Better Living Environment Today, More Adaptable Tomorrow?

Comparative Analysis of Finnish Apartment Buildings and their Adaptable Scenarios

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In Finland, maximising urban land value has often resulted in urban housing designed for increased efficiency. The study highlights how this efficiency, reflected for example in deeper plans and reduced apartment daylighting, limits dwellers' opportunities to adapt spaces to their changing needs over time. This study evaluates the adjustment potential of two case study apartment buildings within the Finnish urban housing context. These cases represent a broader set of housing built in 2019 or planned for 2020–2022 in Finland's largest urban areas. As illustrated by comparative scenarios, the study cases generally lack much capacity to accommodate change, though this limitation can be improved. The results are discussed in the light of the inter-relationship between housing adaptability, dwelling quality, and apartment and building typology, in addition to urban block design at the city plan level.

Keywords: adaptability; flexibility; housing; design; quality; sustainability.

Introduction

By 2050, two-thirds of the world's population is expected to be living in urban areas, with 55% already an urban dweller today (UN, 2018). Finland also follows a similar trajectory: the majority of new dwellings are, and will be, apartment buildings built in urban areas (Vainio, 2016; RT, 2019). Urbanisation comes with increasing concerns about the reduction in housing design quality in urban areas around the world (see e.g. Finlay et al., 2012; Punter, 2010), which is often driven by the need to maximise land value and to increase the number of units per plot and per building. In Finland, this trend has manifested in an increased number of small studio units (Karikallio et al., 2019), deeper building plans and, for example, poorly daylit spaces (see e.g. Helander, 2020).

Simultaneously, the Finnish construction sector must move towards a circular economy to enable Finland to become carbon neutral in 2035 (Finnish Government, 2020). The circular economy aims at keeping products in use and circulation for as long as possible (e.g. Huuhka & Vestergaard, 2019). In construction, this means increased attention should be paid to the use and demolition phase of a building, alongside the construction phase. Clearly, during a building's life cycle, changes in use will be inevitable due to changing needs of dwellers, and over different generations. The need for change can be driven by, for example, the pronounced individualisation in our society leading to different ways of living; new work and leisure practices promoted by growing digitalisation; the diversification of households and family structures; and demographic change (Juntto, 2008; 2010). These issues highlight the need for apartment adaptability potential. Indeed, a building's inability to adapt to the changing needs of dwellers might become a barrier to the goals of the circular economy, when buildings need to be replaced, instead of being able to be adjusted (Huuhka & Vestergaard, 2019, p. 38).

Hence, any new apartment building should be able to spatially adapt in time and meet different dwellers' needs and expectations, to supports citizens' well-being (e.g. Jusan & Sulaiman, 2005) and the broader sustainability of the built environment (e.g. Huuhka & Vestergaard, 2019). Yet this adaptability potential is not reflected in recent Finnish housing production, despite principles of housing flexibility and adaptability being a development objective - although not well-characterised - for construction since the 1990s in Finland (Hakaste, 2015). According to the National Building Code, housing design should not only promote the functionality of housing, but also its suitability for different and changing needs (National Building Code of Finland G1, 2005). However, without monitoring or specifications, adaptability has been interpreted as a recommendation, rather than a mandatory requirement in housing design in Finland.

It is against this background that the paper examines the potential of Finnish apartment buildings to adapt over time, and how to improve this potential. After setting out a brief theoretical basis for the adaptability in housing and implications for housing quality, the paper presents an evaluation model used to study potential apartment adaptability in selected case studies, leading to proposed alternative, adjustable apartment scenarios. Comparison of the original cases and their alternative scenarios enables a discussion about the future Finnish housing stock, and the inter-relationship of housing adaptability and other living environment qualities.

Theoretical background

Spatial adaptability

Buildings are usually presented as if they were constant artefacts. In reality, all buildings eventually change, even if they are not specifically designed for adaptation. Homes, to a greater or lesser extent, are modified by their users throughout their lifespan, whether the designer intended this or not (Brand, 1994). There is an extensive research tradition relating to the flexibility and adaptability of housing architecture (e.g.; Habraken, 1972; 1998; Schneider & Till, 2007; Leupen, 2006; Schmidt & Austin, 2016; Krokfors, 2017; Pinder et al., 2017; Braide, 2019). These concepts are usually divided into two subcategories: the multi-usability approach (often labelled as 'multifunctionality' or 'polyvalence', but also 'adaptability') and the transformability approach (often labelled as 'flexibility', 'modifiability' or 'transformability'). In general, the multi-usability approach emphasises how a fixed spatial configuration can allow for varied uses of a building or a dwelling, whereas the transformability approach covers physical changes in a building or a dwelling. These two main perspectives, which have long been present in international research discussions, were also reported as the spatial principles of the ability to adapt in the Finnish housing context (Tarpio, 2015). However, this conceptual division can also be somewhat artificial and might increase misconceptions about the subject (Schmidt & Austin, 2016) because of overlaps in the two perspectives. The recent categorisations have used the term adaptability as the main umbrella for the capacity of a building to be adjusted to suit new situations (see Schmidt & Austin, 2016; Pinder et al., 2017) with both passive and active ways of adjustment. For example, Schmidt & Austin (2016) see adjustability, versatility, refitability, scalability, convertibility, and movability as subtypes of adaptability. Thus, the terminology of the discipline is far from unambiguous.

Occupants' practical needs, social demands and housing aspirations are regarded in this study as drivers for any housing adaptability potential. In this

FIGURE 1 Illustration of the difference between the apartment 'support' (on the left) and ´infill´ (in the middle), as used in this study. The illustration on the right presents 'support' and ´infill´ together. The apartment ´support´ i.e. community-controlled and slower changing building aspects, as used in this study, is highlighted in darker grey. The apartment ´infill´, as used in this study, can be adjusted more easily by dwellers, and is highlighted in lighter grey. Storage cabinets and replaceable furniture are highlighted in a light grey dashed line. The arrow indicates the apartment entrance.

paper, the term adaptability is used to reflect its broad meaning (Schmidt & Austin, 2016), and the study is focused on adjustable spaces; hence both terms are used interchangeably in this paper. Adjustability "involves ensuring that the 'stuff' inside the building, such as – – fixtures – –, can be reconfigured" to meet the changing needs (Schmidt & Austin, 2016, p. 70). Related to this, the architect and theorist Habraken (1972; 1998) proposed the constructive concepts of 'support' (or 'base-building') and 'infill' (or 'detachable unit'), as long ago as in the 1960s. According to Habraken, 'infill' is the part of the apartment's structure that a household controls and can therefore adjust, and 'support' is the part of the apartment's structure that a larger community is responsible for, and therefore a part that a household cannot usually easily adjust (Fig 1). These concepts show that the need for change is greater and more quickly manifested at the interior arrangement of an apartment (see also Brand, 1994). In this study, with Finnish housing as subject, structure, skin and services are regarded as elements which are part of the community-controlled, slower changing building 'support'. Also, serviced bathrooms are included in the 'support' in this study, because their adjustment usually requires special permits and special skills in apartment buildings in Finland. The remaining apartment aspects are usually controlled by the household, i.e. they are regarded as apartment 'infill' (Fig 1). Indeed, by changing the properties of the building 'support', it is possible to facilitate, complicate or hinder the possible variations of 'infill' adjustments. This is illustrated in this study by two apartment building cases, and their focus apartments.

