

SUSTAINABILITY OF RESIDENTIAL ENVIRONMENTS SOSTENIBILIDAD DE LOS ENTORNOS RESIDENCIALES

A. Maritza Landázuri*

Serafín J. Mercado**

Alejandra Terán***

Universidad Nacional Autónoma de México, México

ABSTRACT

Keywords:

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In the late eighties, Mercado and González (1991) developed the concept of Habitability, defined as the suitability of the built environment for its residents, focused on residential environments. The evidence suggests that housing habitability is an important aspect of social sustainability, as it affects family's quality of life, social climate and health. In this paper we sought to describe several studies that are supported by the Habitability Model which is considered a way of evaluating residential environments, related to a set of design variables and consequences for the inhabitants. The Model was first developed using Multidimensional Scaling, and later confirmed through Path Analysis. The Model shows a central global measure of habitability and three groups of variables surround it: emotional, symbolic and behavioral. The model seems to explain relationships between architectonic design and residential environmental evaluation through habitability, and family's social processes that are linked to sustainability. Practical and theoretical implications of the results are discussed.

* School of Higher Studies Iztacala, CyMA Project. National Autonomous University of Mexico.

** School of Psychology. National Autonomous University of Mexico.

*** School of Medicine. National Autonomous University of Mexico.

This research was funded by the Science and Technology National Council (CONACyT) Project 34898-S. México. Communications for the authors should be addressed to Ana Maritza Landázuri. Av. De los Barrios No. 1. Los Reyes Iztacala. Tlalnepantla Estado de México. C. P. 05490. Phone: + 55 56231120 Email: alandazu@gmail.com

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RESUMEN

Palabras clave:

habitabilidad, modelo de habitabilidad, calidad de vida, sostenibilidad, entornos residenciales

A finales de los años ochenta, Mercado y González (1991) desarrollaron el concepto de habitabilidad, entendida ésta como la adecuación de un entorno construido para sus residentes, centrado en los entornos residenciales. La evidencia sugiere que la habitabilidad de una vivienda es un aspecto importante de la sostenibilidad social, puesto que afecta la calidad de vida de las familias, así como el clima social y la salud. En el presente trabajo nos dimos a la tarea de describir varios estudios que son compatibles con el modelo de habitabilidad; dicho modelo se considera una forma de evaluar los entornos residenciales en relación con un conjunto de variables de diseño y sus consecuencias para los habitantes. Se desarrolló el modelo por primera vez utilizando el escalamiento multidimensional, y luego se confirmó a través de Análisis de Ruta. El modelo muestra una medida global central de habitabilidad, así como tres grupos de variables que le rodean: las emocionales, las simbólicas, y las comportamentales. El modelo parece explicar las relaciones entre el diseño arquitectónico y la evaluación del entorno residencial a través de la habitabilidad y de los procesos sociales de la familia que están vinculados a la sostenibilidad. Se discuten las implicaciones prácticas y teóricas de los resultados.

This article attempts to establish the relationship between social sustainability and the habitability of residential environments. We have reviewed the literature of the research carried out by our team over the last 20 years, thereby providing evidence as to the relationship between housing design, the habitability model of evaluation and the social variables concerning family's welfare. This has implications for social sustainability by demonstrating that dwellings quality, as measured through the housing habitability approach, has effects over it.

It has been accepted that human activities affect the quality of the surrounding environment, and that; in return, such "altered" milieus affect people's life (Gifford, 1997). From this perspective, environmental information interacts with the subject's inner structures in such a way that inner models of reality are constructed, dependent on both: input, and information the subject holds in the form of memories, thoughts motives, expectations, sets, and needs.

Environmental psychology is the discipline which best studies these relationships. One of its major contributions has been to improve the design elements of the built environment,

enhancing the way environmental resources are managed, and also taking into account social sustainability (Roaf, 2010). The house is one place where all these aspects are combined.

