Abstract

According to inhabitants' dimensions and various aspects of human life, flexible spaces are used as a solution in social housing due to the lack of space that architects always confront. In fact, flexible housing responds to inhabitants’ needs throughout time. In other words, it evolves from the change in residents' requirements and promises adaptability to their living conditions. This spatial adaptability replaces spatial hierarchy and enhances life quality. The main purpose of spatial organization is to plan an interior space in order to create functional efficiency in a dwelling layout. This study attempts to research less-focused concepts so as to establish guidelines for future flexible housing design. Encompassing two case studies regarding Dutch housing, this study aims to understand how interrelated space planning enhances spatial arrangements to achieve an efficient spatial configuration. Spatial organization is delved with in depth to understand how functional efficiency can be achieved in flexible housing. Finally, interrelated spatial organization is believed to contribute to placing spaces according to their function by creating a multilateral relationship that responds to the inhabitants’ ever-changing needs.

Keywords: flexible housing; functional efficiency; spatial organization; flexibility.

INTRODUCTION

Residential housing was the first form of architecture that people built for themselves. The primary structural behaviour of the first communities was nomadic or semi-nomadic and their settlements were temporary and movable. Once the first cores of the cities arise, the construction of housing as buildings began; later on, nevertheless, their basic characteristics changed only in inessential features (Förster, 2006). In fact the dwelling as a settlement, throughout the history of humanity, has been the basis of indigenous societies and cultural development. Housing is always influenced by living habits, cultural boundaries and environmental conditions. A house is designed based on the combination of comfort and safety and also a sense of belonging to a dwelling space (Mohamad Mahdi Shabani, Tahir, Shabankareh, Arjmandi & Mazaheri, 2011).

Nowadays, architects not only focus on designing the facade composition and the geometry of the floor plan; they also take into consideration subjects such as the organization within and around the dwelling, the private and public space, the importance of spatial function and domestic structure, the gendered character of interior and exterior spaces, the influence of consumption patterns regarding spaces and decoration, the ways in which space is organized and many other aspects of the occupants’ experiences (Lane, 2007). The main concern with respect to the conditions of the industrial cities was the low standards endured by many urban residences. All of the members of a family would usually inhabit a single room and share unsuitable bathrooms and kitchens with many other people. Even in the early philanthropic houses, where their undertaking and standards were generally good, kitchens and bathrooms were commonly shared. The main purpose of dwelling renovation in the twentieth century is to move from this situation and reach good space standards in housing design (Towers, 2005).
LITERATURE REVIEW

"The prognosis for proponents of modernist design and process was to generate flexibility in the design process. Hill (2003: 32) suggests that flexibility has many meaning nuances, but that it originally refers to the accommodation of changing relationships between events, contexts, and the use of space. The most common meaning of it is flexibility by technical means, which, as Forty (2000) states, can be understood in relation to a couple of types. The first one is flexibility by movement or the reconfiguration of the dwelling’s intricate elements. The second type of technical flexibility refers to the use of lightweight demountable fixtures and fittings, and movable floors, walls and ceiling panels, including open-plan design. Flexibility by means of moveable parts and/or open plan is, for Hill (2003), as much a description of use as it is of form, and it is characterized by a versatile combination between space and use. The flexibility of a space depends in part on the user, or, as Hill (2003:38) suggests, the change of use may well be less dependent on a physical transformation of the space than a change in the perception of the user" (Imrie, 2006).

The concept of flexibility in the context of architectural housing is introduced under two topics: "the evolving conditions of the vernacular" and the "external pressures that have prompted housing designers and providers to develop alternative design solutions, including flexible housing" (Schneider & Till, 2007). According to this, it can be claimed that flexibility in domestic architecture either evolves and improves from the experience of traditional tendencies in housing design or appears as a new design tendency which follows the outward forces of the twentieth century (Albostan, 2009). For example, the main idea of spatial configuration employed in traditional Malay housing is associated with social and cultural patterns, and religious values. The most prominent feature of these houses is their spatial flexibility. The open plan with minimum physical boundaries offers flexibility to the space (Abdul Rahim & Abu Hassan, 2012). Additionally, flexibility is a feature of traditional courtyard housing which is an epitome of introverted structures in Iran (Nosratpour, 2012). In fact, creating different types of space for different functions implies that these houses intend to fulfill family requirements according to their lifestyle throughout time (Arjmandi, Tahir, Che-Ani, Abdullah, & Usman, 2010).