Housing quality

Generally, housing quality includes aspects ranging from neighbourhood setting to dwelling detailing (Bonaiuto et al., 1999). Housing quality is influenced by physically measurable factors, such as noise, indoor air quality and energy efficiency (UKGBC, 2016), and also by "non-measurable" attributes (e.g. Nylander, 2002). Housing quality has been too little studied from dwellers' perspective, especially in the scale of dwellings (Kuoppa et al., 2019), but there are some interesting observations. For example, connections between interior and exterior spaces are valued by dwellers (Kuoppa et al., 2019), as are good daylighting conditions (Finlay et al., 2012; Kuoppa et al., 2019). Also of value are spacious 'main living spaces' (i.e. living, kitchen and dining areas) to enable socialising, but also private space away from other household members (Finlay et al., 2012). Furthermore, sufficient utility space was also considered a desirable housing quality (Kuoppa et al., 2019).

A few studies also explore the relationship between housing qualities valued by dwellers and housing adaptability (e.g. Kuoppa et al., 2019; Finlay et al., 2012; Wong, 2010; Atlas & Özsoy, 1998). For example, in the study of Finlay et al. (2012), flexibility in the 'main living spaces' was noted as a particularly appreciated quality by dwellers. Kuoppa et al. (2019; 16) emphasise that dwellers "wished for flexible housing solutions or possibilities to modify and influence their dwelling — — to better suit their needs and ambitions." Moreover, Atlas & Özsoy (1998, p. 315) state that adaptability is "one of the essential spatial features for residential satisfaction." As such, adaptability might be considered a desirable housing quality aspect from a dweller's perspective, even if attitudes to preferred dwelling layouts varied based on the life stages of respondents (Finlay et al., 2012). Given that urban living expectations are diversifying (Juntto, 2008; 2010) and household and family structures are changing (Keurulainen, 2014), this creates consequences for preferred living arrangements. Additionally, benefits of adaptable dwellings for residents include long-term social sustainability by providing stability and agency when dwellers can stay in the same community for longer if their spatial needs can be accommodated through adaptability rather than moving (Femenias & Geromel, 2019). Hence, adaptability also supports the inclusion of a diversity of people.

Research methods

Building and apartment selection

The material used in this paper consists of two Finnish apartment buildings to be constructed between 2020–2022, purposively selected from a larger sample. In these two buildings, the focus is on apartments over 36 m² in size: altogether seven apartments sized between 37–83 m² were included. This study focuses on the adjustability of multi-room dwellings. Also, evaluation indicators were formed to serve this focus. The exclusion of small (e.g. 36m² and under) apartments is justified because it is more reasonable for that size range to study joining possibilities to other apartments, or the use of e.g. adaptable furniture. However, such study is excluded here.

The data was collected from the Finnish housing sale website Etuovi at the turn of 2019–2020 in a two-stage iterative process of data collection to ensure research validity. In the first stage, 60 cases were located and collected by searching for new apartment buildings put on the market in Finland's largest urban areas, i.e. Helsinki, Espoo, Tampere, Vantaa, Oulu, and Turku (Kuntaliitto, 2019). Similar cases (often located on the same site) were not selected, but otherwise the first sufficiently differentiated buildings were added until data saturation was reached (i.e. when new cases no longer added new information). Some cases were changed during the process if there was insufficient plan material available. These 60 cases highlighted building features that appeared repeatedly, such as central staircases that serve many apartments and a large number of studio units that have windows in one direction only. This sampling strategy most likely captures the salient features of the Finnish housing production of today and the near future. In the second stage, the data collection of the 60 cases led to the selection of two cases for in-depth analysis. The two selected cases (from now on referred to as 'the cases') are considered to be representative of the larger sample, while allowing for diversity in their qualitative characteristics. This diversity is described in more detail in the result section and is based on a characterisation of cases in accordance with their staircase location, because this influences dwelling characteristics.

Research-by-design

Recent research in the field of adaptable housing has focused on developing adaptability evaluation tools (e.g. Conejos et al., 2015). Many of these tools are checklists or quantitative models with little attention to in-depth design characteristics, especially in housing contexts. While quantitative models are useful for analysing large sets of building plans (e.g. Femenias & Geromel, 2019; Herthogs et al., 2019), they lack

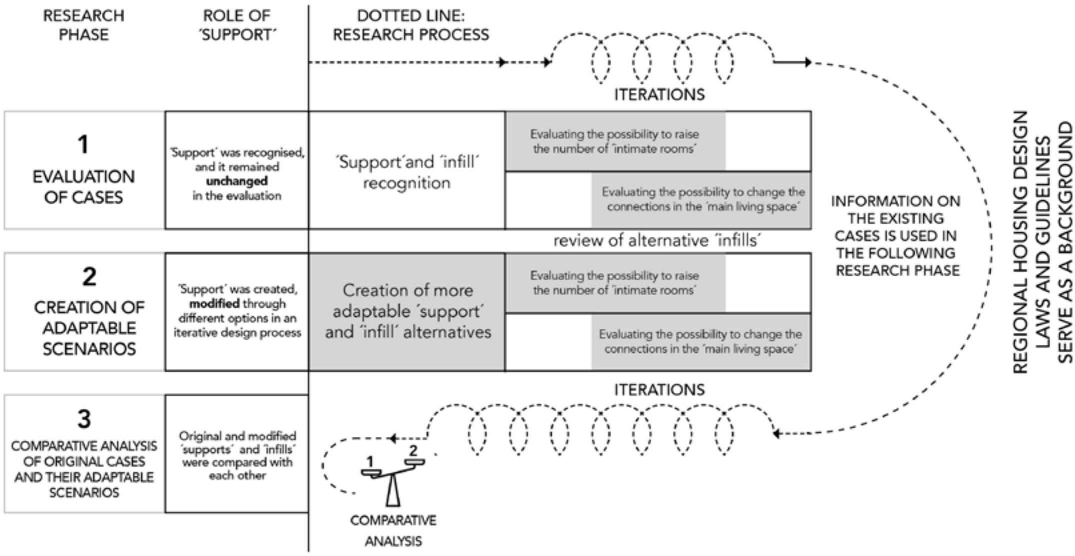


FIGURE 2 The first column indicates the research phases. The second column indicates what role ´support´ had in the research phase. For the purposes of the first evaluation, the original 'support' was kept untouched. For the purpose of the second phase, i.e. the design of the more adaptable ´support' and alternative ´infill' options were developed through a multi-stage design process. In the third phase, the original and modified ´supports´ and ´infills´ were compared. All parts shown in grey contain iterative design activities.

