The Authors.

The combination of different terms was applied to compose strings with Boolean parameters, as shown in Table 1. Snowballing was applied as a process to identify new studies from the initial sample (Kitchenham et al., 2011). Through snowballing, grey literature was included to capture previous studies not published in the primary database.

The screening process excluded papers that were not open-access or did not meet the inclusion criteria of Table 1. Studies that addressed housing in general but were not clearly related to specific interventions, or that dealt with similar contexts without a direct connection to SH, were excluded. Papers that did not explicitly address upgrading issues were removed. In contrast, studies presenting intervention actions related to SH improvements were included in the main sample.

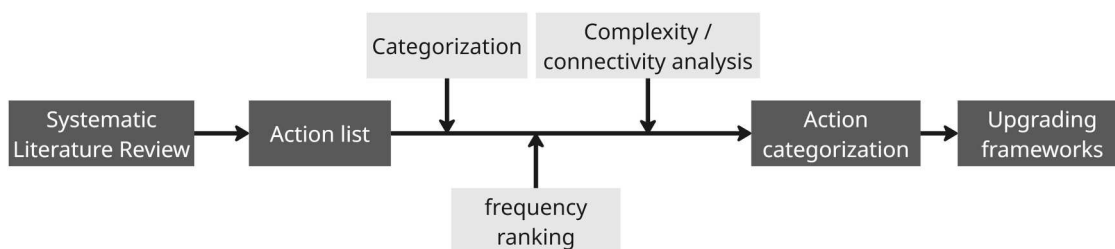


Figure 1. Research procedure.

Source: the Authors.

Seventy-six (76) studies make up our research, referenced in the Appendix. Thus, the studies, published between 2008 and 2024, were identified through academic databases and snowballing techniques, to include seminal and grey literature.

Categorization of intervention actions

An assessment of the literature was conducted to categorize the actions. Previous studies presented categories of actions for housing improvement, although no protocol for interventions was identified. Martin-Goñi et al. (2024) categorize interventions according to various issues and building parts, while Curl et al. (2015) divide internal and external actions. Villa et al. (2017) distinguish according to urban questions and residential unit issues, while Xu and Juan (2021) concentrate on issues relating to the COVID-19 pandemic mitigation questions. Our study identified eight (8) topic categories and 38 (thirty-eight) associated subcategories. Major action topics were identified in each study, grouped, and coded into the proposed categories. The connectivity of actions was analyzed through associated intervention types.

Ranking approach

Upgrading actions collected were analyzed. An indicator-based ranking approach was applied to analyze the frequency of data occurrence in our sample, measured by the cumulative number of studies that cite actions (Sutherland et al., 2016; Torraco, 2016). Thus, ranking was established varying from 1 (one) to 69 (sixty-nine).

Complexity assessment

Action complexity was discussed and assessed by the authors according to four underlying subscales comprising: scope, investment level, technical expertise requirement, and coordination effort, as shown in Table 2. The initial assignment of complexity scores was preceded by a calibration round involving all members of the research team. During this phase, we jointly assessed a subset of cases to discuss and align interpretations of the scoring criteria for each sub-scale. This collaborative step allowed us to refine the definitions and thresholds for each level of complexity, thereby enhancing inter-rater reliability. To maintain internal consistency, any discrepancies observed in individual assessments during the primary analysis were resolved through a collective discussion, ensuring that final scores reflected a shared understanding of scores.

Table 2. Complexity assessment framework for actions.

Scope	Score
Low Complexity: Affects a single or very few categories	1
Moderate Complexity: Impacts multiple categories but does not deeply alter them.	2
High Complexity: Addresses multiple interconnected categories	3
Investment level	
	Score
Low Complexity: Minimal investment; no major financial resources required.	1
Moderate Complexity: Moderate investment; requires more financial commitment but remains feasible within existing resources.	2
High Complexity: High investment; requires substantial financial commitment.	3
Technical expertise	
	Score
Low Complexity: Low expertise needed; can often be implemented without specialized knowledge.	1
Moderate Complexity: Moderate expertise needed; may require skilled labour or coordination between different professionals.	2
High Complexity: Advanced expertise required; involves feasibility studies, engineering solutions, and expert knowledge.	3
Coordination effort	
	Score
Low Complexity: Minimal coordination; can often be done individually or with little planning.	1
Moderate Complexity: Increased coordination; requires planning and collaboration between different actors.	2
High Complexity: High coordination effort; balancing competing interests and integrating diverse stakeholder inputs.	3

Source: The Authors.

Each subscale has three levels of complexity (Low = 1, Moderate = 2, High = 3). To determine the overall complexity score of an action, subscale scores were added to gain a total score according to the ranges:

- Low complexity: scores between 4 and 6.7
- Moderate complexity: scores 6.7 and 9.3
- High complexity: scores between 9.3 and 12.

Equal weighting of the sub-scales was based on the assumption that each dimension contributes in a balanced way to the overall complexity of an intervention. However, in specific contexts, such as large-scale infrastructure or technology-intensive projects, specific sub-scales, such as financial investment or required expertise, may have a disproportionate impact. While the equal weighting approach was appropriate for the exploratory and comparative analysis conducted in this study, extrapolating this analysis to specific contexts should be supported by testing of alternative weighting schemes

Findings and discussion

Findings present the results and discussion of the SLR, the classification of actions identified in the literature review with ranking and complexity scores, as well as their connectivity to other actions. Upgrading impacts

and their analysis are outlined, and to aid decision-making for upgrading processes, frameworks are presented. Processes for mandatory and non-mandatory upgrades are distinguished.

SLR analysis and classification of actions

After defining strings and applying these in the databases, one thousand and forty-seven (1047) articles were identified (Table 3). The screening process, as outlined in the research procedure, removed papers that were not open-access and also those that did not cover the inclusion criteria, according to Table 1. Papers that fail to address upgrading issues directly were removed, while papers that cover housing configurations and conditions of the built environment were added. A snowballing technique, to identify studies not found in the databases directly through keyword combinations of the initial sample, identified a further thirteen (13) studies.

To emphasize common patterns and broader tendencies across the sample, all studies were reviewed and synthesized in terms of their topics, approaches, methodologies, and specific contributions, which are presented in Table 4. Details of this table, including methods and results of each study, are presented in the appendix. References are numerically ordered.

Table 4 shows that the majority of the studies in the sample were conducted in Europe, accounting for 46% of the sample. These publications emphasize comfort and energy issues. South America represents 30%, which can be attributed in part to the use of the SciELO database for article collection. Asia accounts for 9%, while Australia, North America, and global studies each comprise 4% of the sample. These studies demonstrated a diversity of issues, but also showed that comfort and energy are more expressive. The intervention topics and their corresponding upgrading actions were assigned specific codes as shown in Tables 5 and 6.

Table 6 presents the codes and descriptions of 77 different actions, along with the research that supports

these. Actions were ranked according to the number of citing studies (frequency) to indicate priorities. To support decision-making in an upgrading process, each action gained a complexity score. The actions are also categorized according to mandatory or non-mandatory upgrading processes, building typology and specifics of SH projects (type of occupation, tenure and management).

The ranked actions demonstrate that the HC category (Housing quality & comfort), which represents 42% of the most cited actions, is essential for environmental comfort, emphasizing thermal comfort, which impacts climate change. Comfort emerges as the most frequently cited aspect, with a strong correlation with energy efficiency. This finding also reflects the predominance of studies on SH conducted in Europe, where energy efficiency is a central focus of the mandate, as illustrated in Table 4.

Shading elements, envelope insulation, green walls, and window glazing changes are predominant actions. The twelve most reported actions are: MS5, HC17, HC13, HC18, HC7, FDA8, HSW4, US4, HC6, GOS8, HSW1, HSW7, followed by WWM, HSW, GOS, ERE, FDA, and BSI in sequence. The complexity distribution of upgrading actions is illustrated in Figure 2.

Although some actions are presented as low and moderately complex, such as HC1 (mould and damp), HC2 (toxic material), HC16 (reflective light), GOS4 (landscaping areas), ERE9 (user behaviour), HSW4 (dwellers interaction), HSW12 (community activities), MS1 (police station), WWM3 (urban garbage), MS4 (training programs), GOS1 (socializing spaces)1, GOS6 (private garden), GOS9 (maintenance), most actions fall into more complex ratings. Complex actions are only feasible in non-mandatory programs according to the availability of resources, both financial and technical.

Care must be taken to assess all actions concerning toxic material removal to avoid health risks. Also, actions that affect the wider community should be evaluated and coordinated with permission from public authorities. Upgrading processes require building permits and approvals from various authorities, which involve resolving legal issues and add time to the planning and execution of essential SH upgrades. Various legal obligations demonstrate the administrative complexities of upgrading processes, while specific interventions involve technical complexities.

Most actions apply to both mandatory and non-mandatory processes and can be adapted to different housing typologies and contextual specificities. However, their level of complexity, defined by factors such as scope, required investment, technical capacity, and

Table 3. Sample analysis.

Database	First sample	Sample analysis – open access
Scielo	2	2
Scopus	123	33
Web of Science	127	45
Science Direct	795	108
Sample 1	1047	188
Removed (exclusion criteria)	–	138
Sample 2		63
Snowballing	+	13
Final sample		76

Source: The Authors.

Table 4. Study topics and geographical distribution of the sample.