Whenever the literature makes reference to sustainable housing it typically refers to green buildings which help to save our natural resources and do not contribute to additional pollution; however, sustainable housing is more than just the environmental or economic aspects of sustainability. There is another component which politicians and real estate professionals should consider when thinking about sustainable housing: i.e. social sustainability (Forster-Kraus, Reed & Wilkinson, 2009; Milfont, 2009).

Social sustainability is a broad concept which covers the important issues of poverty, equity and health at a macro level. This is translated into affordable housing schemes and measures at the micro or community level, in order to enhance community space for the enjoyment and use by all. This social dimension is increasingly important in the overall economy and also in the real estate sector, where population demographics are

changing (Forster-Kraus et al., 2009; Vargas-Mendoza, Maldonado-Aragón, Cruz-Clemente, & Aguilar-Morales, 2012).

Evaluating environments has been a central issue for environmental psychology since its inception, and the evaluation of residential environments has been a specific concern. The evaluation of residential environments has been approached from four different vantage points: housing perception, preference, choice and satisfaction (Ewing & Rong, 2008; Gifford, 1997; Tognoli, 1991). Our approach is within the housing satisfaction approach, where we attempted to measure different aspects of the house's milieu through Semantic Differential items, which in turn were used to construct the set of psychometric scales that constitute our model.

Schorr (1978) approaches the issue in terms of complaining or the absence of it, while Wiesenfeld (1992) views it in terms of a balance between the needs and aspirations of inhabitants and the actual housing situation. On the other hand, Amérigo (1995) approaches it in terms of the distance between cravings and achievements. She stresses the difference between the perspective of researchers or planners and that from residents, as the latter is experiential. Ours differs from the usual way of tackling it, because we think of satisfaction as a continuum, which is not unitary, but constituted by several factors, although our methodological approach (housing habitability) to their identification was different form of the usual factor analytic one.

The habitability model

The Habitability Model was developed as a way to measure residential satisfaction, comprised by a complex system of different features, involving both environmental and psychosocial factors. What is important about this way of measuring residential satisfaction through habitability is that we could empirically state that it affects family related quality of life, family climate, stress, health and several variables related to family's

interaction. All these aspects are essential to social sustainability.

Another important aspect is that we could identify a range of environmental and architectural design variables that affect habitability. This makes it possible for us to generate recommendations for architectural and interior designers, related to habitability and, through it, to the welfare implied in social sustainability.

We hereby present some housing studies designed to look for strategies to improve the quality of life of its residents based in the Mercado's Model. Our goal was to describe the variables that are important for housing habitability.

Mercado and González (1991) defined the habitability concept as the quality of spaces (behavior settings) to provide satisfaction and to allow a healthy biological, psychological and social development of the residents. It is a measure of the level of satisfaction felt by the inhabitants for their houses, which is in turn a function of their needs and expectancies. They first developed a habitability scale, to measure inhabitants' satisfaction with their house. Afterwards, they developed a battery with the Habitability Scale and a translation and adaptation of the Mehrabian and Russell's (1974) Emotional State Scale; which is constituted by three subscales that measure pleasure, arousal, and control.

These variables are the emotional and affective reactions to a subjective evaluation of a house by its inhabitants. They measure the degree in which the house arouses pleasant experiences, induces activation of the cortex and gives the perception of the degree of control over the surrounding circumstances. That is, they measure the emotional experiences aroused by the residential environment.

The arousal and the control variables feed pleasure; so the subject has direct pleasant or unpleasant experiences and indirect ones, due to the other two. Arousal has an inverted U shaped relationship with pleasure.

Mercado, Ortega, Luna and Estrada (1994) continued with the research to develop the scale, thereby trying to find other variables. They used

Kelly's (1955) grid technique to uncover the constructs people use to understand a house. Using the most common rooms (bedroom, living room, kitchen, and bathroom) as the basis for their comparison, they obtained a set of traits. They developed scales to measure them and then tested the model.