a detailed evaluation of how a building's community-controlled 'support' can foster dweller-driven 'infill' adjustments. This is acknowledged for example by Herthogs et al. (2019, 3), noting that their quantitative method "results in a loss of sensitivity compared to conventional architectural or sociological plan analysis". Given that the cases were under construction at the time of writing, real changes made by the dwellers could also not be analysed. Hence in this paper, a detailed evaluation was undertaken through architectural plan analysis, as a systematic synthesis process which includes a research-by-design approach. In this approach, design is used as a research tool "to explore, spatialise and visualize new concepts" (Vervoort & Pisman, 2016, p. 4) and "to understand the nature of a problem by the production of alternatives" (Vervoort & Pisman, 2016, p. 3). Research-by-design overcomes the research limitations arising from quantitative tools and working with buildings under construction. The study consists of three parts, two of which use design as a tool. These three parts are illustrated in Figure 2 and described in more detail in the following.

Phase 1: Evaluation of cases

The cases were 3D modelled and their adjustability potential was evaluated through a systematic evaluation method, based around three main indicators, described below in Table 1. The summary indicators of Table 1 were further transformed into a 'traffic-light' system as an initial approach to objectively and transparently evaluate the adjustment potential of apartments, and to allow use of the evaluation by other researchers. In this process, habitable and closeable rooms of apartments are referred to as 'intimate rooms', according to Robinson's (2004, p. 176) terminology, because they offer greater privacy. In addition, the spaces shared with many household members, such as kitchen, living room and dining room, are referred to as 'main living space' after Finlay et al. (2012, p. 17).

Phase 2: Creation of adjustable apartment scenarios

After the evaluation of the adaptability potential of the cases, as shown in Figure 2 and Table 1, alternative scenarios were created through research-by-design. For this study, the objective was the creation of alternative apartment plans with improved possibilities to be adjusted in the same sizes of units. This entailed the exploration of different 'infill' variations through iterative design drafts, which then influenced the creation of new alternative 'supports'. The indicators for adjustable apartments described in Table 1 above were used to create, evaluate and compare alternative adaptability scenarios. Moreover, the basic qualities of the existing case apartments, such as the number of bathrooms, utility areas and private outdoor areas, were retained (Tables 4–5).[1] (Note that the sizes of all existing and adapted apartments are rounded evenly in the work, so e.g. 54.5m^2 = 55m^2.)

Excluded from this study were adaptation measures based on extra technical services to allow, for example, for different locations of kitchens or bathrooms, as these are likely to increase the cost of construction. In this study, changing the sizes of the apartments was also excluded. Hence this work excluded reviewing the division of larger apartments into smaller ones (or smaller ones combined into a larger one).

Phase 3: Comparative analysis of the original cases and their adaptable scenarios

In the third phase, the original building plans were systematically compared to the new scenarios by means of the indicators described in Table 1, using a

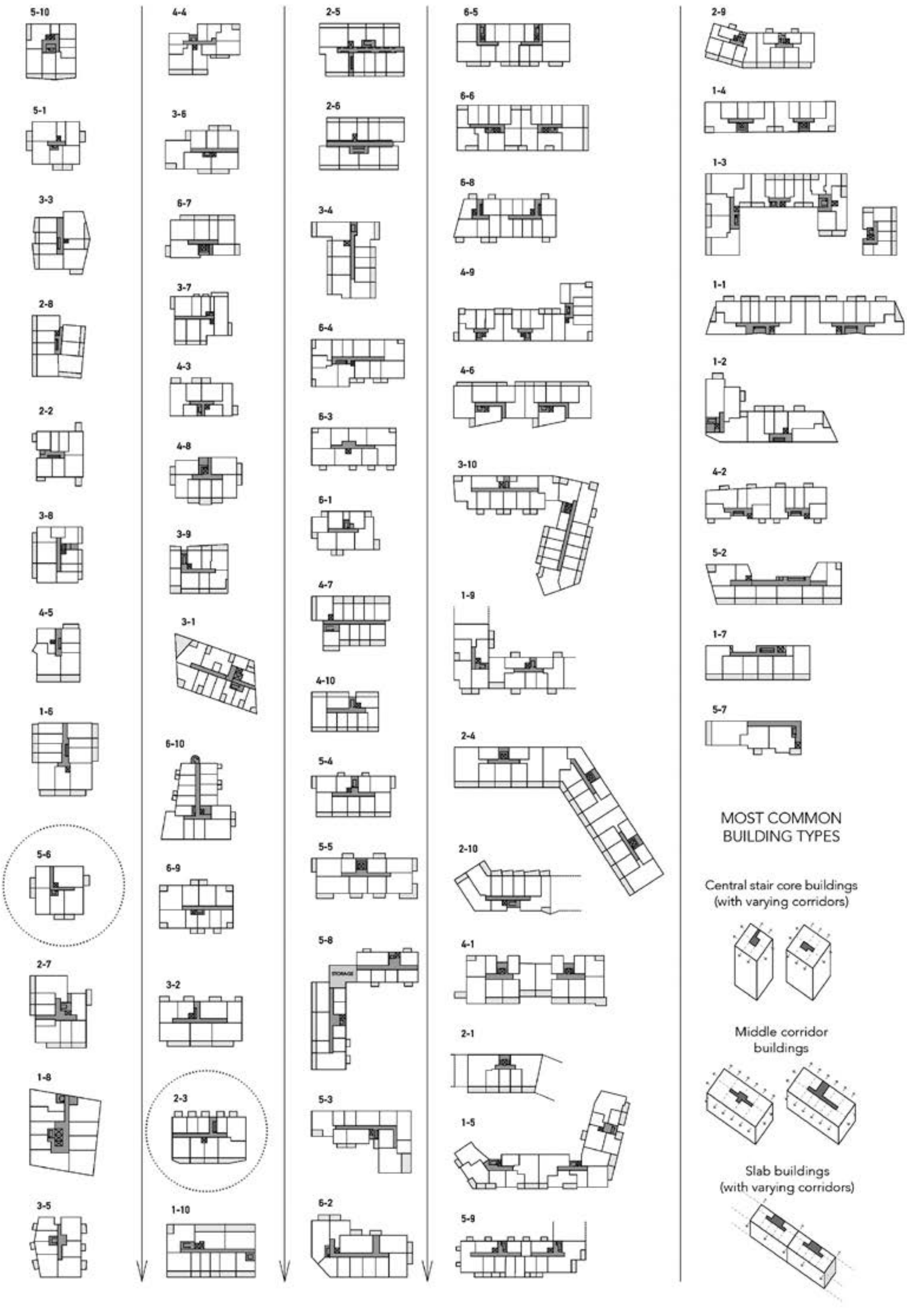
1 Throughout the study, both the analysis and creation of the adaptable scenarios and the regional and national laws and guidelines were taken into account (see e.g. Finnish Land Use and Building Act 1999), as well as accessibility considerations for each apartment and the building's staircases.