Code	Study topic	Country
26	Cities, energy, climate, and competitiveness	Europe
31	Energy and functional rehab of European housing	Europe
39	Key barriers to energy-efficient retrofits in public housing	Europe
63	Energy retrofit analysis	Czech Republic
66	Energy-efficient renovation	Greece
5	Feasibility of retrofitting interventions	Italy
54	Post-renovation energy use is shaped by behaviour, rebound effects, and cultural patterns	Ireland
9	Strategies for sustainable interventions.	Italy
17	Enhanced insulation and (solar thermal and PV) improve energy savings and indoor comfort	Italy
48	Acoustic aspects in retrofitting	Italy
49	Occupant behaviour impacts on comfort and air quality in retrofitted social housing	Italy
14	Eco-cost assessment in housing renovation strategies	Netherlands
29	Human behaviour–built environment interaction in facility management	Netherlands
40	Commuting, neighborhood, and housing satisfaction linked to wellbeing and liveability	Netherlands
69	Relationship between housing problems, energy affordability, and health	Netherlands
72	User requirements in affordable social housing design	Netherlands
46	Spatial structure and changes in residential neighbourhoods	Poland
61	Energy-efficient in social housing retrofits	Portugal
2	Acoustic, sound insulation via window retrofit	Spain
15	Life cycle assessment of energy energy and cost performance of cool roof retrofits	Spain
34	Eco-Efficiency analysis of social housing renovation proposals	Spain
65	Acoustic retrofit strategies for reducing environmental noise in residential buildings	Spain
37	Private outdoor spaces significantly enhance housing quality	Serbia, England, Ireland
22	Participation & place identity	Sweden
64	Participation in renovation	Sweden
6	Energy costs link cold, damp housing to health	UK
10	Analysis of indoor environments and thermal comfort	UK
16	Passivhaus criteria choice and design resilience	UK
33	IAQ in Passivhaus homes	UK
52	UK social housing upgrades impact on residents' wellbeing beyond energy and housing quality	UK
7	Integrated study of energy-saving behaviours and factors	England
74	Building energy use before and after energy efficiency retrofits	England
11	Barriers to information access for disadvantaged youth	Scotland, UK
12	Health post-housing improvements	Scotland, UK
60	Passive solar energy and occupant behaviour	Scotland, UK
25	Urban renewal's impact on health in disadvantaged communities	Australia
36	Integrating community gardens into parks and enhancement of urban ecosystem services	Australia
75	Inclusive housing for disabilities, focusing on environmental and social needs	Australia
50	Design affects health and quality of life, especially during COVID-19	USA, Canada
68	Perception of IEQ, include visual comfort	Canada
24	Health & residential environment	USA
3	Organization of user requirements in the conceptual phase.	Brazil
4	CO ₂ reduction of solar water heating	Brazil
8	Social housing and urban sustainability	Brazil
13	Social housing adaptation to Passive House via thermal envelope	Brazil
18	Sustainable social housing by state	Brazil
19	Implementation of solar water heaters	Brazil
20	Small solar water heaters in low-income housing projects	Brazil
21	Innovative precast construction	Brazil
30	Urban heat islands reduce thermal comfort in low-income housing	Brazil
32	Low-tech, low-cost retrofits improve quality	Brazil
35	Affordable Architectural Upgrade for Quality and Energy-Efficient Social Housing	Brazil
42	Cost-effectiveness and energy savings of Solar Water Heating systems in low-income households	Brazil
43	Flexible, sustainable use of minimum housing	Brazil
44	Thermal comfort in buildings meeting minimum standards across climates.	Brazil
51	Slum upgrading via participatory budgeting, comparing self-help and public housing	Brazil
56	EPS lightweight concrete for optimal strength and sound insulation in lab and real buildings	Brazil
67	Cost-effective envelope strategies to boost comfort and energy efficiency	Brazil
70	Resilience study of adaptive ability to recover and regenerate from natural, social, or physical impacts	Brazil
71	Design to adapt to residents' changing needs.	Brazil
73	Participatory budgeting for upgrading decisions	Brazil
1	Enhanced Trombe Wall thermal efficiency with vertical water storage.	Chile
53	Energy-efficient social housing offers strong returns and lower energy costs	Mexico
55	Status of social housing (energy aspects)	Mexico
38	Housing policy and land politics drive urban change	Southeast Asia & Latin America
76	Analyze of SH refurbishment	China
57	Optimizing interior layout for IEQ	India
58	Optimized ventilation and furniture design	India
62	Natural ventilation	Indonesia
23	Environmental impacts on children's activity in low-cost housing	Malaysia
27	IEQ satisfaction in re-engineered housing	Malaysia

(Continued)

Table 4. Continued.

Code	Study topic	Country
45	Youth facility design and accessibility in Malaysian low-cost housing to meet young residents' needs	Malaysia
59	Design elements of secure residential areas	Malaysia
28	Community engagement in open source projects	Global
41	Water-Energy-Food nexus to assess resource interconnections and future management challenges.	Global
47	Risks in energy-efficient renovation	Global

Source: The Authors.

coordination efforts, serves as a key determinant in assessing their feasibility within mandatory processes. This feasibility is contingent upon the specific characteristics and constraints of the context in which they are implemented.

Special attention should be given for actions classified as most complex, such as: HC18 (built façade

appearance), HSW8 (extend building up and out), GOS8 (add spaces), HC9 (trombe walls), HC13 (envelops), ERE1 (exchange electrical installations), ERE9 (exchange hydraulic installations), ERE8 (improvement of façades), BSI4 (new water infrastructure), BSI5 (new energy infrastructure), HSW11 (increase in surface area), HSW3 (personalization), FSA4 (elevators and

Table 5. Housing improvement factor categories and subcategories with identification codes.

Category	Description	Category code	Subcategory	Subcategory code
Housing quality & Comfort	The studies (27, 43, 44, 68) highlights how improving ventilation, space, and materials enhances thermal, acoustic, and visual comfort in housing.	HC	Indoor air quality	HC-IA
			Thermal comfort	HC-TC
			Acoustic comfort	HC-AC
			Lighting comfort	HC-LC
Energy and Resource Efficiency	The studies (15, 21, 63) covers life cycle assessments, retrofit impacts, and energy-saving behaviours, examining carbon footprints, material trade-offs, and how user awareness affects health and performance.	ERE	Consumption Efficiency	ERE-CR
			Innovative solutions,	ERE-IS
			Clean energy	ERE-SE
Building Systems and Infrastructure	The studies (11, 28, 34, 52, 71) present the necessity of IT needs, as well as housing infrastructure improvements which also may affect wellbeing. Also efficient infrastructure is considered.	BSI	Sustainable energy supply	ERE-SE
			Structural elements	BSI-SE
			Installations (electrical & hydraulic)	BSI-IT
			Fire control	BSI-FC
			Heaters installation	BSI-HI
			Communication system	BSI-CS
			IT systems	BSI-ITS
			Control and security systems	BSI-CSS
Health, Psychological and Social wellbeing	The studies (6, 7, 50, 52) explore how housing quality directly and indirectly affects physical and mental health. Issues like poor insulation, dampness, overcrowding, and environmental stressors are linked to negative health outcomes, while improved living conditions contribute to better wellbeing and foster social interaction.	HSW	Privacy	HSW-PV
			Territoriality	HSW-TT
			Psychological security	HSW-PY
			Personal space	HSW-PS
			Status	HSW-ST
			Crowding	HSW-CD
			Social needs	HSW-SN
			Social cohesion	HSW-SC
			Health	HSW-HL
			Functional needs	FDA-FN
Functional Design and Accessibility	Studies (43, 57, 58) focus on home and neighborhood layouts, showing that optimized, flexible, and ergonomic designs enhance usability, privacy, and adaptability.	FDA	Layout organization	FDA-LY
			Ergonomics	FDA-EG
			Accessibility	FDA-AS
			Aesthetics	FDA-AT
Green and Open Spaces	The studies (22, 23, 24, 25, 26) highlight the importance of enhancing visibility and access to leisure areas, incorporating private gardens, and improving landscaping to support wellbeing.	GOS	Open areas	GOS-OA
			Leisure spaces	GOS-LS
			Green areas	GOS-GA
			Parks and squares	GOS-PS
Mobility and Services	The studies (3, 38) highlight how housing policies impact systemic inequalities, stressing the need for equitable approaches to ensure affordability, access, and service quality in marginalized areas.	MS	Paths and car parking	MS-PC
			Mobility and transportation services	MS-MTS
			Security services	MS-SS
			Community facilities	MS-CF
Waste and Water Management	The studies (70, 71, 76) emphasize waste collection, recycling systems, sewage connections, and land revitalization to enhance living conditions and empower communities.	WWM	Solid Waste treatment	WWM-ST
			Wastewater treatment	WWM-WT

Source: The Authors.

Table 6. Actions, supporting research, ranking and complexity analysis.