In fact, flexibility as a solution, in today’s social housing, is an issue that has been considered on different levels throughout time in eastern architecture. In Japanese traditional architecture, sliding doors have the finality of separating spaces as well as changing the dimensions of these in the house. As a result, multi-functional spaces are created by opening them up. (Shabani, Tahir, Arjmandi, Abdullah & Usman, 2010).

For instance, in the rural house designed by Kazuhiko and Kaoru Obayashi in Osaka bay, "The actual flexibility and adaptability of the dwelling is completely dependent on the active participation of its users (as well as a specific type of furniture): by pulling out futons from a storage cupboard, a room that is used as a dining or sitting room can be transformed into a bedroom; the minimal use of furniture and the relative lack of untidiness demands discipline in order to achieve flexibility, which may be beyond normal living patterns, but nonetheless the principle remains. Flexibility is also enabled by means of a modular approach to design. The size of the rooms is based on the standard dimension of tatami mats; the house has rooms made up of a set of these mats. The openness of the plan as well as the frame construction suggest that functional and social changes can be dealt with easily - both on a daily basis as well as on a periodic or even longer term. Connections between rooms can be undertaken by opening or closing sliding screens, which can change the size and function of a space in a matter of seconds: two individual rooms can be united by simply opening up two large screens so that a couple of small spaces become one large room that can be used either for a specific festivity or for a family gathering" (Figure 1) (Schneider & Till, 2007).
Designing Flexible floor plans has been experimented since 1920. Particularly the Netherlands has a long and ongoing tradition to which great architects such as Rietveld, Stam, Van Doesburg, Van den Broek, Van Tijen, Habraken, Hertzberger and Van Eyck, and also the most recent generations, have made their innovative contributions. However, the spirit of flexibility appeared to flow throughout Europe in this century and the Netherlands was the country where this subject was systematically integrated in the construction development of social housing and where it has never completely disappeared from sight since then (Van Eldonk & Fassbinder, 1990).

RESEARCH METHODOLOGY
The manner in which interrelated space planning enhances spatial arrangements in order to achieve an efficient spatial configuration will be corroborated in this article. The main goal of this paper is to develop functional efficiency by means of improving spatial organization in flexible housing. This approach helps achieve adaptability between domestic space and life, and ultimately enhances the quality of life. The evaluation method is based on floor plan analysis encompassing two case studies of Dutch modern social housing; the Vroesenlaan apartment blocks designed by the Dutch architect J. H. van den Broek in the Blijdorp neighbourhood of Rotterdam (1934-35) and the Bergpolder apartment building designed by the Dutch architect Willem van Tijen in the north of Rotterdam (1933-34).

STATE OF THE MATTER
"At a basic level the case of flexible housing is a straightforward matter of common sense. Why, to put it simply, would one not design in terms of flexibility and adaptability? Housing is volatile, - subject to a whole range of cyclic, non-cyclic and tendency changes-, and if it is not able to respond to these changes it becomes at best unsatisfactory, at worst obsolescent. Yet, despite
the fact that a dwelling is inevitably dynamic, it is often framed intellectually and physically as something immobile. In fact, one of the problems of treating housing as if it were a static commodity with rigid design parameters is that it reaches a world of changing demographics. A mix of units that meet immediate demand might well be inappropriate in thirty, let alone one hundred, years’ time. Thus, over the past twenty years there has been a decrease in the number of traditional family units, a higher proportion of elderly people, an increase in the number of single-person households, a rise in the demand for shared accommodation and a growing move towards home-working. Statistical data shows that these tendencies will probably continue into the next decades, though they will be overlapped by as yet unseen and uncertain demographic developments. Probably the only thing that one can state with any certainty is that the needs of housing at the end of the twenty-first century will be different to the requirements and desires today; the necessity for housing that can adapt to these changing demographics becomes compelling. Changing demographics require new architectural solutions that incorporate flexibility into emergent types of housing. Housing should also respond to the internal changes occurring during the lifetime of its inhabitants. These internal micro-changes come at a housing unit level. If it cannot adapt then the inhabitants will have to move home, which is both financially and socially disruptive. Housing has to be flexible enough to deal with two conditions. Firstly, the necessity to adapt to the changing needs of individuals as they grow old or become less physically capable. Secondly, a dwelling that can respond to the changing constitution of a family as it grows and then later on contracts (Schneider & Till, 2007).