TABLE 1 Evaluation indicators for adjustable apartments and their description as used in this study.

Adjustable apartments: Evaluation indicators**	Description *
Task: Mapping of the 'support' and 'infill'	Mapping of community controlled aspects of the apartment, such as load-bearing structure, facade, the kitchen's building services and bathrooms (i.e. 'support'), and the other parts which are dweller-controlled (i.e. 'infill'). This is based on, and adapted from, Habraken (1972; 1998), as described earlier. Reason: To evaluate an apartment's capacity to adapt from a user perspective, there is a primary need to first distinguish what usually can and cannot be easily changed by the users.
Indicator 1: Is it possible for a user to add an intimate room?	Identification and analysis of the possible number of intimate rooms. Reason: An apartment that accommodates a changeable number of 'intimate rooms' is more likely to meet the needs of various households of different sizes (e.g. Keurulainen, 2014) and with different needs (Juntto, 2008; 2010). For example, one of the common needs for dwelling adjustment is to provide an additional room (Wong, 2010, p. 177).
Indicator 2: Is it possible for a user to change the connections in the 'main living space'?	Identification and analysis of the different connections in the 'main living spaces' shared in the household unit. Reason: If the apartment's design can accommodate a number of options between 'main living space' connections, this will support dwellers' different preferences at different life stages. For example, some prefer open plan layouts (a joint space for preparing food, eating and spending time together), while others prefer a separate kitchen, dining and living room (Finlay et al., 2012, p. 24).
Indicator 3: Are there two or more orientations in the apartment?	Identification and analysis of the number of orientations and facades of the housing unit. Reason: A sufficient number of windows available is needed to allow the separation of spaces. Also, an apartment with more than one orientation is more likely to accommodate different spatial configurations (Živkovic & Jovanovic, 2012, p. 20).

* All evaluations to be undertaken with case-specific regional and cultural design regulations and guidelines. For example, when studying the intimate rooms, only spaces that are at least 7m² size with a certain sized window were taken into account (RakMK G1 2005, p. 5); only windows with external access (outdoors/balcony) were considered in this study.

** The terms adaptability and adjustability are used interchangeably in this paper.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MOST COMMON BUILDING TYPES
Central stair core buildings (with varying corridors)
Middle corridor buildings
Slab buildings (with varying corridors)

traffic-light system. In this comparison, the characteristics of the apartment's building 'support' that enhanced or hindered the apartment's capacity for the adjustments of the 'infill' are discussed.

Results

Overview of the 60 apartment cases and case selection for detailed study

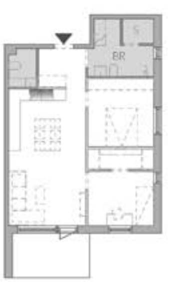
The 60 selected cases were first categorised according to their staircase configurations and the way in which the apartments were arranged around them (Fig 3). This is because the location of the staircases and potential corridors appeared to have a significant impact on dwelling characteristics. While there are clear distinctions between circulation systems of buildings (highlighted with darker grey, Fig 3) there are many gradations in between. Hence, rather than a strict categorisation of the case study buildings, a continuous gradation is more appropriate to describe the differences in the cases. The three most common building types were:

- central stair core buildings with varying corridors (for example, 5-10 to 3-9, Fig 3)
- middle corridor buildings (for example, 3-1 to 6-2, Fig 3)
- slab buildings with varying corridors (for example, 6-5 to 1-4, Fig 3).

On one end of the categorisation are central stair core buildings, most of which include some kind of middle corridor sections, gradually changing to elongated mid-corridor buildings, and to various kinds of slab buildings, most of which include middle corridor sections. On the other end are a few side-corridor typologies, which are clearly in the minority. The first two types, i.e. central stair core and middle corridor, represent the most common building types of the 60-case-study sample. For this reason, the two building cases for detailed study were selected from these categories and are a likely representative of these common types. The selected cases (circled in Fig 3) are located in different cities: case 5–6 is a central stair core building in Oulu, and case 2–3 is a middle-corridor building in Espoo.

← **FIGURE 3**

The 60 cases selected in the first phase of the research. The two cases selected for more detailed discussion are marked with a dotted line. In this study, the five columns represent a continuous gradation of the collection of cases, as it is a more appropriate way to describe the differences of building types, compared to strict categories. Thus, the figure can be read as a continuous gradation starting from building 5-10 and ending to building 5-7. The series of numbers indicate the authors' chronological process of material search, not material categorisation. The darker grey shade indicates the circulation area and lighter grey shade indicates the apartment specific outdoor areas. Axonometric pictures on the bottom right illustrate the three most common building types in this sample.

EXISTING UNIT: ADJUSTABILITY EVALUATION - Building case 1				
Case	Task: Recognition of support and infill	Indicator 1: Is it possible for a dweller to add an ´intimate room´?	Indicator 2: Is it possible for a dweller to change the connections in the ´main living space´?	Indicator 3: Are there two or more orientations in the apartment?
1B(A) 46m²				2 orientations, 2 facade planes
1B(B) 46m²				
1C 55m²		yes, but consequences (unusual room shape) 	yes, but consequences (5,5 m² wasted area) 	2 orientations, 2 facade planes
1D 73m²		yes, but consequences (e.g. window small and in bad position)  * window appears to be 1/10 of the room area, but the material does not provide absolute certainty of it		2 orientations, 2 facade planes

1 2 3 4m

TABLE 2 Existing case 1: adjustability evaluation. The dark grey colour (´traffic light red´) indicates that the adaptability indicator is not met; middle grey colour (´traffic light yellow´) means that it is partially met, and light grey colour (´traffic light green´) that the adaptability indicator is met. Dotted line in plan indicates challenges in meeting the indicators. The separate kitchens are highlighted with hatched pattern. The arrow indicates the apartment entrance.

Description of the two selected cases

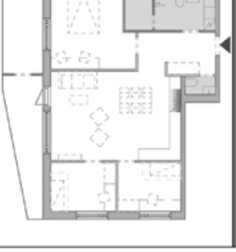
The first case (Fig 4) is part of an area with several similar buildings under construction in Oulu. The selected case has a centralised stair and lift solution, located at the L-shaped intersection of two corridors, one end of which allows daylight in through a window opening. The four of the seven apartments per floor are dual aspect, i.e. they open in two directions. The building is almost square in its plan shape, from which stacked balconies protrude. The apartments are sized between 24–73m^2.