They found two additional groups of variables; the symbolic one and the behavioral one. In the symbolic, there were two variables, meaningfulness and accomplished values. Meaningfulness measures the features that have a symbolic significance and accomplished values are the values that are actualized in the dwelling. Accomplished values feed into significativity. The behavioral area is constituted by operability, functionality and privacy. Operability is the ease to move around and execute tasks. Functionality is the congruence between the arrangement of objects and spaces that is congruent with the behavioral sequences necessary to carry out the required tasks. Finally, privacy is the degree of control you have of the information that you give away or receive. Privacy and functionality feed into operability (Fig. 1).

The model was first developed using Kruskal's monotonic multidimensional scaling, to establish the relationships among the implicated variables, and confirmed afterwards using path analysis, that gave a well-adjusted one. To develop it, the distance relationships found through the scaling procedure were used to create the links among the variables of the model in the path analysis.

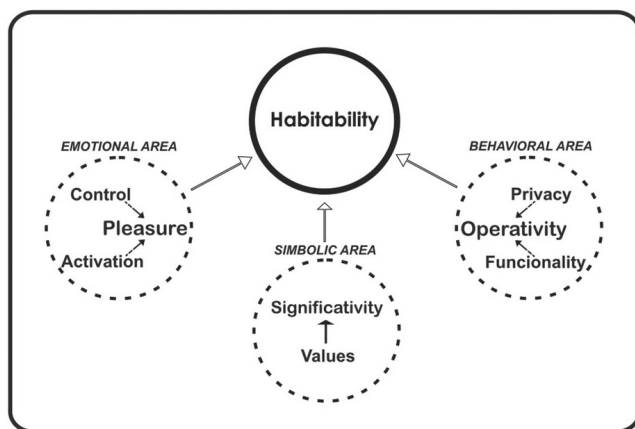


Figure 1. Mercado's Model of Habitability

To find other variables, Mercado, Ortega, Estrada and Luna (1995) tested the effect of some environmental factor generated by the house design and location, on the variables of the model. They found significant effects for noise, transparency of walls and doors, temperature and humidity levels, on the habitability model variables. The transcendence of the model lies on its relationship to design variables, which shows that, at least to an important degree, habitability depends on the designed and constructed surroundings. The other aspect, which connects directly to sustainability, is the family's welfare variables, which are determined to a significant degree, by habitability. In this sense, habitability is a model for measuring residential environments satisfaction, which is determined by design, and that thus measures the way in which this designed environment affects family life. It is this effect that has relevance for social sustainability. These issues are what will be seen in the next sections.

Quality of family life and housing habitability

Here, we review the research on the effects of habitability on family's life. In a first study, Aguilar and Estrada (1994) used Moos' Family Climate Scale (1974), made up of three subscales: personal growth, relationships, and system maintenance, and found that the habitability has an influence on family's behavior. Monsalvo and Vital (1998) showed that although the habitability of housing does not affect global quality of life, i.e. with all its components such as health, quality of work life, free time, etc., it affects the specific area of quality of life related to the family.

In another study, with a more systematic approach than Monsalvo and Vital's (1998), Ávalos (2003) attempted to find out the way in which the internal habitability of living environments determines family's quality of life.

She tested the variables of internal habitability of housing: pleasure, operability, meaningfulness and values, her hypothesis

was that they contribute to the quality of family life, measured with a scale constituted by the sections: affective relationships, solidarity, cohesion and communication. The scale was used as a single instrument with a reliability of $\alpha = .95$. In Avalos' instrument emphasis was placed on psychological factors that determine the needs and family expectations and the degree in which they are satisfied.

Taking into consideration that quality of family life is a critical aspect of social sustainability; these results provide ways to improve it. Results confirm the hypothesis that the operability, meaningfulness and values variables have an effect on quality of life, but pleasure was not significant. Even though we can state so, good housing habitability improves families' life quality.

Diversity of settings and housing habitability

In a study by Grajeda (2002), the hypothesis was that house's interior organization influences its habitability. The main objective was to estimate how some features of the behavior settings organization (shape, size, diversity, disposition and distribution) influence two variables of the internal habitability of housing: functionality and operability. He evaluated how these variables were affected by shape, size, diversity, arrangement, distribution, and characteristics of the setting.