Nowadays, as in the past, we build or change houses in order to respond to our requirements beyond it being a basic refuge. In turn, due to the fact that dwellings are a physical space, they impose limitations on their inhabitants and at the same time create opportunities for them (Ward, 1999). The evolution of the private habitat is an intrinsic feature of human beings. Housing is the means where inhabitants have the most environmental intervention power because it is the first factor of relationship with the environment. It is the place where inhabitants and their needs are encountered. Any alteration, change, creation or modification is an attempt to reach the sense of belonging to a place. A home is a place where family life occurs, as a series of changing or permanent conflicts. The heterogeneity of living life makes each house a customizable, unique and unrepeatable place (Valenzuela, 2004).

Architects now pay considerable attention to the users of residential units whose creative motivations have an influence on their homes. According to past experiences which have seldom been recognized, the inhabitants of a dwelling, including the owner or the family group who resides there, shape their homes. Sometimes they design and build them by themselves. At times they design them, and employ a carpenter, builder or architect. From time to time they influence the design by choosing out of a series of patterns. Nevertheless, inhabitants always modify and remake their home spaces by rebuilding, decorating, furnishing, remodelling, landscaping or simply by dwelling within the forms and spaces of domestic architecture. Therefore, the places where people inhabit are comprehended as a space in which to illustrate the ideas of family, individuality, lifestyle, privacy and socio-cultural patterns; to create, in other words, the general cultural patterns of an era (Lane, 2007).

Spatial organization influences the way in which family members find themselves inside a dwelling or within a building. The distribution and arrangement of space is a building aim and not just its physical objective. Put another way, buildings are not just objects, but transformations of space by means of objects. As a consequence, configuration is a fundamental relationship between form and space, which is appropriated in the processes, by which buildings are transformed from physical objects into social and cultural objects. In both senses, society acquires a definite and recognizable spatial order (Abdul Rahim & Abu Hassan, 2012)

"…Market research in the Netherlands has shown that people are more likely to stay in their homes if they can adapt them, and by a corollary high percentage want to move because they cannot adjust their dwellings to their needs” (Danko, 2013). Therefore, applying users’ ideas
in the planning and designing processes of the dwelling is a way to find out the relation between people’s expected needs and their upcoming ones. This enhances the adaptability of the dwelling to the needs of its occupants and consequently their satisfaction. Providing adaptability and flexibility to dwelling spaces according to different lifestyles is a feature of the ideal home (Abbaszadeh, Kalani Moghadam & Saadatian, 2013).

Frank Bijdendijk, Director of the Amsterdam Housing Corporation, argues that without the love and pride of its inhabitants, a building is not assured a long life even when the flexibility requirement is met. To gain its users’ love, a building need not necessarily meet standards which are popular among architects. However, it need not be in conflict with them either. "The meaning of what an architecture loved by its inhabitants is, is no doubt debatable, but the requirement needed unmistakably connects architecture to the quality of the everyday environment" (John Habraken, 2008).

Furthermore, "Flexible housing directly addresses issues of social and economic sustainability. Social aspects are not only sufficed by the user’s involvement, but also by the capacity of flexible housing to accept demographic change and thus stabilise communities. The economic aspects are addressed by means of the long-term vision that flexible housing engenders through future-proofing and avoiding obsolescence. The beauty of flexible housing is that if one follows through its principles and combines them with a response to climate change, one almost inevitably reaches a sustainable solution that integrates the complete range of sustainable issues; however, the green rhetoric is a quiet one that eschews the superficial gestures of some types of sustainable architecture. Flexible housing potentially exceeds the accepted definition of sustainability — providing for the needs of the present without compromising the ability of future generations to meet their own needs — in as much as it is not about avoiding future compromise but encouraging the coming change" (Schneider & Till, 2007).