The second case (Fig 5), located in Espoo, is part of an area currently being built, with several similar buildings also planned. The selected case has one set of straight stairs with a window providing daylight and connected to a central corridor which extends almost through the entire building. This leads to many single-aspect apartments, i.e. they open in one direction, distributed alongside the corridor as an efficient way to organise units. There are a total of nine apartments per floor, of which only four are dual aspect. Tunnel-like studios and one-bedroom apartments are placed on both sides of the corridor. The majority of apartments are sized between 28–48m^2, with three larger apartments sized between 59–84 m^2.

Existing case studies: adaptability evaluation

In general, neither of the two cases allow for much adjustment potential, though case 1 is more robust in supporting dwellers' changing needs in the future; this is highlighted in Tables 2 and 3, which use a traffic-light system to indicate greater or lesser adaptability potential in accordance with the key indicators for adjustable apartments, as described in Table 1. Here, the traffic light system is illustrated with black and white figures in the following manner: the dark grey colour (´traffic light red´) indicates that the adaptability indicator is not met; middle grey colour (´traffic light yellow´) means that it is partially met, and light grey colour (´traffic light green´) that the adaptability indicator is met.

For case 1, the only indicator that is met in all but one apartment is indicator 3, i.e. there are two or more orientations in the apartment, a principle which promotes a dwelling's ability to adapt (Živkovic & Jovanovic, 2012, p. 20). However, in all cases, other reasons prevent the realisation of adaptability (Table 2). Despite one-bedroom apartments being reasonably sized (45–55m^2) and including different variations of open plan layouts with a separate bedroom, only types 1C and 1D enable changing of the 'intimate rooms', as shown in Table 2. However, this is not without problems: while a two-bedroom option is possible in apartment 1C, this creates an impractical room shape (if the bathroom area does not change). Moreover, in the original case 1C, the presence of several windows on the long exterior apartment wall allows the division of the spaces into separate

EXISTING UNIT: ADJUSTABILITY EVALUATION - Building case 2				
Case	Task: Recognition of support and infill	Indicator 1: Is it possible for a dweller to add an ´intimate room´?	Indicator 2: Is it possible for a dweller to change the connections in the ´main living space´?	Indicator 3: Are there two or more orientations in the apartment?
2B 48m²				
2C 59m²				2 orientations, 2 facade planes
2D 70m²			yes, but consequences (room demolition or large wasted area) 	2 orientations, 2 facade planes
2E 84m²				2 orientations, 2 facade planes

1 2 3 4 m

TABLE 3 Existing case 2: adjustability evaluation. The dark grey colour (´traffic light red´) indicates that the adaptability indicator is not met; middle grey colour (´traffic light yellow´) means that it is partially met, and light grey colour (´traffic light green´) that the adaptability indicator is met. Dotted line in plan indicates challenges in meeting the indicators. The separate kitchens are highlighted with hatched pattern. The arrow indicates the apartment entrance.

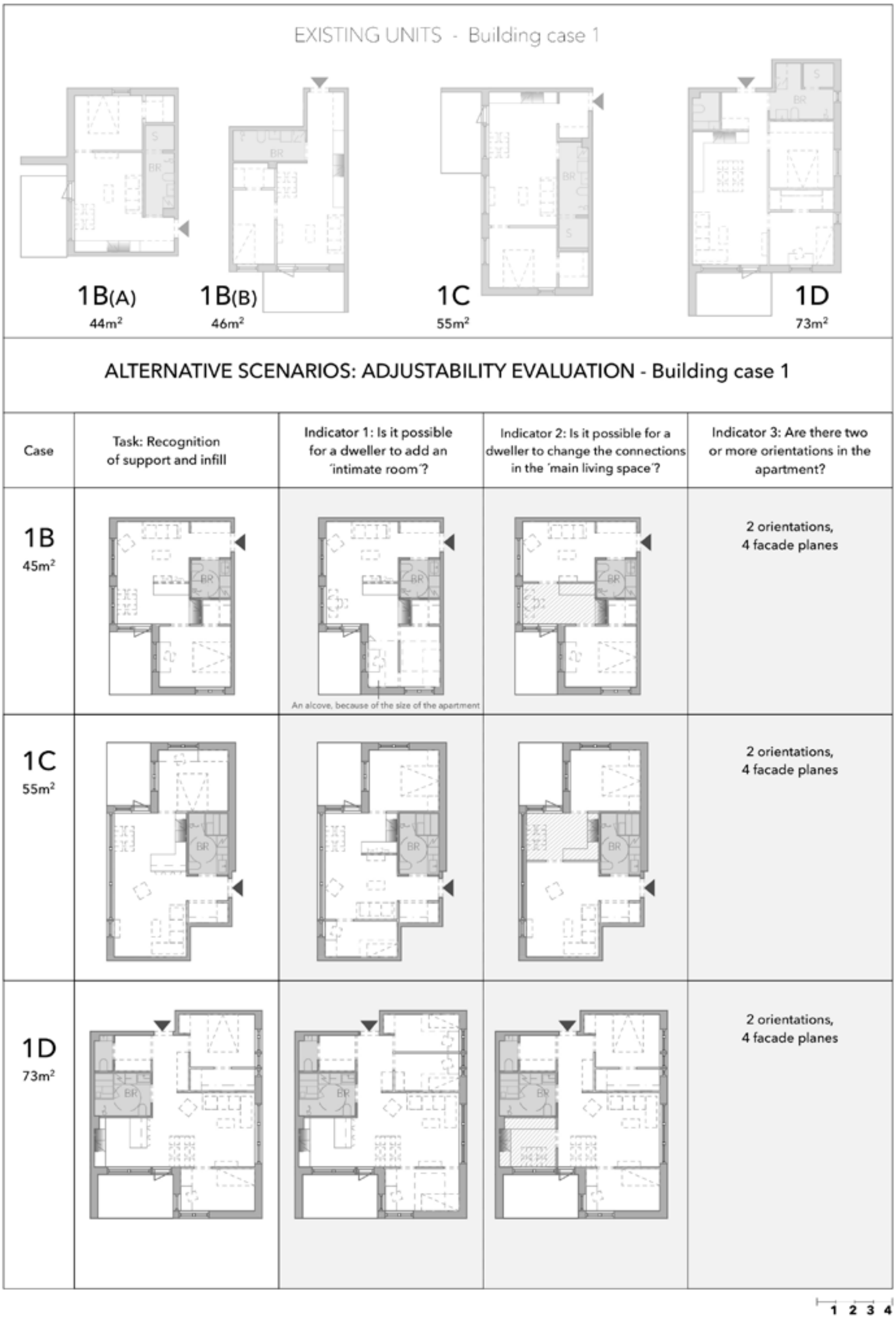
kitchen and living areas, although at the expense of creating a large wasted circulation space near the entrance.