Subcategory associated	Code	Action	MA/NM SF/MF TE/MN	Supporting research	Rank	Complexity according to Table 2			Total score of each action	Rating
						SC	INV	TER		
MS-CF MS-MTS HSW-SN FDA-AS	M55	Provide public and private services	MA/NM SF/MF TE/MN	5; 8; 11; 18; 21; 22; 23; 24; 27; 29; 34; 35; 36; 38; 40; 45; 46; 61; 70; 71; 72; 73; 75; 76	1	1	3	3	28	H
HC-LC HC-TC	HC17	Adjust or add shading elements/devices for window shading according to specific sun orientations. Introduce window black-outs for bedrooms	NM SF/MF TE/MN	1; 2; 4; 9; 13; 15; 16; 30; 33; 34; 39; 44; 47; 50; 52; 54; 57; 63; 64; 66; 67; 68	2	1	2	2	10	H
HC-TC	HC13	Replace the building envelope	NM SF/MF TE/MN	2; 5; 9; 13; 27; 30; 34; 39; 44; 58; 63; 66; 67; 68	3	1	3	3	28	H
HC-TC FDA-AT HSW-ST GOS-GA	HC18	Improve building facade appearance. Introduce new design concepts such as eco places and green walls	NM SF/MF TE/MN	1; 2; 9; 16; 27; 34; 35; 39; 48; 63; 65; 67; 68; 69	3	2	3	3	31	H
ERE-IS HC-TC HC-AC	HC7	Introduce porous insulation materials (polystyrene, biomass) in ceiling, envelope, floor, and walls	NM SF/MF TE/MN	9; 13; 19; 21; 30; 34; 39; 48; 49; 53; 56; 63	5	1	3	3	23	H
HSW-PS HSW-ST FDA-LY FDA-EG	FDA8	Improve layout, consider furniture	NM SF/MF TE/MN	10; 23; 35; 37; 38; 43; 49; 52; 56; 58; 71; 72	5	2	2	3	21	H
HSW-HL HSW-SN HSW-SC HSW-ST FDA-FN	HSW4	Promote interaction between housing dwellers through interactive external areas	NM SF/MF TE/MN	11; 23; 29; 36; 38; 40; 45; 47; 49; 60; 71; 76	5	1	1	1	4	L
HSW-HL WWM-ST WWM-WT	WWM3	Provide urban garbage collection, and recyclable systems. Provide adequate trash services and equipment. Connect with existing community recycling networks	MA/NM SF/MF TE/MN	17; 22; 24; 34; 39; 50; 51; 62; 63; 70; 71; 76	5	1	1	1	4	L
HC-AC HC-TC	HC6	Replace windows and doors (double glazing and sealing elements)	MA/NM SF/MF TE/MN	2; 13; 14; 33; 34; 39; 63; 65; 66; 67; 68	9	1	3	2	18	H
FDA-FN GOS-OA	GOS11	Add verandas, balconies or terraces	MA/NM SF/MF TE/MN	5; 9; 10; 12; 34; 35; 37; 43; 50; 62; 76	9	2	3	3	31	H
HSW-PV HSW-TT HSW-PS HSW-ST HSW-PY FDA-AS	HSW1	Introduce visual barriers: blinds, curtains, vegetation and brise soleil	MA/NM SF/MF TE/MN	3; 7; 10; 33; 34; 50; 59; 69; 70; 75	11	2	2	2	16	H
HSW-PS HSW-CD FDA-FN	HSW7	Increase room sizes	MA/NM SF/MF TE/MN	18; 31; 35; 43; 50; 58; 62; 72; 74; 76	11	1	2	2	13	H

(Continued)



Table 6. Continued.

Subcategory associated	Code	Action	MA/MM SF/MF TE/MN	Supporting research	Rank	Complexity according to Table 2				Total score of each action	Rating
						SC	INV	TER	CE		
HSW-HL HC-IA	HC1	Eliminate mould spots, damp stains, water damage, and odour	MA/MM SF/MF TE/MN	6; 7; 29; 47; 52; 54; 60; 61; 63	13	1	1	1	1	4	L
ERE-IS ERE-CR	ERE9	Exchange hydraulic installations: replace electrical showers, replace fixtures and faucets	MA/MM SF/MF TE/MN	4; 14; 19; 22; 34; 52; 53; 71; 76	13	1	3	3	3	28	H
HSW-CD FDA-FN	FDA1	Add an optional toilet or bathroom in unit, with decentralized water seal design for wet and dry areas	MA/MM SF TE/MN	12; 25; 43; 44; 50; 52; 69; 75; 76	13	1	2	2	2	13	H
FDA-FN FDA-AS GOS-OA GOS-OA FDA-FN	GOS5	Create secure physical access for wheelchairs or prams, and introduce accessible paths, ramps, and handrails	MA/MM SF/MF TE/MN	10; 23; 36; 37; 43; 45; 71; 72; 75	13	2	2	2	2	16	H
GOS-LS GOS-PS	GOS6	Add private garden spaces	MA/MM SF/MF TE/MN	10; 22; 29; 36; 37; 40; 70; 75; 76	13	1	1	1	1	4	L
MS-MTS GOS-PS FDA-AS HSW-SN HC-TC	GOS7	Improve landscaping of outdoor areas and community gardens.	MA/MM SF/MF TE/MN	10; 22; 25; 29; 36; 37; 46; 70; 75	13	1	2	2	1	10	H
HC-TC	MS9	Provide pathways, and bike lanes, with guardrails and security signalization. Promote urban design of street layout for pedestrian mobility	MA/MM SF/MF TE/MN	6; 10; 16; 25; 26; 37; 40; 52; 59	13	1	3	3	3	28	H
ERE-SE ERE-CR	HC8	Add thermal wall mass	MA/MM SF/MF TE/MN	17; 30; 32; 53; 55; 60; 65; 67	20	1	3	3	2	23	H
FDA-EG FDA-FN FDA-AT GOS-OA FDA-FN	HC15	Introduce sealing systems (aluminium frames & polycarbonate honeycomb panels) as thermal curtains	MA/MM SF/MF TE/MN	7; 9; 17; 35; 43; 63; 66; 67	20	1	3	2	2	18	H
HC-LC HC-IA HC-TC HC-AC BSI-HI ERE-CR ERE-SE	ERE1	Replace electrical installations	MA/MM SF/MF TE/MN	9; 13; 14; 19; 34; 41; 42; 43	20	1	3	3	3	28	H
	FDA2	Redesign the external open/public area geometry	MA/MM SF TE/MN	10; 22; 25; 30; 37; 59; 75; 76	20	1	2	2	2	13	H
	FDA7	Provide sliding doors, folding partitions, adaptable or folding partitions	MA/MM SF/MF TE/MN	9; 34; 50; 65; 71; 72; 75; 76	20	1	2	2	2	13	H
	HC4	Change the position of openings	MA/MM SF/MF TE/MN	13; 50; 57; 58; 62; 66; 68	25	1	2	2	2	13	H
	BSI4	Install new water infrastructure, and new heating systems	MA/MM SF/MF TE/MN	15; 19; 20; 42; 49; 52; 71	25	1	3	3	3	28	H

(Continued)

Table 6. Continued.

Subcategory associated	Code	Action	MA/NM SF/MF TE/MN	Supporting research	Rank	Complexity according to Table 2			Total score of each action	Rating
						SC	INV	TER		
ERE-CR ERE-SE	ERE6	Install Photovoltaic Panels (PSS)	MA/NM SF/MF TE/MN	9; 17; 39; 51; 63; 66	27	1	3	2	23	H
HSW-TT HSW-PS HSW-ST FDA-AT	HSW2	Improve internal finishings	MA/VO SF/MF TE/MN	14; 34; 35; 52; 65; 69	27	2	2	1	13	H
HSW-ST HSW-PS FDA-EG FDA-AT	HSW3	Individualize the appearance of buildings	MA/NM SF TE/MN	10; 12; 20; 50; 71; 72	27	2	3	2	26	H
GOS-OA HSW-SN	GOS9	Keep buildings, open areas and paths well maintained	MA/NM SF/MF TE/MN	23; 24; 25; 37; 43; 64	27	1	1	1	4	L
MS-CF HSW-SN	MS4	Offer training programmes and knowledge exchanges, such as promoting local and regional production and consumption	MA/NM SF/MF TE/MN	11; 25; 33; 39; 41; 66	27	1	1	1	4	L
MS-SS MS-CF	MS6	Introduce security services in the neighbourhood	MA/NM SF/MF TE/MN	23; 37; 46; 59; 61; 71	27	1	1	1	4	L
ERE-SE ERE-CR BSI-HI	ERE5	Install solar water heaters	MA/NM SF/MF TE/MN	4; 19; 20; 42; 66	33	1	2	2	13	H
BSI-SE	BSI3	Improve ventilation under ground floor spaces	MA/NM SF TE/MN	13; 32; 33; 39; 57	33	1	3	2	23	H
HSW-PV HSW-PS HSW-CD FDA-FN FDA-LY	HSW6	Add a neutral space for multi-use purposes	MA/NM SF/MF TE/MN	10; 14; 50; 72; 76	33	2	2	2	16	H
HSW-PS HSW-TT HSW-ST FDA-AT FDA-FN	HSW8	Extend buildings upwards or outwards for design balance, and symmetry	MA/NM SF/MF TE/MN	14; 31; 37; 46; 64	33	2	3	3	31	H
GOS-LS HSW-SN HSW-PY	GOS2	Make leisure/recreation spaces (private or common) visible from residential units	MA/NM SF/MF TE/MN	23; 24; 37; 38; 45	33	2	2	2	16	H
HSW-HL WWM-ST WWM-WT	WWM2	Connect housing to sewage treatment plants	MA SF/MF TE/MN	22; 34; 71; 73; 76	33	1	3	3	28	H
MS-CF HSW-SN	MS7	Improve/provide local schools; with adequate space per student; infrastructure; environmental comfort conditions; quality teaching staff and school meals	MA SF/MF TE/MN	11; 46; 72; 74; 76	33	1	3	3	28	H

(Continued)

Table 6. Continued.