Flexible housing is aimed to conceive appropriate spaces for inhabitants with diverse lifestyles. In this manner, the ability to respond to users’ demands, starting from the very beginning of the dwelling’s occupation and lasting over time, can be considered as the main objective of flexibility in the context of domestic architecture. In other words, flexibility creates adaptable residential spaces according to the requirements of inhabitants with different lifestyles. Flexibility and adaptability, in this sense, are closely associated (Albostan, 2009). The primary intended scope of flexibility in domestic architecture is the creation of a building that can remain in use longer due to being able to satisfy current requirements rather than being used under an external drive. The advantages of flexibility include the capability to fulfil its objective in an ameliorated way by accommodating the occupant’s intervention, accepting new technology and being more economically and ecologically viable. Accordingly, these buildings can respond to these alterations by adapting their use or function (Geehee Yu, 2011).

THE PURPOSE OF FLEXIBLE HOUSING
Flexible housing is identified as a planning choice in the design phase of domestic architecture; either both in terms of construction and social use, or designed for change over its lifetime. The degree of flexibility is highlighted in two ways. First of all the in-built opportunity for adaptability, defined as enabling different social uses, and second the opportunity for flexibility, defined as enabling different physical arrangements. The incorporation of flexibility into the design allows architects the illusion of designing their control over the building in the future, beyond the period of their actual responsibility for it (Schneider & Till, 2005).

In fact, flexible housing is a layout that can be adapted to inhabitants’ requirements and will lead to carrying out their expectations and demands with their own collaboration. Inhabitants’ collaboration in this process will finally result in increasing the general satisfaction of the users (Zandiyeh, Mehdi; Eghbali, Seyed rahman; Hesari, 2012). In general, a flexible house is a dwelling layout that can adapt to changing requirements and patterns, both social and technical issues. These changing demands may be technological (e.g. the updating of old services),
practical (e.g. the onset of old age) or personal (e.g. an expanding family). The changing patterns might be demographic, environmental or economic ones. Hence, flexible housing undertakes all of the housing development process. In fact, flexibility in domestic architecture allows its’ inhabitants to take part in the design process of the different possibilities of using their living space. Therefore, inhabitants have the opportunity to carry out adaptations to their home spaces (Schneider & Till, 2007).

Flexibility, as a helpful and effective method, has been utilized in different architecture spaces to reach functional efficiency. It has a comprehensive function in architecture that can be defined by open plans and sections, and by portable and changeable elements or furniture. Flexibility as an initial solution, in today’s modern social housing, is a subject that has been employed in different levels throughout different time periods. The Dutch architect, Herman Hertzberger, said that when flexibility became the catchword, it was the panacea to cure all of the illnesses of architecture (M M Shabani et al., 2010).

CASE STUDY 1: VROESENLAAN HOUSING COMPLEX
The Vroesenlaan apartment blocks, designed by the Dutch architect J.H. van den Broek and built by the housing association De Eendracht in the Blijdorp neighbourhood of Rotterdam, have become a symbol of modern architecture (Komossa, 2005). J.H. van den Broek was one of the protagonists and forerunners of flexible design. He stated that by means of a more efficient spatial arrangement of the floor plan and by integrating folding beds and sliding walls, the housing dwelling typology could become smaller without losing comfort (Schneider & Till, 2007). In this housing complex, three characteristics of modern architecture have been incorporated: 1) An open block structure, in which one head end of the block is eliminated and the corners are opened up. 2) A modern spatial hierarchy that organizes the floor plan in order to achieve day and night use. 3) A facade design which was revolutionary for its time, with large glass areas and a concrete skeleton with yellow brick filling the open spaces. When designing these housing blocks, the architect replaced the closed urban block for three wings, arranged around a courtyard which is like an ornamental garden. The corners are open, omitting in this manner the corner flats with poor sun light. The U shape form created is open towards the direction of Vroesen Park, so that all of the dwellings have a view of Vroesen Park from the rear. The dwellings on the street side are 9.5 meters deep and 7.5 meters wide. All of the apartments have four rooms and the area of each dwelling is about 72 m² (Komossa, 2005). The floor plan was designed to respond to the family’s changing needs. The small corridor, which is close to the entrance in the centre of the floor plan, has three doors. One gives access to the kitchen. The other two doors, which are next to each other and separated by a short stretch of wall between them, give access to a long space. The extended central space that functions as a living / dining and study room can be divided into two rooms of the same size by means of sliding doors (Figure 2). The room next to the kitchen is designated to be a dining and living room and the rest of the area is dedicated to a study room, although these functions may be changed throughout time. The study room can be converted into a bedroom by folding down beds that were incorporated into the design (Figure 3) (Schneider & Till, 2007).
On the other side of this extended space, there is a sequence of sliding doors that separate the living and dining room from a small room, one door, a short stretch of wall, another door (which mirrors the disposition on the opposite side of the room) and then a longer partition wall. Behind the two doors, there is another small corridor that has another four doors. One door opens to the room next to the dining and living room, the second one provides access to the bathroom, the third one leads onto the rest room, and the last one provides access to the only existing bedroom of the house (Schneider & Till, 2007).