The larger two-bedroom apartment 1D could in principle support adaptability in terms of changing the number of 'intimate rooms', though in this case, room daylight would be compromised by a remaining single small window, located in a non-optimal position. In common for all cases, the window placements, in relation to the apartment shape and size, limit the further separation of the 'main living spaces'. For example, in apartment 1D, the kitchen area cannot be separated from the living-dining room, because in doing so, there would be no daylight in the kitchen. So while there is some adjustment potential in some of the units, the adjusted layouts are not optimal to enable adaptable living environments of good quality to accommodate dwellers' changing needs.

As Table 3 highlights, the efficiently organised apartments along either side of the middle corridor in case 2 are difficult to change. In common with some of the smaller case 1 apartments, narrow room shapes and deep plan layouts, as well as the existing window opening placements, hinder future adaptability possibilities. Therefore the 'main living spaces' cannot be split in any of the case 2 apartments by the dwellers, because the kitchen is dependent on the natural light of the living room space. Even the larger apartments (2C and 2E) offer little adaptability potential for the reasons described above. While building case 2 includes many single-aspect apartments, these are mainly small units not evaluated here. Most of the remaining larger apartment types meet indicator 3, i.e. there are two or more orientations in the apartment. Yet, despite meeting indicator 3, their window placements or deep plan configurations mean that the adaptation possibilities of indicators 1 and 2 are hindered. Case 2 illustrates that different adaptability indicators seem dependent on other dwelling quality parameters, specifically related to good daylighting conditions from an increased number of windows and with less deep apartment plans.

Evaluation of alternative adaptability scenarios

Given the generally less than optimal adaptation potential of the selected cases, research-by-design exercise explored how the apartments could be optimised for better adaptability. This led to a re-proportioning of the units and buildings (i.e. significant change of the 'support') to enable a variety of adaptability 'infill' scenarios with the same apartment basic qualities, floor area and number per floor. Per focus apartment, one new 'support' was created, and its adaptability potential was illustrated with alternative 'infill' scenarios. Tables 4 to 5 illustrate the evaluation of these new scenarios against the previously identified evaluation indicators.



ALTERNATIVE SCENARIOS: ADJUSTABILITY EVALUATION - Building case 1

Case	Task: Recognition of support and infill	Indicator 1: Is it possible for a dweller to add an ´intimate room´?	Indicator 2: Is it possible for a dweller to change the connections in the ´main living space´?	Indicator 3: Are there two or more orientations in the apartment?
1B 45m²		An alcove, because of the size of the apartment		2 orientations, 4 facade planes
1C 55m²				2 orientations, 4 facade planes
1D 73m²				2 orientations, 4 facade planes

TABLE 4 Adjustability evaluation of the scenarios for case 1. The light grey colour (´traffic light green´) indicates that the adaptability indicator is met. The separate kitchens are highlighted with hatched pattern. The arrow indicates the apartment entrance.

EXISTING UNITS - Building case 2

ALTERNATIVE SCENARIOS: ADJUSTABILITY EVALUATION - Building case 2

Case	Task: Recognition of support and infill	Indicator 1: Is it possible for a dweller to add an 'intimate room'?	Indicator 2: Is it possible for a dweller to change the connections in the 'main living space'?	Indicator 3: Are there two or more orientations in the apartment?
2B 48m²				2 orientations, 2 facade planes
2C 59m²				2 orientations, 4 facade planes
2D 70m²				2 orientations, 4 facade planes
2E 84m²				2 orientations, 2 facade planes

1 2 3 4m

TABLE 5 Adjustability evaluation of the scenarios for case 2. The light grey colour (´traffic light green´) indicates that the adaptability indicator is met. The separate kitchens are highlighted with hatched pattern. The arrow indicates the apartment entrance.

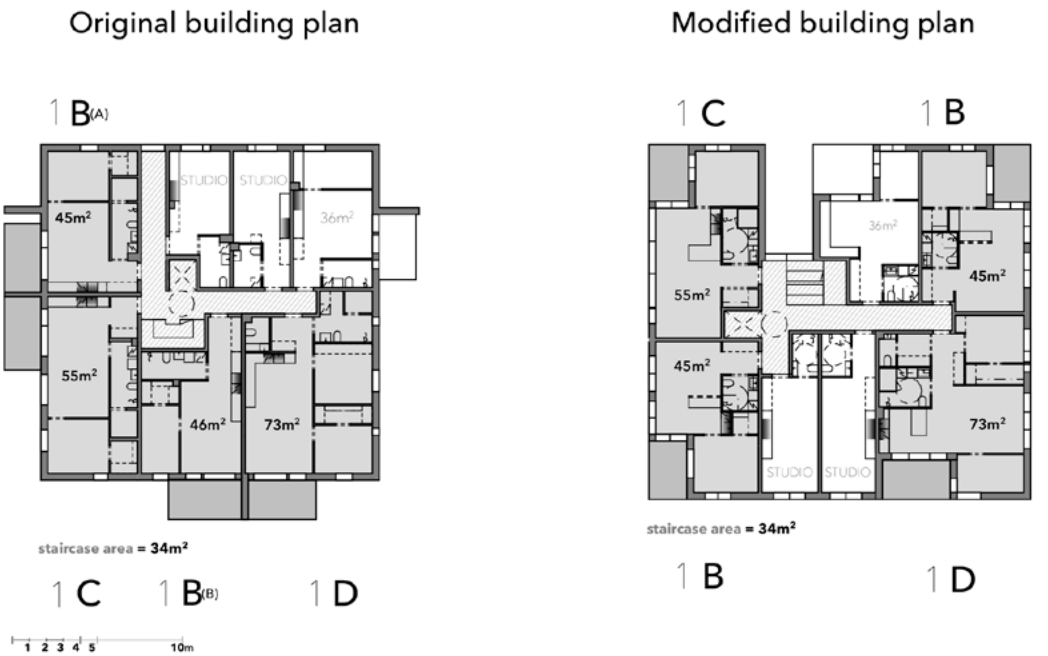


FIGURE 4 Case 1, the original building plan on the left and the proposed modified building plan on the right. The grey colour highlight the focus apartments in this study. The staircases are highlighted with hatched pattern. The adaptation potential of cases is separately evaluated in Tables 2 and 4.

Following on from the adaptability evaluation of the existing cases, an increase in window numbers through additional apartment orientations was explored as a means to improve adaptability. This required a combination of other changes, such as reduction in overall plan depth and/or changing the plan shape and proportions, sizes and location of windows, resulting in a change in building typology. All alternative options now meet all adaptable indicators in all cases (Tables 4 and 5). The spatial modifications that illustrate possible improvements to the apartment's adaptability potential are discussed in more detail below. These modifications are grouped in two main themes, i.e. change of the apartment 'support' and change of the building 'support' as a result.