Subcategory associated	Code	Action	MA/NM SF/MF TE/MN	Supporting research	Rank	Complexity according to Table 2				Total score of each action	Rating
						SC	INV	TER	CE		
HC-LC HC-IA HC-TC HC-LC HC-TC	HCS	Add windows	MA/NM SF/MF TE/MN	48; 50; 52; 67	40	1	2	2	2	13	H
BSI-SE BSI-IT	HC16	Introduce reflective light coloured internal and external surfaces (walls and ceiling)	MA/NM SF/MF TE/MN	32; 60; 69; 72	40	1	1	1	1	4	L
BSI-IT	BSI1	Promote housing maintenance (general repairs)	NM SF/MF TE/MN	23; 32; 34; 72	40	1	3	2	2	18	H
BSI-IT ERE-SE ERE-IS ERE-CR	BSI5	Provide a new installation for efficient energy infrastructure	MA/NM SF/MF TE/MN	34; 42; 52; 71	40	1	3	3	3	28	H
FDA-AS HSW-HL	FDA4	Install elevators/ more then one, in multi-storey buildings, considering the right size for better accessibility	MA/NM SF/MF TE/MN	14; 29; 50; 76	40	1	3	3	3	28	H
GOS-LS GOS-PS HSW-PY	GOS3	Provide safe playground equipment	MA SF/MF TE/MN	23; 37; 40; 76	40	2	2	2	2	16	H
MS-PC FDA-FN	MS2	Provide individual or common car parking spaces in outdoor spaces	MA/NM SF/MF TE/MN	22; 45; 72; 75	40	1	2	2	2	13	H
HC-LC HC-TC HC-IA HC-AC	HC12	Introduce ventilated roofs, solar and roof chimneys	MA/NM SF/MF TE/MN	15; 32; 50	47	1	2	3	2	18	H
HC-LC ERE-CR GOS-OA GOS-OA GOS-GA	HC14	Install sound proof windows	MA/NM SF/MF TE/MN	50; 70; 71	47	1	2	2	1	10	H
ERE-IS ERE-CR	ERE2	Install sensors for lighting in public areas, and in hallways, stairs, and lobbies	MA/NM SF/MF TE/MN	19; 34; 76	47	3	1	1	1	12	H
ERE-IS ERE-CR	GOS4	Improve landscaping of open areas: afforestation, trees, bushes and flowerbeds	MA/NM SF/MF TE/MN	25; 70; 75	47	1	1	1	1	4	L
ERE-IS ERE-CR	ERE3	Install water reuse systems: introduce rainwater harvesting systems	MA/NM SF/MF TE/MN	17; 32; 35	47	1	2	2	2	13	H
BSI-FC	BSI2	Provide safety equipment (fire control, safety instructions, risk zone control)	MA/NM SF/MF TE/MN	23; 52; 60	47	1	2	2	2	13	H
BSI-CSS BSI-CS BSI-ITS	BSI7	Improve IT infrastructure. Improve access to internet systems. Provide assistance to IT literacy skills and technological knowhow	NM SF/MF TE/MN	11; 24; 28	47	1	2	2	2	13	H
HSW-PV FDA-FN HSW-HL	HSW5	Add an on – suite bathroom to the master bedroom	NM SF TE/MN	50; 75; 76	47	2	2	2	2	16	H

(Continued)

Table 6. Continued.

Subcategory associated	Code	Action	MA/NM SF/MF TE/MN	Supporting research	Rank	Complexity according to Table 2				Total score of each action	Rating
						SC	INV	TER	CE		
HSW-ST HSW-TT HSW-PY FDA-FN FDA-AS FDA-AT FDA-EG FDA-FN HSW-CD GOS-PS	HSW9	Remove physical barriers in open areas (high walls, fences, solid gates, and landscape elements)	MA/NM SF/MF TE/MN	14; 59; 75	47	2	2	2	2	16	H
FDA3	FDA3	Add storage space in the kitchen and increase the kitchen area for daily tasks	MA/NM SF	58; 71; 76	47	1	2	2	2	13	H
GOS8	GOS8	Add urban furniture and parklets	MA/NM SF/MF TE/MN	25; 70; 75	47	1	3	2	2	18	H
HC-IA HSW-HL	HC2	Remove indoor toxic materials	MA/NM SF/MF TE/MN	29; 47	58	1	1	1	1	4	L
HC-AC	HC10	Provide floating floors (resilient material placed between two stiff plates: a structural slab and a subfloor)	MA/NM SF/MF TE/MN	39; 56	58	1	3	2	2	18	H
HC-TC	HC11	Introduce Cool Roofs (cold materials on the external surface of a roof), white coloured roofs	MA/NM SF	4; 15	58	1	3	3	2	23	H
ERE-CR	ERE4	Add individualized water, energy, and gas metering	MA/NM SF/MF TE/MN	22; 52	58	1	2	2	2	13	H
ERE-CR HC-TC	ERE8	Rehabilitate the façades, ETICS (External Thermal Insulation Composite System) and add ventilated cladding	MA/NM SF/MF TE/MN	14; 31	58	1	3	3	3	28	H
HSW-PV HSW-TT FDA-FN	HSW10	Provide well insulated day and night zoning (separate kitchen and living area from bedrooms and study areas)	MA/NM SF/MF TE/MN	75; 76	58	1	2	2	2	13	H
HSW-PV FDA-FN FDA-LY FDA-AS HSW-HL	HSW11	Increase surface areas, by incorporating a balcony, verandas, multifunctional spaces, with different attributes	MA/NM SF/MF TE/MN	14; 31	58	1	3	3	3	28	H
FDA-AS HSW-HL	FDA5	Provide a hand basin in bedrooms used by people which have long term illnesses or reduced mobility	MA/NM SF/MF TE/MN	75; 76	58	1	2	2	2	13	H
FDA-FN	FDA6	Provide outdoor living areas designed for prevailing weather conditions	MA/NM SF/MF TE/MN	50; 76	58	1	2	2	2	13	H
HSW-SN HSW-HL HSW-ST	HSW12	Promote community activities	MA/NM SF/MF TE/MN	25; 40	58	1	1	1	1	4	L
GOS-OA GOS-LS HSW-PS	GOS10	Introduce picnic and barbecue areas	MA/NM SF/MF TE/MN	25; 68	58	1	2	2	2	13	H

(Continued)

Table 6. Continued.

Subcategory associated	Code	Action	MA/NM SF/MF TE/MN	Supporting research	Rank	Complexity according to Table 2			Total score of each action	Rating	
						SC	INV	TER			
HC-LC HC-IA HC-TC HC-TC	HC3	Eliminate obstructions to openings	MA/NM 58 SF/MF TE/MN		69	1	2	1	1	7	M
	HC9	Introduce tromb walls with a vertical water storage system	MA/NM 1 SF/MF TE/MN		69	1	3	3	3	28	H
ERE-CR	ERE7	Improve user behaviour related to energy saving	MA/NM 26 SF/MF TE/MN		69	1	1	1	1	4	L
BSI-CSS BSI-CS	BSI6	Install security cameras. Create controlled housing entrances (video monitoring services: security guard, interphones)	MA/NM 59 SF/MF TE/MN		69	1	2	2	1	10	H
GOS-LS HSW-HL HSW-SC HSW-SN MS-SS	GOS1	Introduce semi-public outdoor and socializing spaces	MA/NM 50 SF/MF TE/MN		69	1	1	1	1	4	L
	MS1	Install police stations in neighbourhoods	MA/NM 22 SF/MF TE/MN		69	1	1	1	1	4	L
WWM-ST WWM-WT HSW-HL	WWM1	Revitalize local wastelands/empty spaces. Reduce environmental risks	MA/NM 71 SF/MF TE/MN		69	1	3	3	3	28	H
MS-MTS GOS-PS FDA-AS HSW-SN	MS3	Connect neighbourhood roads and paths with urban and commercial amenities	MA/NM 40 SF/MF TE/MN		69	1	2	2	3	18	H
MS-MTS GOS-PS FDA-AS	MS8	Reduce distances between street corners (shorten length of city blocks)	MA/NM 40 SF/MF TE/MN		69	1	3	3	3	28	H

Source: The Authors.

Legend: Scope complexity (SC), Investment (INV), Technical expertise required (TER), Coordination effort (CE), Complexity: Low – L, Moderate – M, High – H). **Actions categorization:** Renovation character (Mandatory-MA / Non-Mandatory-NM), building typology (Single Family-SF/Multifamily-MF), social housing specificities (Tenure-TE, Management-MN).

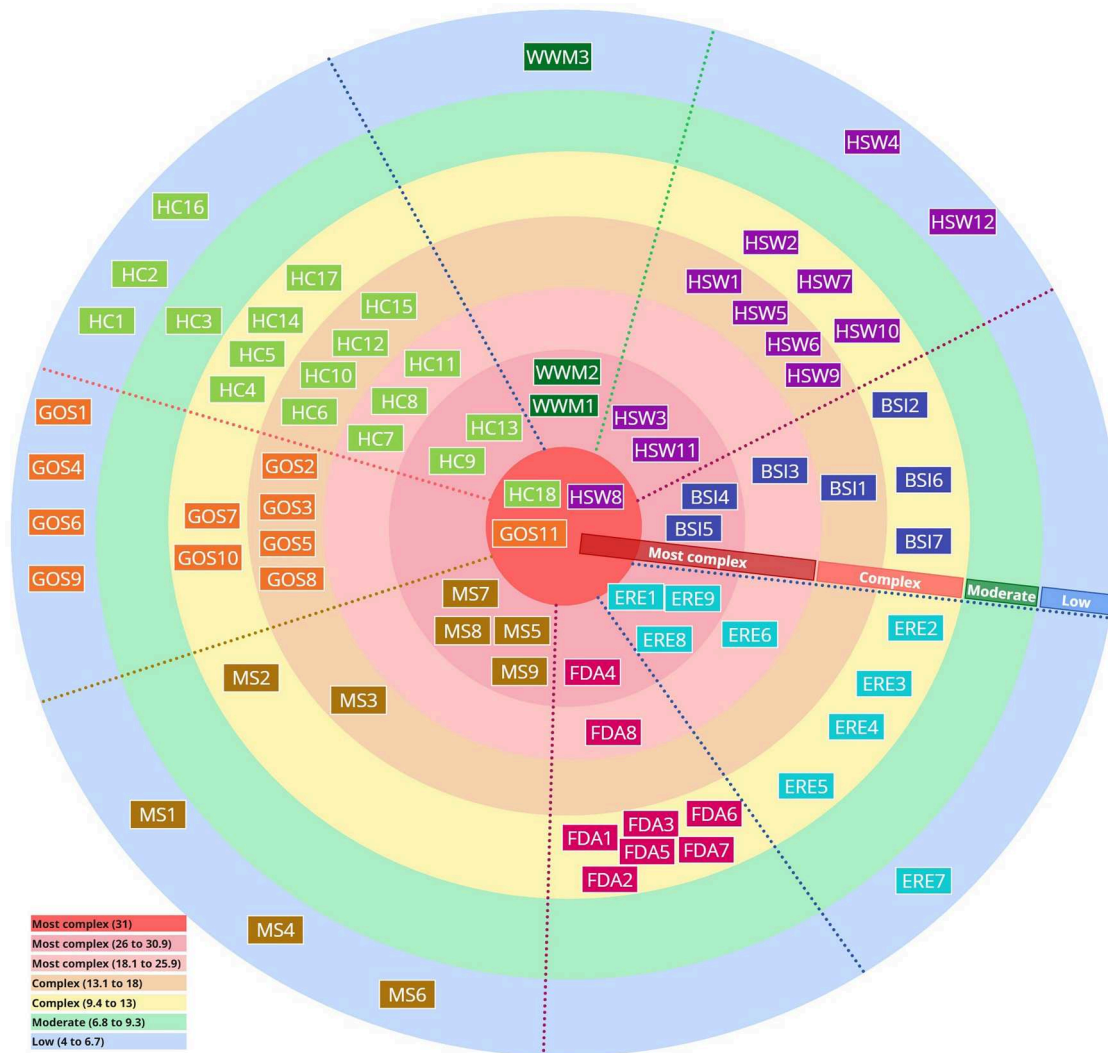


Figure 2. SH upgrading actions are organized according to complexity.