Actually, the architect proposes day and night use, entirely in the analytic-functionalist tradition. Opening the sliding doors during the day and folding the parents’ and older children’s
beds into built-in cabinets, providing an L shape living space with a sitting room and a playroom for the smaller children. The kitchen is designed to be efficient and minimal with a long Cabinet. It also has a door that opens onto the balcony, where the coal box is located (Komossa, 2005).

CASE STUDY 2: BERGPOLDER APARTMENT BUILDING

The Bergpolder apartment building was constructed between 1933 and 1934, it is considered a pioneer social housing block due to its height. The Bergpolder block is built in a working class area, in the north of Rotterdam (Martí Arís & Alegre, 1991).

The Dutch architect, Willem van Tijen, had a passion for designing empirical social housing. This building was one of the series of high-rise housing projects that Van Tijen designed in Rotterdam. The block includes 72 flats for small working-class households destined to couples or families with young children. It has nine floors with eight apartments per floor. They all follow the same type of floor plan design with an area of approximately 50 m². The spatial design of the Bergpolder flats is quite simple. Each floor is formed by four pairs of mirror-like flats which are accessed via a gallery (Barbieri, van Duin, de Jong, van Wesemael, & Wilms Floet, 2003).

The architect carried out a careful study in order to achieve efficient space in the flats. He wanted the flats to be practical and to create a roomy space sensation in them in spite of their small size. He also adopted the principles of a day and night floor plan. The flats dimensions are 8.2m deep and 6.2m wide, and have a clear height of 2.55m (Figure 4). Its spatial organization has been designed as follows: acceding from the gallery, one enters a corridor in which on one side is the kitchen and on the other side is the rest room as well as the bathroom. The corridor connects the entrance to the living room, which has a store cupboard on one side and on the other side a door that opens onto the children's bedroom (Figure 5). The master bedroom and the living room adjoin the balcony. They are kept separate from each other by a glass sliding door. During the day, the beds swing up into the wall and the sliding doors are opened (Barbieri et al., 2003).

Figure 4. Plan view (Source: Authors)
Glass sliding doors and folding beds create the possibility to use the flats in two different ways. During the daytime, the beds are folded up and the master bedroom joins the living room space; and the glass sliding doors are closed at night time (“Architecture in Rotterdam” n.d.). In fact, this separation via sliding doors allows improving the function and size of the living area throughout the daytime. Furthermore, the generated space, with a long dimension which is parallel to the windows of the balcony, creates a pleasant living room during the daytime (Gringberg & Bakema, 1977).

**DISCUSSION**

In order to develop the idea of "responding to changing needs" in housing, Van den Broek collaborated with H. Leppla, who undertook the research concerning apartments' requirements. Leppla carried out detailed studies of the processes of night-time and daytime uses, according to various family members' lifestyles. He related studies of day and night zones to the studies of the life cycles of the different household members and to their requirements and changing customs. In this work, he distinguished the different life phases that could perfectly occur in the course of a family's life cycle (baby, child, son, daughter, husband and wife). A dwelling, he argued, had to be able to meet all the functional needs of these individual users (van Eldonk & Fassbinder, 1990).