Results show that setting's organization has a significant influence on inner habitability: the greater the setting diversity, the greater the functionality and operability. Diversity of settings, defined by the sort of activities taking place, was significant at the .05 with a coefficient of 4.55, using the multiple linear regression approach. That is, the greater the diversity of settings, the greater the operability. Distribution also contributes with low - though significant - coefficients to functionality and operability.

These results agree with Proshansky, Ittelson and Rivlin's point of view (1983), when they mention the congruence that there should be

between the design elements and the activities. They pointed out that space requirements are approximately 37 m² per person, 70 m² for two people, 93 m² for three and so on; it should be noted that nearly all the households surveyed in this study - with an average family size of 4.2 members - were in the range between 16 to 100 m² and social-interest housing averages 30 m². One can notice, then, that spaces were not adequate.

Therefore, the size of the dwelling and the inner structure stand out as a fundamental feature. It is important to realize that size by itself is only important as a status symbol; what is important is the capability to give space for the different activities taking place.

Overcrowding and habitability

Ocaña (2003) studied social interaction, density, sociopetal spaces, and the perception of overcrowding in social-interest housing and how this affects internal habitability. Her hypothesis was that there will be greater internal habitability in social interest housing if there are places that foster interaction and social communication (sociopetal spaces), and do not exceed the social density for which they were designed, and therefore do not generate perceptions of overcrowding.

It was also noted in Ocaña's results that the living room is the place where most residents meet to interact and live together, and that as the number of inhabitants by household increases, the family's integration decreases; thus we conjecture that available spaces in this type of housing were not designed to generate integration. However, social density was not found to be greater than that for which homes were designed, and there was no perception of overcrowding. This type of dwellers use alternate spaces out of it and this would explain the social disintegration, exacerbated by the level of noise, which was one of the participants' main complaints. Ocaña finally proposed that builders of social housing should take into account these environmental and social factors in order to help reverse family's

disintegration. Other studies found important interactions between physical interactions and different social aspects (Flores-Herrera, 2003; Flores-Herrera, & Bustos-Aguayo, 2000; Flores-Herrera, Bustos-Aguayo, Mercado, & Covantes-Rodriguez, 2009).

Architectural design and housing habitability

The research carried out by Landázuri and Mercado (2004) analyzed how some characteristics of architectural design have an influence on the housing's internal habitability. The aim of this research project was to analyze how some of the characteristics of the architectural design and its dimensions, such as depth, number of circulations, safety, connectivity, sociopetality¹, and vigilability

influence the residential environment's habitability, as well as the psychological transactions that take place between the person and his or her surroundings (the dwelling in this case), attempting to establish its link with the Habitability Model: control, arousal, pleasure, privacy, meaningfulness, functionality and operability. Architectural design influences habitability through its effect upon the evaluation variables included in the Model.

This was an exploratory, ex-post facto study. A multiple linear regression analysis was carried out so as to establish the relationship amongst variables. The results as can be seen in Table 1, confirmed that the architectural design of the house is related to habitability. Arousal was linked significantly with the number of spaces, the total number of circulations, sociopetality and connectivity. We can see that arousal,

Table 1
Arrangement of relationship between dependent and independent variables, according to the multiple linear regression analysis

DEPENDENT \ INDEPENDENT	Total habitability	Pleasure	Arousal	Control	Operability	Privacy	Functionality	Meaningfulness
	Total square meters							
Constructed square meters								
Number of places (rooms)								
Average size								
Depth								
Distance of the rooms to public spaces								
Total number of circulations								
Safety								
Vigilability								
Sociopetality								
Connectivity								

1 Sociopetality refers to an environment in the residential environment being sociopetal, in Osmond's sense (1957)

which should be intermediate to be optimal, is affected by these variables, as circulations help to control stimulation, and sociopetal places, as well as connections between rooms, encourage social interactions. The number of circulations has an inverse relationship with the arousal variable as it provides greater privacy and diminishes interference and conflict. Pleasure was related to building's size, the number of spaces (rooms), and the distance from the rooms to public spaces. The size of the house and the number of rooms mold the number and type of activities people can do, and the relationship with the outside of the house is also source of pleasant experiences. Control is affected by the number of connections between areas, which gives greater influence over the environment: with a greater number of connections you have a broader choice of routes and greater access to places.