Source: The Authors.

accessibility), WWM1 (local revitalization), WWM2 (sewage treatment), MS5 (public and private services), MS7 (local education), MS8 (reduce distances), and MS9 (bike lanes and pathways). These actions need investments and agenda planning for implementation. Also, preparation should include special attention to communication between users, executing companies and authorities. Further evaluations are essential in upgrading processes. Financial resources, the context of an SH development, and the impact of actions or the benefits attained need to be analyzed.

Figure 3 depicts the relationships between various actions and associated subcategories. Arrows indicate the connections between actions and subcategory actions.

According to Figure 3, FDA (Functional Design and Accessibility) has the most connections, linking HC, HSW, GOS, MS, and ERE categories. Specific actions

span subcategories from other main categories of housing improvement factors, as shown in Table 7.

The overlaps illustrated in Table 7 suggest that specific interventions produce cross-cutting effects, simultaneously contributing to multiple dimensions of housing quality. The relationship between FDA and HSW (Health, Psychological and Social Well-being) is particularly prominent, as many actions within these categories are interconnected through shared benefits. Furthermore, FDA and HSW are also influenced by GOS (Green and Open Spaces). Similarly, connections can be observed among ERE (Energy and Resource Efficiency), BSI (Building Systems and Infrastructure), and HC. For example, the implementation of HC18 may not only enhance comfort but also contribute to improvements in aesthetics, perceived status, availability of green spaces, and innovation. Similarly, MS9, in addition to promoting mobility, may enhance

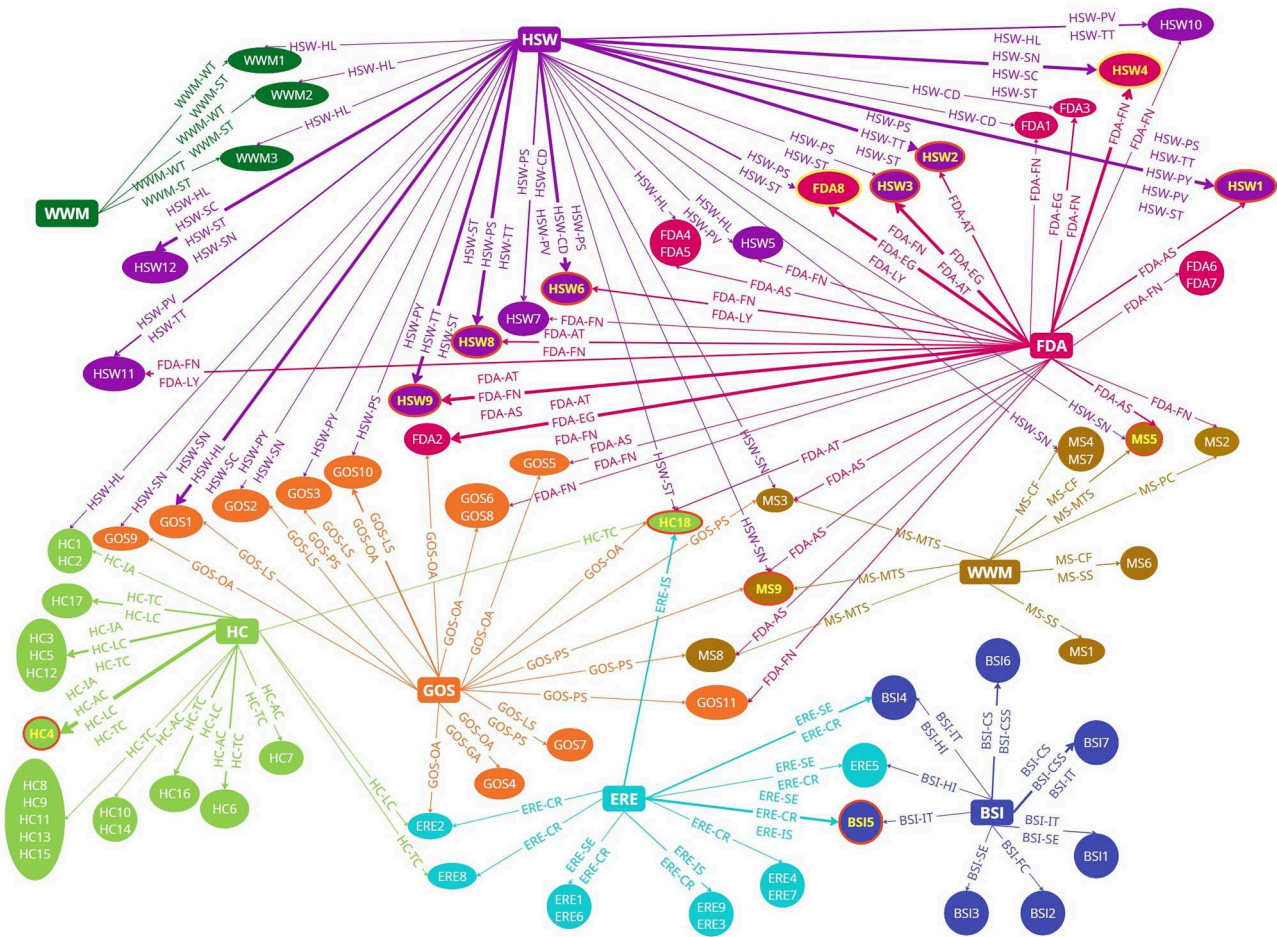


Figure 3. Action categories with connected subcategories.
Source: The Authors.

accessibility and address broader social needs. This condition is observed in 43 (forty-three) out of the 77 (seventy-seven) actions analyzed, which impact more than one category of housing improvement factors. Recognizing these interdependencies is essential for understanding the integrated nature of upgrading processes and for formulating more holistic and effective intervention strategies.

Upgrading impact analysis

Existing SH developments vary in size, urban location, building type and age as well as construction technology. A context analysis must assess these variables as well as the user types and their status as tenants, owners, landlords or other authorities as housing administrators. These evaluations will impact decision-making on actions and the responsibility of the various stakeholders in the upgrading process. To justify upgrading projects, benefits to all stakeholders should be assessed through an impact/effort matrix prior to execution and should be evaluated once upgrading is accomplished (Diana,

2023). Impact analysis should touch on social, environmental and economic benefits (Lizana et al., 2016).

Renovating buildings often faces several challenges that limit investments. One of the main issues is the high upfront cost of retrofitting, which usually leads to long payback periods (Monteiro et al., 2017). For SH, the situation is more difficult because projects depend on public funding, which is often limited. As a result, investments must clearly show benefits such as better health outcomes, improved energy efficiency, and overall cost savings (Soares et al., 2017).

Each stakeholder (users/owners, tenants, self-builders, landlords, housing authorities, associations, government agencies, councils, construction companies, construction workers, and the larger society) will have specific concerns and encounter various risks. Responsibilities and benefits will also differ for stakeholders. Impacts should be measured beyond monetary and tangible gains (Asinyaka, 2023).

Users are vulnerable stakeholders in upgrading processes. There are health and safety issues during project execution. Tenants may fear rent increases, and users, as

Table 7. Multi-category impact actions.

	Housing improvement factors	Action	Short description
HC; FDA; HSW; GOS; ERE	comfort; aesthetics, status, green areas, innovation	HC18	new design concepts
MS; GOS; FDA; HSW	mobility, park, accessibility and social needs	MS9 MS3	pathways, and bike lanes connect neighbourhood with urban amenities
MS; HSW; FDA ERE; GOS; HC MS; GOS; FDA HSW; FDA	mobility, facilities, needs and accessibility consumption, open areas, lighting mobility, park, accessibility health, needs, cohesion, status, functional territoriality, spaces, status, aesthetic status, spaces, ergonomics and aesthetics privacy, space, crowding, needs, and layout space, territoriality, status, aesthetic and needs privacy, territoriality, space, status, Psychological security, accessibility privacy, functional needs, health status, territoriality, psychological security, functional needs, accessibility, aesthetic privacy, territoriality and functional needs privacy, territoriality, functional needs and layout spaces, crowding, needs	MS5 ERE2 MS8 HSW4 HSW2 HSW3 HSW6 HSW8 HSW1 HSW5 HSW9 HSW10 HSW11 HSW7	public and private services light sensors reduce distances between street corners interaction of dwellers internal finishing appearance of buildings neutral space extend buildings upwards visual barriers suite bathroom remove physical barriers in open areas insulated day and night zoning increase surface areas room sizes
FDA; HSW	accessibility and health	FDA4 FDA5	install elevators hand basin in bedrooms for long term illnesses
FDA; GOS GOS; HSW	ergonomics, functional needs, and crowding ergonomic, needs, spaces, status crowding and functional needs ergonomics, needs, aesthetic and open areas open areas and social needs leisure, social needs and privacy leisure, park and Psychological security open areas, leisure and space leisure, health, social cohesion and needs	FDA3 FDA8 FDA1 FDA2 GOS9 GOS2 GOS3 GOS10 GOS1	storage space layout vs furniture optional bathroom redesign the external open buildings well maintained leisure spaces visible safe playground equipment picnic and barbecue areas semi-public outdoor
HC; HSW	air quality, health	HC1 HC2	eliminate pathologies indoor toxic materials
GOS; FDA	functional and open areas needs open areas, needs, accessibility open areas and needs	GOS11 GOS5 GOS6	verandas, balconies or terraces physical access for wheelchairs private garden spaces
WWM; HSW	health, status, waste treatment health, treatment	WWM3 WWM2 WWM1	garbage collection, and trash services sewage treatment revitalize local wastelands
BSI; ERE	heaters, installation, consumption and elements infrastructure, installation, consumption and innovation	BSI4 BSI5	new water infrastructure new installation for efficient energy
MS; HSW	facilities and social needs	MS7 MS4	provide local schools training programmes
ERE; HC ERE; BSI MS; FDA	consumption, thermal comfort sustainable, consumption, heaters paths, functional needs	ERE8 ERE5 MS2	rehabilitate the façades solar water heaters provide car parking

Source: Authors.

owners, have concerns about overall costs. To mitigate risks, concerns, and reduce complaints, SH upgrading must be well prepared. Users must be informed to avoid unwillingness to possibly relocate temporarily. Informed consent is advised. A facilitator is recommended to handle communication between users and executors of upgrades. Most SH developments have social workers who act as facilitators to mitigate conflicts between tenants or landlords. They also act as liaisons between users and housing authorities.