Changing the apartment plan shape and proportion:

As described above, the apartment plans were changed to enable improved adaptability by providing more interior spaces with a window, creating a better link between the interior and exterior spaces, which is also highly valued by dwellers (Kuoppa et al., 2019). Often this meant a change from a rectangle to a multi-angular, more complex apartment plan shape, where the balcony can be, for

FIGURE 5 Case 2, the original building plan on the left and the proposed modified building plan on the right. The grey colour highlight the focus apartments in this study. The staircases are highlighted with hatched pattern. The adaptation potential of cases is separately evaluated in Tables 3 and 5.

example, indented to the apartment.[2] These multi-angular plan modifications allowed for more facade planes per apartment, enabling more spaces to have direct access to natural light and dual-aspect 'main living spaces'. Specifically, this allowed for both an open-plan 'main living space' and a separated living and kitchen area in the apartments, with the kitchen having access to an

2 In this case, careful window position and daylight considerations need to be undertaken when doing so, especially when enclosing the balcony with glass walls.

external window, instead of being part of the main circulation space near the entrance. Due to this, in case 2, the kitchen areas are generally moved further away from the entrance.

Reshaping or changing the building block typology:

To achieve improved adaptability, alternative plan proportions were created to provide more windows to the interior spaces, which had implications for the building block design and for how individual plans related to building access through staircase and corridor configurations.

In the modified case 1, the building remains a central stair core building[3], and the proportions of the building block are not significantly affected by this alteration (Fig 4). However, in case 2, the depth of the existing building (over 17.5m, and 22m with balcony depths), and a majority of single-aspect apartments that are deep in plan, create a difficult starting point for improving adaptation potential, as highlighted earlier. Therefore, this building type was significantly altered: a new elongated slab building typology was suggested (Fig 5). This includes increasing stair and lift cores, and avoiding the long middle corridor to create more apartments with two or more orientations. While this is likely to increase both construction costs and the thermal envelope (increasing energy use), it significantly improves natural light and natural ventilation conditions, and also improves solar gains, thus fostering residents' health and well-being (e.g. Boubekri, 2008; Beute, 2014). The need for a cost-benefit analysis of the adaptability scenarios has been highlighted as the focus of future research. This significant shift in building typology also has site and city plan implications, as further discussed below.

Discussion, generalisability and further research

This study highlighted that the majority of the 60 residential properties in Finland were based on a middle corridor solution, where several apartments are deep in plan and single aspect. The results indicated that improving daylighting conditions, avoiding deep plan configurations, increasing apartment orientations, and placing windows in a considerate way, would positively affect the future adaptability potential of the apartments (see also Živkovic & Jovanovic, 2012; Wong, 2010). It would also be highly valued by residents due to the increased connections between interior and exterior spaces, and better lit apartments (Finlay et al. 2012; Kuoppa et al., 2019). These changes could also promote residents' health and

3 In the building scenario presented, the staircase and the facade wall are located next to each other, increasing the external envelope (and hence affecting heat loss). However, the building would also function so that the staircase window could be part of the straight northern facade.

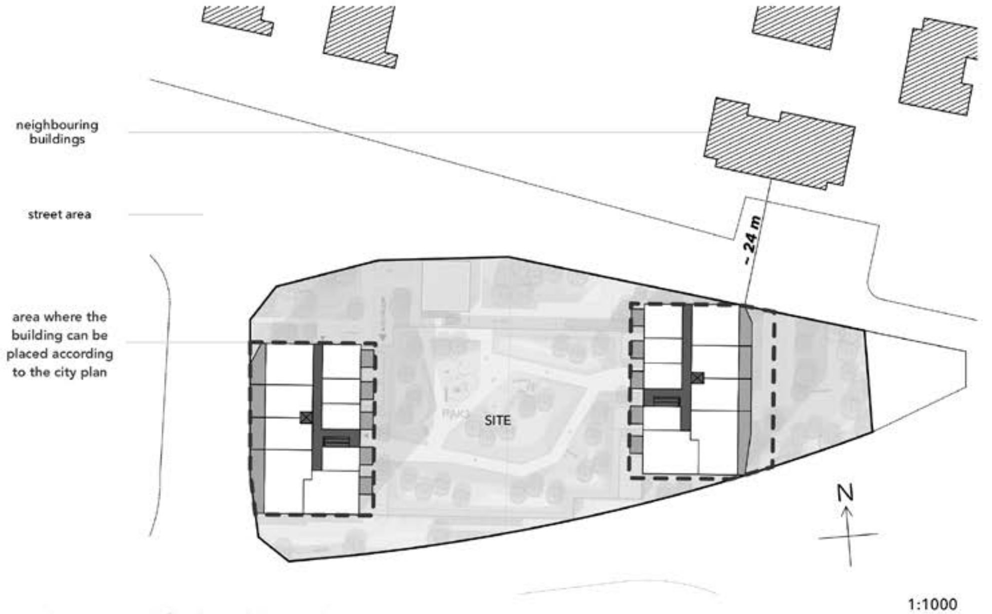
well-being (Boubekri, 2008; Beute, 2014). The study confirms the importance of apartment orientations to promote the adaptation potential (Živkovic & Jovanovic, 2012, p. 20), but it also highlights that this alone is not enough if other factors of the building 'support' do not assist adaptability (e.g. cases 1C, 2C, 2D and 2E). Specifically, the number and location of windows are crucial for adaptation potential (also Wong, 2010). Moreover, corner entrances to apartments appeared to be problematic for adaptability aims in larger apartments. This is because such design resulted in dark entrance spaces with long, often L-shaped corridors that are not only difficult to furnish and use, but also difficult to adjust to suit other uses. The change of plan shape also revealed an important relationship with entrance access and building services: removing wasted corridors in the entrances, by placing the entrance more centrally, made it possible to enlarge the 'main living spaces', which is also highly valued by residents (Finlay et al., 2012).

In summary, the alternative adaptability scenarios illustrated that it is possible to design solutions that are more adaptable for the same sites, in the same apartment sizes. These changes also have other consequences, which will need to be considered to fully assess the implications. For example, the alternatives scenarios increase the thermal envelope, and at the same time provide better daylighting, and depending on orientation, better solar access that could lead to increased solar gain. These factors may offset each other and need to be explored with an energy model to be fully understood. The alternative scenarios might increase construction costs for material and labour, and operational (in-use) costs related to potential increased heat loss. Yet, previous research suggests residents value flexible layouts and good daylighting (Finlay et al., 2012; Kuoppa et al., 2019). The comparison of the capital (and in-use) cost versus rental or sale income as a cost-benefit analysis was excluded in this study, but noted for valuable further research. Indeed, further research is needed to fully understand the economics of these alternatives. Finally, a change in the overall apartment and building block proportions might have significant implications for land use. For instance, the city plan encouraged the building typology of case 2 with its deep and problematic proportions and depth of plan (Fig 6). The alternative scenario for case 2 challenges the city plan, yet it does not detrimentally affect lighting conditions or neighbours' views and would also not detrimentally affect the quality of the outdoor common space (Fig 6).