As it might have been expected operability and functionality had an important overlap, both being affected by rooms' average size, and the number of circulations. Operability is the accessibility of displacement and action in order to get around doing different everyday chores, while functionality implies the congruence between the organization of space and objects, and the sequence of actions in a task. Both are supported by the availability of space to move around and to organize it, the size of the rooms and the availability of circulations. This entails the size of the room and its connections through circulations allow for a better organization of activities.

Privacy however, was only affected by the number of circulations, which make it possible to go from a place of the house to another without intruding in other rooms. Meaningfulness was affected by the number of built square meters, the number of spaces, room's average size, and the closeness to public spaces, which certainly are related to status.

In sum, we can see that architectural design variables have an effect on housing habitability, that is, the perception of the suitability of the inner residential environment. We are sure that this is not an exhaustive list of variables, and

that further research might yield more that are pertinent. Even though, this shows quite clearly that habitability, as measured by our evaluation Model, is related to the dwelling's design.

Green areas and housing habitability

Evidence found in the literature allows reveals that architectural design could be complemented with green areas, in order to increase habitability. In Mexico, some residential areas have augmented green areas within and between buildings to prevent the impoverishment of the environment; unfortunately, we can't say the same about other areas like Neza City, one of the poorest zones of México, where the grey color dominates the aerial view. It seems a carpet divided by urban stroke of almost perfect straight lines but with a seemingly endless succession of roofs, and no green areas. There are more than 303,000 homes on a surface of little more than 63 km² (Fig. 2) (Pérez, 2011).

Domestic gardens make substantial contributions to the provision of green space in urban areas. Loram, Warren and Gaston (2008) presented the first detailed analysis of variation in the composition of urban gardens, in relation to housing characteristics and the nature of the surrounding landscape, across different cities in the United Kingdom. In addition, due to the fact that there is a pressing need to generate conditions that lead to welfare, it is of vital importance to create pleasant environmental conditions that can induce tranquility. For example, Ghosh (2010) says "gardens are important elements of Australian suburban residential environments, and can provide multiple sustainability benefits and could have significant sustainability potential similar to that of dwellings".

From this perspective, Landázuri, Lee, Terán and Mercado (2008) carried out a study on importance of greenery for human welfare. The purpose of this research was to know how people's relationship to the green areas within and surrounding their dwelling, affect their evaluative perception of the house (habitability),

understanding for green areas: grass, shrubs, foliage of plants, trees, and flowers, all of them natural.

The authors' hypothesis was: the inhabitants that enjoy more their natural spaces have a more positive emotional reaction to their home. The ways in which they are pleased about their natural ambiance allow them to have more positive emotions about it. They established that the restorative properties of greenery are important for the habitability of residential environments, which is consistent with what is found in the literature. There is a close relationship between greenery and positive emotions, the possibility of preservation and recovery of health, and the role of greenery as a

restorative environment, with important effects upon the inhabitant's welfare and quality of life (R. Kaplan & Kaplan 1987; Ulrich et al., 1991; Velarde, Fry & Tveit, 2007).

A non-probabilistic intentional sample was used with 220 participants (100 from Mexico City and 120 from St Andrews, Scotland) with an age rank between 15 and 75 years. The interviewed subjects had an equal proportion of gender, social class and marital status levels and lived in owned, rented or borrowed houses or apartments.

Another purpose of this project was to explore which were the emotional reactions of respondents, measured through Mehrabian and Russell's Semantic Differential Scales



Figura 2. Aerial view of Neza City.a

^aPhoto: Rodrigo Cruz, published in: <http://www.ngenespanol.com/articulos/328787/ciudad-neza-historia-contrastes/>

of Emotional States (1974), which measure pleasure, arousal and dominance, and were related to the existence of natural green areas and flowers in the environment, both inside or outside the dwelling.