Furthermore, workers should be trained to respect user privacy and reduce user health risks. Construction companies will have concerns about the unknowns of existing constructions affecting their gains. Responsible executive authorities must procure resources and strive for social, environmental and economic benefits.

Effective communication should ensure engagement of all stakeholders, and feedback is essential to avoid mistrust. Face-to-face focus groups are important, and digital methods, including Virtual Reality, should be employed to visualize the construction process. Once executed, upgrading impacts and benefits should be evaluated through assessment tools (Diana, 2023; Lizana et al., 2016).

Asinyaka (2023) developed a study that detailed the social benefits of improving physical and mental health, reducing fuel poverty and upgrading neighbourhood quality in mandatory upgradings. Environmental benefits relate to indoor environmental quality and thermal comfort. To mitigate climate change, upgrades can save energy and reduce the carbon footprint. Concerning economic benefits, energy bills are reduced,

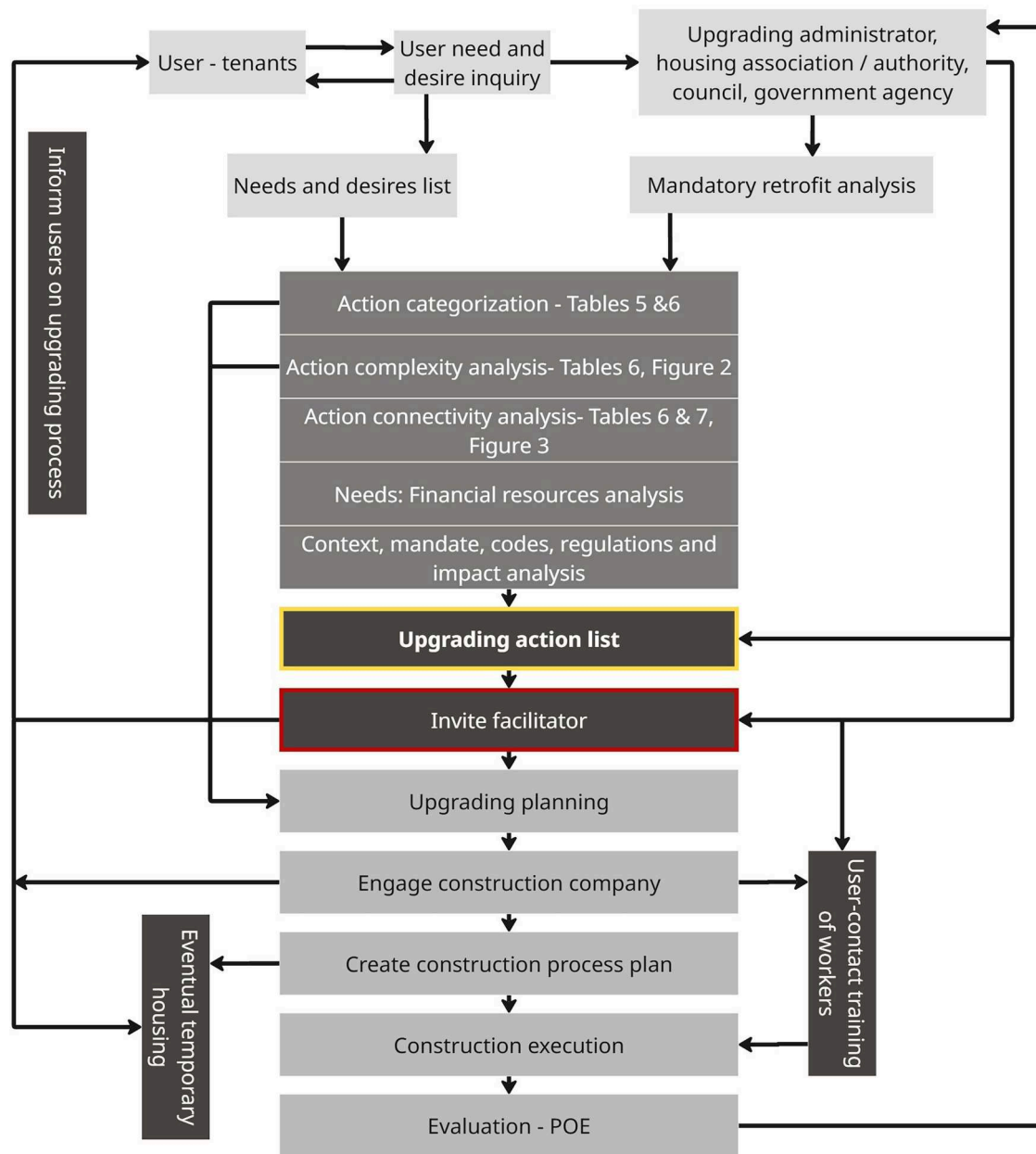


Figure 4. Framework for a process of mandatory SH upgrading.

Source: The Authors.

and property values increase. Better living conditions can also promote better employment conditions, and the upgrading process itself may create new jobs. Nevertheless, financial benefits depend on the cost efficiency of the upgrading project and its complexity (Asinyaka, 2023).

The various analysis indicators are essential to characterize the action list. To execute an upgrading action plan, a process framework for specific contexts is essential to aid stakeholders in the choice of actions for different complexities of the physical context and available investments, technical capabilities and knowledge on upgrading procedures.

Upgrading process frameworks

Our study developed two frameworks: one for mandatory processes and the other for non-mandatory upgrades, which users often execute as owners. These are shown in Figures 4 and 5. Both processes enable the development of more tailored retrofit roadmaps.

For mandatory upgrades, actions (Figure 4) must be analyzed for various factors, including complexity, priority ranking, cost and resource availability, mandate, code and regulation obligations, and context specificity, as well as impacts and benefits. A detailed mandatory retrofit analysis is essential, depending on the

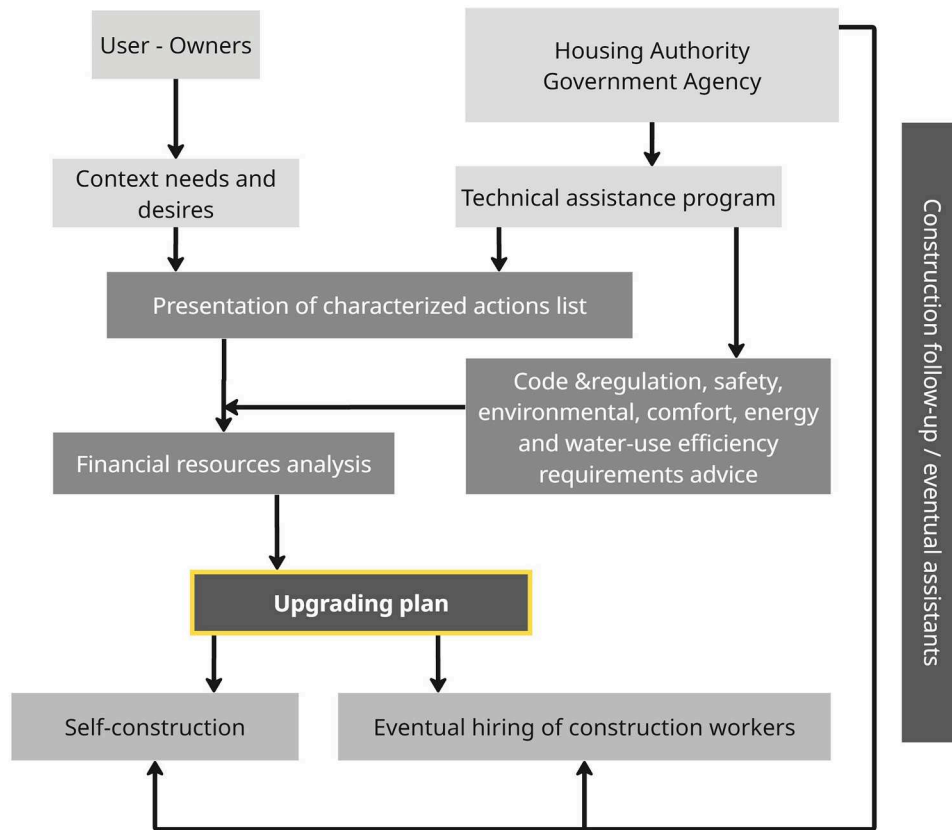


Figure 5. Framework for a process of non-mandatory SH upgrading.