Generalisability of the results and further research

Seeking statistical significance of the results, which were obtained from research-by-design and a small, purposively selected sample of case studies, in the wider Finnish housing stock is neither possible (Robson, 2011; Flyvbjerg, 2006), nor the

Land use, original building plan (case 2)



Land use, modified building plan (case 2)

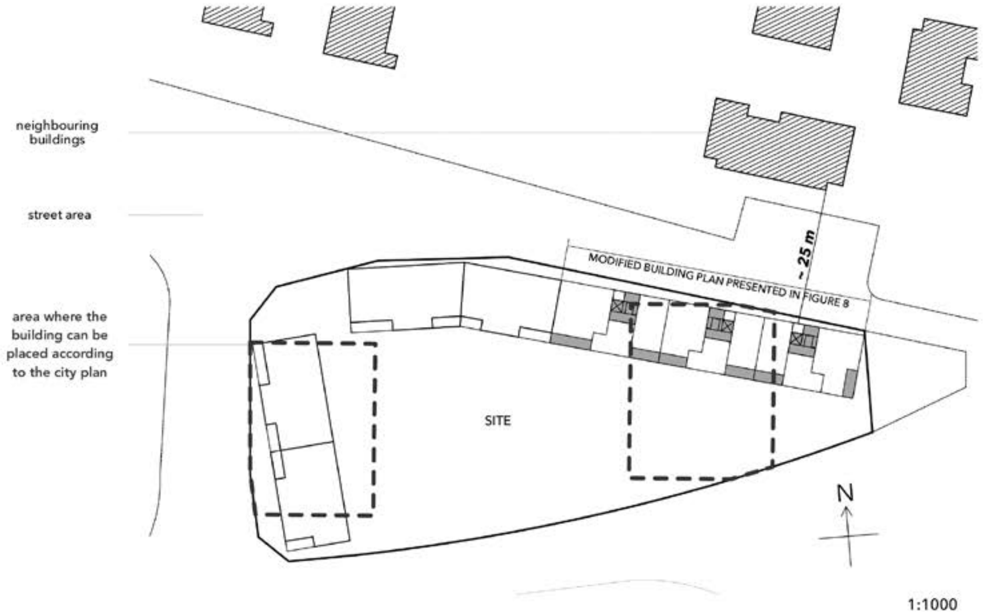


FIGURE 6 The top image presents the current land use and city plan of case 2. The lower image illustrates the modified building plan scenario and how it can be situated on the site. In both images, the thick dashed line represents the construction boundary guided by the city plan. Adjacent neighbouring buildings are highlighted with hatched pattern. The comparative pictures highlight that despite the significant building type change, this is not at the expense of site-use efficiency (i.e. the same number of built square metres can fit on the site).

purpose of this study. While the study findings are specific to the individual cases, they provide conclusive empirical proof that deep plan, single-aspect apartments do not provide an adaptable plan, especially when the window number and placement is not well thought out. These results provide a critical lens to view the wider future Finnish housing stock to understand their potential for adaptability. Additionally, the use of Habraken's (1972) concepts of 'support' and 'infill' were successfully applied to evaluate future housing construction. Moreover, the evaluation indicators (Table 1) were provided as a tool to evaluate the adaptability of existing and planned apartments, enabling future researchers to undertake a study of this kind. These results suggest future research into the effect of housing typologies, shape and especially depth of dwellings through a more quantitative study with a larger data set, in addition to the energy implications and cost-benefit analysis mentioned above. Further research might also refine the indicators in Table 1.

Conclusion

The potential for user adjustments in apartments is central to the concept of adaptable housing. The study evaluated and further developed the adjustment potential of two cases that represent a broader set of current housing cases in Finland. In-depth analyses were used to identify qualities of apartment 'support' that promote or prevent 'infill' adjustments. Generally, the selected cases lack the capacity to accommodate spatial changes, despite flexibility and adaptability having been regarded as a recommended goal in the development of Finnish urban housing (Hakaste, 2015). This suggests that even though knowledge of adaptable architecture has increased significantly, it has seemingly not influenced actual housing design. Alternative adaptation scenarios of the cases were generated, illustrating how careful design considerations can allow for spatial adaptability within the same apartment size. This study highlighted not only the importance of orientation and number of windows, but of the appropriate positioning of windows together with shallow plan designs. The results indicate that daylight provision, determined by building 'support' features, is a precondition for enabling apartment adaptability.

The study also highlighted that building typology, plan depth and shape, which are influenced by the city plan, can enhance or hinder housing adaptability, and thus, long-term sustainability. Especially, this is shown in building case 2, where significant modifications were suggested to the entire building block configuration. While modified building 2 can still be accommodated on the building site, it challenges the city plan (Fig 6). This highlights the often under-acknowledged inter-relationship between the different scales of the urban plan, the building typology and the apartment plan, all of which affect the quality of the dwellers' living environments. Living environment considerations do not only need to be considered at 'infill' and 'support' level, but also at 'urban design' level, as the city plan enables or hinders certain housing design possibilities (Habraken, 1998). While a city plan indicates where a building can be placed, the developer does not need to build to the extreme edges of this plan. Nevertheless, high land prices encourage the developer to use all of the building rights, leading to deep building types, which proved problematic in this study. Hence, acknowledging this reality in policy decision-making, through different proportioned city plans, or by including other criteria that safeguard good living environment conditions, would better promote housing quality now and in the future. Considerations of living environment qualities need to be embedded at all scales and design stages. This is illustrated by case 1, where building proportions were more supportive of better living environments, though this potential was not fully utilised in its housing design.

Finally, of concern is that deep buildings with middle corridors made up around 40% of the 60 mapped cases in this study. This building type is a relatively new entrant to the Finnish residential urban building typology, but it is currently popular, possibly due to its plan efficiency and reduced construction costs associated with a deep building depth along with a single stair and lift core (Pitkänen, 2009). However, this building typology was shown to be problematic in terms of dwelling quality and adaptability aspects. If these findings are representative of the wider (future) housing stock, this risks 'locking in' poorly daylit housing that is unable to accommodate user changes for years to come.

It is worth remembering that dwellings affect their residents' health and well-being and are valuable property, not only to their users, but also to society: the housing stock forms a significant part of the wealth of nations, outlasting human generations. The findings of this paper highlight that through certain design considerations, housing can enable changes in time to support dwellers' different life stages and needs, while simultaneously improving the living environment.

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