Following the consideration that the organization of architectural space is principal, the apartments' fix spaces and elements as well as its flexible ones have been arranged (Figure 6). The dimension and spatial distribution of both apartments can be easily changed according to the occupants' requirements during the day and night-time (Figure 7). In fact, not only is there a spatial independency but there is also a multilateral cooperation between architectural spaces and the liberty of choosing among the different options provided to the occupants throughout the day and night-time. As a result, the inhabitants can make multi-functional spaces, with minor changes, in both apartments. In the Vroesenlaan housing complex, the restroom and bathroom are integrated as a compact part of the layout while allowing considerable freedom to the remaining part of it. The restroom unit does not have any connection whatsoever to the kitchen and the open kitchen is connected to the dining room and a flexible bedroom. Together they can create an enormous space in the day time. Therefore, the flexible bedroom and the living room are integrated with each other so as to make a suitable space for the day time.

In both apartments, there is at least one bedroom which is defined as a multifunction space. These bedrooms are not accessible directly from the hallway and have ultimately given the inhabitants the opportunity to be able to extend their space for daily activities. The kitchen is one of the most important spaces in housing design. It is not only for cooking and serving foods but it can also be used as a dining or living room or a place where the family can get together and do their diverse domestic activities. The activities that take place in these spaces have a close
connection. As an outcome, their spatial layout must be in an adjacent connection, which consequently leads to reforming spatial hierarchy. In both projects, the architects have considered the kitchen and bathroom units as static spaces. In other words, they are placed on the floor plan as fixed-feature spaces. The living/dining room and one bedroom work as multifunction spaces. Space has been divided and organized based on spatial hierarchy by making appropriate connections according to its inhabitants’ needs, activities and lifestyles. In fact, organizing the interrelated flexible spaces has enabled its inhabitants’ freedom of choice. Home spaces have the capability to be arranged and configured according to inhabitants’ lifestyles and changing requirements. Put another way, each family member has the autonomy to engage various activities in complete freedom. In both apartments, the organization of interrelated flexible spaces gives inhabitants the liberty to change their living spaces and helps achieve functional efficiency in housing.

Figure 7. Day and night time spaces according to different spatial organization. Left: Vroesenlaan apartment. Right: Bergpolder apartment (Source: Authors)

CONCLUSION
Flexible housing presents an opportunity for inhabitants to participate in the design of their dwelling and to arrange their living spaces according to their lifestyles and needs by creating new and temporary spaces during the day and night time. Based on both presented case studies, architectural spaces may be subject to change in order to meet inhabitants’ requirements. This entails the autonomy of incorporating various activities when necessary and enhancing the variability and versatility of the connections between adjacent spaces without any geometrical change in the form of the architectural spaces. In both of the apartments’ layouts, family members have been offered the opportunity to redesign and rearrange their household in accordance to their changing lifestyles. The dimensions of the rooms can vary when conforming new spaces and fulfilling new requirements without extra expenditure. If the number of house members increases, the dwelling’s layout will have the possibility to change to a new layout. In fact, the flexibility of space in housing seeks to create diversity, dynamism and adaptability which are decisive in order to satisfy inhabitants’ variable needs. Spatial organization determines the boundaries of the functions of space in housing. Hence, it’s main task being that of arranging spaces according to its residents’ requirements. The spatial organization of the floor plans of both of the cases studied is based on the interaction between different parts of the dwelling, which are configured as far as their function is concerned by situating spaces in close connection. Sequential and interrelated spaces create new spaces with various types of spatial relationships by employing sliding doors, walls and flexible elements. These new spaces meet the needs of the
dwelling’s residents, which arise from the activities of the family members during day/night-time. This spatial organization creates interaction between its domestic spaces so as to achieve functional efficiency. In an overall view, flexible housing gives its inhabitants the opportunity to get involved in the design process of creating a suitable spatial environment throughout their lifetime. This will notably present them with a sense of belonging to their living place by fulfilling their expectations as well as by adapting it to their different demands instead of taking an architecturally-predetermined approach. Flexible housing places its emphasis on the fact that advanced architecture not only is put forth through form, but is accomplished in practice by discreetly incorporating functionality and usability into the dwelling’s layout with the aim to accommodate the diverse needs of its inhabitants over a long period of time.

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