Source: The Authors.

availability of a well-structured classification of interventions and their interrelationships as well as available data on housing type and users (Buchholz & Lützkendorf, 2023). A meaningful sequence of measures within a renovation roadmap is essential to assess the community spirit or conflicts, and to communicate actionable strategies to building owners in a clear and comprehensible way. Such strategies are also needed to support building workers, as they are often the first point of contact for renovation advice (Maby & Gwilliam, 2022). Trusted local professionals can significantly influence the scope and quality of the upgrading work to be undertaken. However, while many professionals are aware of the broader benefits of energy efficiency, such as improved comfort and lower energy bills, they often lack the tools or confidence to communicate these effectively, particularly in cases of facing cost-sensitive clients or competitive bidding (Maby & Gwilliam, 2022).

Broader benefits should be the aim of upgrades, including health, indoor comfort, and the adaptive capacity of buildings under climate change scenarios, particularly increasing temperatures and rising cooling demands. These objectives need to be communicated to all agents involved. Communication with tenants to

explain the upgrading process is essential and should be supported by a facilitator as a go-between for users, authorities and construction workers. Better communications may offer many potential benefits, including better documentation, more precise guidance, and improved stakeholder coordination. The facilitator is envisioned as a multidisciplinary professional with strong communication skills, capable of mediating between residents, technical teams, and institutional actors. The upgrading process itself should be presented through visual means, such as Virtual Reality. Construction noises should be simulated to prepare tenants for temporary inconveniences. Construction workers should be instructed on questions of privacy while working inside occupied residential units. Construction companies, in discussion with facilitators and authorities, may decide to relocate tenants to temporary housing to avoid significant disturbances, especially with elderly and infirm residents.

For non-mandatory upgrading (Figure 5) processes, action analysis should assess costs, resource availability and context specificity. Users are usually owners in non-mandatory upgrading processes. They should be advised by housing authorities on codes and regulations, security, safety, construction quality,

environmental comfort, energy and water-use efficiency issues related to upgrading actions. Choices of actions and their detailing, executed by users alone as well as existing construction contexts, may affect construction quality negatively. For instance, additions may hamper the ventilation and lighting of existing rooms. Housing authorities may extend their assistance with technical support and a follow-up evaluation of user interventions.

Conclusion

Many studies on housing improvements do not describe implementation procedures or their difficulties in detail. In this study, a classification and characterization of upgrading interventions is presented. The complexity of actions is classified based on their scope, investment, technical expertise, and coordination needs. The interrelation of upgrading actions is mapped. To support the upgrading of SH developments, frameworks are created for both mandatory and non-mandatory processes.

These contributions address essential insights on SH upgrades. For the most part, the identification of problems triggers necessary actions to overcome these. The location of SH developments and the specific requirements of context should be drivers for assertive upgrading processes. In developed countries, these are based on existing public policies for mandatory upgrading with the inclusion of the desires and needs of individual households and collective users. Actions to make SH functional and efficient through innovative upgrading processes should also align with the UN 2030 Agenda for Sustainable Development, with special attention given to combining sustainability actions with reduced use of resources, both financial and natural.

Some countries are still lacking mandatory upgrading processes in favour of sustainability. To mitigate this situation, our study identified actions that may be implemented by residents themselves, without extensive technical and financial support. Many simple actions are economically feasible with a high improvement potential.

Limitations of results concern the specificity of contexts demanding distinct actions relating to construction methods and the cultural characteristics of people and their ways of life. This study acknowledges limitations concerning the selection and classification of actions as available in the literature, which may not fully capture the complexity and diversity of real-world interventions. The reliance on secondary and descriptive data limited the ability to assess the actual implementation conditions and outcomes of each action. Furthermore, although prior studies and structured criteria informed the categorization of housing

improvement factors and their interconnections, some degree of interpretive subjectivity remains. Additionally, the absence of direct engagement with beneficiaries, practitioners, and decision-makers restricted insights into practical challenges, contextual variables, and the lived experience of implementation. These limitations highlight the need for future research incorporating participatory approaches, field-based assessments, and longitudinal analyses to validate and expand upon our findings.

Further studies should evaluate actions concerning their efficacy and productivity. Intervention evaluations should tackle the urgent demands of climate change. Political will must exist, and user needs and desires should be respected. Accumulated knowledge on SH upgrading should guide studies that promote participative processes for better decision-making. Well planned and executed upgrades should respond to stakeholder demands, offering opportunities to improve people's quality of life, while at the same time mitigating the impacts of climate change. Finally, society as a whole may profit from an increased ecological payback and reduced social costs.

Author contributions

CRedit: **Elisa Atália Daniel Muianga:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing; **Doris C.C.K. Kowaltowski:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing; **Jelle S. J. Koolwijk:** Data curation, Formal analysis, Investigation, Methodology, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article and its supplementary materials.

ORCID

Elisa Atália Daniel Muianga  <http://orcid.org/0000-0002-7070-3903>

Doris C.C.K. Kowaltowski  <http://orcid.org/0000-0003-3088-6124>

Jelle S. J. Koolwijk  <http://orcid.org/0000-0002-7395-3115>

References

- Asinyaka, M. (2023). *Measuring the benefits of social housing retrofits: A comprehensive framework for evaluating wider impacts* [Ph.D.]. Nottingham Trent University, United Kingdom. <https://www.proquest.com/docview/3122640881/abstract/19B2D7F5102349D2PQ/1>
- Bienert, S., Kuhlwein, H., Schmidt, Y., Gloria, B., & Agbayir, B. (2023). *Embodied carbon of retrofits. Ensuring the ecological payback of energetic retrofits*. European Public Real Estate Association. p. 73. <https://www.shareyourgreendesign.com/wp-content/uploads/2024/03/texy.pdf>
- Buchholz, M., & Lützkendorf, T. (2023). European building passports: Developments, challenges and future roles. *Buildings and Cities*, 4(1), 902–919. <https://doi.org/10.5334/bc.355>
- Buckley, R. M., Kallergis, A., & Wainer, L. (2016). The emergence of large-scale housing programs: Beyond a public finance perspective. *Habitat International*, 54, 199–209. <https://doi.org/10.1016/j.habitatint.2015.11.022>
- Cauvain, J., Karvonen, A., & Petrova, S. (2018). Market-based low-carbon retrofit in social housing: Insights from Greater Manchester. *Journal of Urban Affairs*, 40(7), 937–951. <https://doi.org/10.1080/07352166.2018.1439340>
- Curl, A., Kearns, A., Mason, P., Egan, M., Tannahill, C., & Ellaway, A. (2015). Physical and mental health outcomes following housing improvements: Evidence from the GoWell study. *Journal of Epidemiology and Community Health*, 69(1), 12–19. <https://doi.org/10.1136/jech-2014-204064>
- DellaValle, N., Bisello, A., & Balest, J. (2018). In search of behavioural and social levers for effective social housing retrofit programs. *Energy and Buildings*, 172, 517–524. <https://doi.org/10.1016/j.enbuild.2018.05.002>
- De Mel, I., Bierkens, F., Liu, X., Leach, M., Chitnis, M., Liu, L., & Short, M. (2023). A decision-support framework for residential heating decarbonisation policymaking. *Energy*, 268, 126651. <https://doi.org/10.1016/j.energy.2023.126651>
- Diana, L. (2023). *Analysis and evaluation of public social housing tools for a sustainable regeneration*. Springer. <https://link.springer.com/book/10.1007978-3-031-42928-6>
- Directive (EU). (2024). Directive (EU) 2024/1275 of the European parliament and of the council. *Official Journal of the European Union*, L275, 1–68.
- Ebrahimigharehbaghi, S., Qian, Q. K., de Vries, G., & Visscher, H. J. (2022). Identification of the behavioural factors in the decision-making processes of the energy efficiency renovations: Dutch homeowners. *Building Research & Information*, 50(4), 369–393. <https://doi.org/10.1080/09613218.2021.1929808>
- Fabbri, M., De Groote, M., & Rapf, O. (2016). *Building renovation passports: Customised roadmaps towards deep renovation and better homes*. Buildings Performance Institute Europe (BPIE). p. 46.
- Galvin, R., & Sunikka-Blank, M. (2017). Ten questions concerning sustainable domestic thermal retrofit policy research. *Building and Environment*, 118, 377–388. <https://doi.org/10.1016/j.buildenv.2017.03.007>
- Gruis, V. H., Roders, M. J., & Straub, A. (2011). *Supply chain partnership within housing renovation: Approaches and expectations in the Dutch housing association sector*. Management and Innovation for a Sustainable Built Environment. p. 1–13. <https://www.hu.nl/onderzoek/publicaties/supply-chain-partnerships-within-housing-renovation-approaches-and-expectations-in-the-dutch-ho>
- Gustavsson, E., & Elander, I. (2016). Sustainability potential of a redevelopment initiative in Swedish public housing: The ambiguous role of residents' participation and place identity. *Progress in Planning*, 103, 1–25. <https://doi.org/10.1016/j.progress.2014.10.003>
- Hackitt, D. J. (2018). *Building a safer future. Independent review of building regulations and fire safety: Final report* (Cm 9607; p. 159). Secretary of State for Housing, Communities and Local Government.
- Helms, A. C. (2012). Keeping up with the joneses: Neighborhood effects in housing renovation. *Regional Science and Urban Economics*, 42(1–2), 303–313. <https://doi.org/10.1016/j.regsciurbeco.2011.07.005>
- Kamaruzzaman, S. N., Razali, A., Zawawi, E. M. A., Basir, S. A., & Riley, M. L. (2018). Residents' satisfaction towards the indoor environmental quality of re-engineered affordable housing scheme in Malaysia. *International Journal of Technology*, 9(3), 501–512. <https://doi.org/10.14716/ijtech.v9i3.826>
- Karvonen, A. (2013). Towards systemic domestic retrofit: A social practices approach. *Building Research & Information*, 41(5), 563–574. <https://doi.org/10.1080/09613218.2013.805298>
- Kitchenham, B., Li, Z., & Burn, A. (2011). Validating search processes in systematic literature reviews. In H Zhang, Y Yang, & R Conradi (Eds.), *Proceeding of the 1st international workshop on evidential assessment of software technologies* (pp. 3–9). SciTePress. <https://doi.org/10.5220/0003557000030009>
- Konstantinou, T., de Jonge, T., Oorschot, L., El Messlaki, S., van Oel, C., & Asselbergs, T. (2020). The relation of energy efficiency upgrades and cost of living, investigated in two cases of multi-residential buildings in The Netherlands. *Smart and Sustainable Built Environment*, 9(4), 615–633. <https://doi.org/10.1108/SASBE-04-2019-0044>
- Kowaltowski, D. C. C. K., Silva, V. G., Oel, C. V., Granja, A. D., Muianga, E. A. D., Kabisch, S., Moreira, D. C., Koolwijk, J. S. J., Poessneck, J., Tzortzopoulos, P., Soliman Junior, J., Bridi, M. E., & Freeke, A. (2024). Living labs for user empowerment and value delivery in social housing upgrading processes. *Habitat International*, 145, 103019. <https://doi.org/10.1016/j.habitatint.2024.103019>
- Kæseler, S. M., Neve, H. H., Wandahl, S., & Jensen, S. R. (2019). Towards developing a framework for user-driven innovation in refurbishment. In I. Lill & E. Witt (Eds.), *Emerald reach proceedings series* (pp. 427–435). Emerald Publishing Limited. <https://doi.org/10.1108/S2516-285320190000002016>

- Kurvinen, A., Huovari, J., Lahtinen, M., Sen, T., & Saari, A. (2024). A dynamic model for estimating the long-term need for repairs and renovations in residential buildings. *Building Research & Information*, 52(5), 533–550. <https://doi.org/10.1080/09613218.2024.2306371>
- Ledent, G. (2017). Permanence to allow change. The archetypal room: The persistence of the 4×4 room. In M. J. R. C. da Costa, F. Roseta, S. C. da Costa, & J. P. Lages (Eds.), *Architectural research addressing societal challenges* (pp. 339–344). CRC Press. <https://www.taylorfrancis.com/chapters/edit/10.12019781315116068-47/permanence-allow-change-archetypal-room-persistence-4-4-room-ledent>
- Lizana, J., Barrios-Padura, J., Molina-Huelva, M., & Chacartegui, R. (2016). Multi-criteria assessment for the effective decision management in residential energy retrofitting. *Energy and Buildings*, 129, 284–307. <https://doi.org/10.1016/j.enbuild.2016.07.043>
- Maby, C., & Gwilliam, J. (2022). Integrating energy efficiency into private home repair, maintenance and improvement practice in England and Wales. *Building Research & Information*, 50(4), 424–437. <https://doi.org/10.1080/09613218.2021.1963652>
- Maduta, C., D'Agostino, D., Tsemekidi-Tzeiranaki, S., Castellazzi, L., Melica, G., & Bertoldi, P. (2023). Towards climate neutrality within the European Union: Assessment of the Energy Performance of Buildings Directive implementation in Member States. *Energy and Buildings*, 301, 113716. <https://doi.org/10.1016/j.enbuild.2023.113716>
- Maia, I. E. N., Harringer, D., & Kranzl, L. (2024). Household budget restrictions as reason for staged retrofits: A case study in Spain. *Energy Policy*, 188, 114047. <https://doi.org/10.1016/j.enpol.2024.114047>
- Martin-Goñi, P., Avellaneda, J., & González, J. M. (2024). Energetic and functional rehabilitation of residential buildings in Europe: Analysis and cataloguing of the strategies used. *Buildings*, 14(2), 525. <https://doi.org/10.3390/buildings14020525>
- Mogensen, D., & Gram-Hanssen, K. (2023). Why do people (not) energy renovate their homes? Insights from qualitative interviews with Danish homeowners. *Energy Efficiency*, 16(5), 40. <https://doi.org/10.1007/s12053-023-10121-9>
- Monteiro, C. S., Causone, F., Cunha, S., Pina, A., & Erba, S. (2017). Addressing the challenges of public housing retrofits. *Energy Procedia*, 134, 442–451. <https://doi.org/10.1016/j.egypro.2017.09.600>
- Muianga, E. A. D., Kowaltowski, D. C. C. K., Silva, V. G., Da; Moreira, D. C., Granja, A. D., Oliva, C. A., & Silva, R. F. (2021). Critical analysis of housing condition impacts on residents' well-being and social costs. *Gestão & Tecnologia de Projetos*, 16(4), 33–66. <https://doi.org/10.11606/GTP.V16I4.178511>
- Murto, P., Jalas, M., Juntunen, J., & Hyysalo, S. (2019). Devices and strategies: An analysis of managing complexity in energy retrofit projects. *Renewable and Sustainable Energy Reviews*, 114, 109294. <https://doi.org/10.1016/j.rser.2019.109294>
- Ortiz, M., Itard, L., & Bluyssen, P. M. (2020). Indoor environmental quality related risk factors with energy-efficient retrofitting of housing: A literature review. *Energy and Buildings*, 221, 110102. <https://doi.org/10.1016/j.enbuild.2020.110102>
- Peters, T., & Halleran, A. (2021). How our homes impact our health: Using a COVID-19 informed approach to examine urban apartment housing. *Archnet-IJAR: International Journal of Architectural Research*, 15(1), 10–27. <https://doi.org/10.1108/ARCH-08-2020-0159>
- Preciado-Pérez, O. A., & Fotios, S. (2017). Comprehensive cost-benefit analysis of energy efficiency in social housing. Case study: Northwest Mexico. *Energy and Buildings*, 152, 279–289. <https://doi.org/10.1016/j.enbuild.2017.07.014>
- Rashidfarokhi, A., & Danivska, V. (2023). Managing crises 'together': How can the built environment contribute to social resilience? *Building Research & Information*, 51(7), 747–763. <https://doi.org/10.1080/09613218.2023.2191922>
- Saffari, M., & Beagon, P. (2022). Home energy retrofit: Reviewing its depth, scale of delivery, and sustainability. *Energy and Buildings*, 269, 112253. <https://doi.org/10.1016/j.enbuild.2022.112253>
- Sandberg, N. H., Sartori, I., Heidrich, O., Dawson, R., Dascalaki, E., Dimitriou, S., Vimmer, T., Filippidou, F., Stegnar, G., Šijanec Zavrli, M., & Bratlebø, H. (2016). Dynamic building stock modelling: Application to 11 European countries to support the energy efficiency and retrofit ambitions of the EU. *Energy and Buildings*, 132, 26–38. <https://doi.org/10.1016/j.enbuild.2016.05.100>
- Sesana, M. M., Salvalai, G., Brutti, D., Mandin, C., & Wei, W. (2021). ALDREN: A methodological framework to support decision-making and investments in deep energy renovation of non-residential buildings. *Buildings*, 11(1), 3. <https://doi.org/10.3390/buildings11010003>
- Soares, A., Gomes, Á, Antunes, C. H., & Oliveira, C. (2017). A customized evolutionary algorithm for multiobjective management of residential energy resources. *IEEE Transactions on Industrial Informatics*, 13(2), 492–501. <https://doi.org/10.1109/TII.2016.2628961>
- Sombrio, C. M. O., Guinancio, C., & Zanoni, V. A. G. (2025). Redes como arranjos estratégicos para ganho de escala em ações de melhorias habitacionais. *CIDADES, Comunidades e Territórios*, 50, 1–20. <https://revistas.rcaap.pt/cct/article/view/35023>
- Sutherland, G. D., Waterhouse, F. L., Smith, J., Saunders, S. C., Paige, K., & Malt, J. (2016). Developing a systematic simulation-based approach for selecting indicators in strategic cumulative effects assessments with multiple environmental valued components. *Ecological Indicators*, 61, 512–525. <https://doi.org/10.1016/j.ecolind.2015.10.004>
- Thomsen, A., & van der Flier, K. (2011). Understanding obsolescence: A conceptual model for buildings. *Building Research & Information*, 39(4), 352–362. <https://doi.org/10.1080/09613218.2011.576328>
- Tiellemans, N., Kemperman, A., Maussen, S., & Arentze, T. (2022). The influence of group decision-making on residents' preferences for sustainable energy measures of dwellings. *Building Research & Information*, 50(4), 410–423. <https://doi.org/10.1080/09613218.2021.1992261>
- Tipple, G. (Eds.). (2000). *Extending themselves: User-initiated transformations of government-built housing in developing countries*. Liverpool University Press.
- Torraco, R. J. (2016). Writing integrative literature reviews: Using the past and present to explore the future. *Human*

- Resource Development Review*, 15(4), 404–428. <https://doi.org/10.1177/1534484316671606>
- Van de Moortel, E., & Allacker, K. (2023). To what extent could alternative economic models increase investment in the renovation of and reduce energy poverty in social housing in flanders? *Buildings*, 13(12), 3001. <https://doi.org/10.3390/buildings13123001>
- van Geenhuizen, M. (2018). A framework for the evaluation of living labs as boundary spanners in innovation. *Environment and Planning C: Politics and Space*, 36(7), 1280–1298. <https://doi.org/10.1177/2399654417753623>
- Villa, S. B., Garrefa, F., Stevenson, F., & Bortoli, K. (2017). Co-production and resilience in a Brazilian social housing: The case of shopping park neighbourhood. In *PLEA 2017* (Vol. 1, pp. 1–9).
- Villa, S. B., Vasconcellos, P. B., de Bortoli, K. C. R., & de Araujo, L. B. (2022). Lack of adaptability in Brazilian social housing: Impacts on residents. *Buildings and Cities*, 3(1), 376–397. <https://doi.org/10.5334/bc.180>
- Xu, Y., & Juan, Y.-K. (2021). Design strategies for multi-unit residential buildings during the post-pandemic era in China. *Frontiers in Public Health*, 9, 1–14. <https://doi.org/10.3389/fpubh.2021.761614>