The specific reaction to vegetation was explored, using a scale of Green Areas and Housing that was designed for the study. The hypothesis was that people need trees, gardens, parks and nature as an important part of their housing environments. They need to see leaves from their windows and doors, to sit in green spaces, and to play in the shade (Fig. 3). Trees move people out from behind walls of wood or brick and glass, and by getting in touch; neighbors built relationships, and build a sense of community.



Figura 3. Example of a house with widespread greenery.

The pleasure and arousal variables are significantly related to attitudes towards greenery, which entails a direct relationship between green areas and the pleasure and arousal variables. In other words, green areas in the house produce in the inhabitants increased pleasure sensations, as well as increased motivation in all the activities inside their house. In the case of Mexico City case results were similar. The main contribution of this study was to demonstrate that restorative environments are important for the household.

Housing habitability and health

Finally, another study was carried out (Landázuri et al., 2008) to prove the relationship between habitability and health. The hypothesis was that the degree of adequacy of the dwelling's design had an effect on health, directly through comfort, and indirectly through its effects upon family's life.

The outcome shows that housing habitability had no effect on health in general, digestive disorders, or emotional disturbances. For gastrointestinal diseases, the result contradicts expectations, since many of the disorders in this area are derived from stress (gastritis, colitis, ulcers).

In the case of respiratory diseases, it was found that information rate is significant at the .05 level, even though the explained variance is very small (2 %). This can be understood in terms of information rate being a measure of how stressful the environment is, fact that is congruent with our hypothesis. Therefore, we assume that stressful environments reduce defense systems and increase infections. The very low percentage means that other external factors such as contamination, contagion, and temperatures, prevail in the determination of these diseases; however, there is a distinct effect of housing on this kind of incidents.

Regarding blood pressure, we found significant effects on arousal at the .01 level of significance; on control at the .001 and on operability at the .05. They explain 19% of the variance. This means that when the residential

environment is not manageable, it seriously affects blood pressure due to emotional factors related to over stimulation, perception of lack of control of the home's environment, and loss of the capability to operate efficiently within it.

Results demonstrated that when there is an adequate architectural design, it brings about relaxation; when there it is absent, the person remains stressed, affecting several health spheres. A recent study by Corral-Verdugo, Barrón, Cuen & Tapia-Fonllem (2011) shows that stress is affected by the levels of habitability. Similar results were founded in the study of Cantarero and Potter (2012), and Lederbogen, Haddad, and Meyer-Lindenberg (2013) study related with mental disorders.

Discussion

It has been possible to relate this model with variables of architectural and environmental design and with social variables that have a direct impact on sustainability. This technique allows to assess the quality of housing in terms of social sustainability, which has implications for potential assessment and development programs of both governments and nongovernmental organizations.

We can see from our review that habitability is an important concept to understand the relationship between inhabitants and their dwelling. We have found a number of environmental and design variables that affect it, and have been able to demonstrate that habitability affects family life (Mercado, Urbina & Ortega, 1987).

Social sustainability depends on the fact that the milieu provides the conditions for a good quality of life. Housing habitability is an adequate measure of how residential environments provide for family's life standards and, the family being the main primary group, it provides for the quality of living conditions for the individual as well, contributing in a significant way to social sustainability.

Good housing design provides for habitability and through it, quality of family relations and well-being. The further research will have to find

new design variables, and to take in account the current design theoretical models, such as Universal Design, Isovist Theory (Benedikt, 1979; Turner, Doxa, O'Sullivan & Penn, 2001) and Space Syntax Theory (Hillier, 1999; Hillier & Hanson, 1984; Jiang & Claramunt, 2002).

We also have to find the way to translate our theoretical insights into design norms as a way to introduce them into architectural programming, being also important for environmental designers to become receptive of this approach so it might be incorporated into architectural theory. As mentioned by Buys et al. (2005), the ideal house also allows occupants to move around easily, feel safe from accidents, such as slips and trips on dangerous flooring surfaces, secure in the knowledge that entry points are protected, and that monitoring devices can detect visitors and potential intruders outside. Thus, having less anxiety about household risks and security, it can provide a sense of satisfaction and well-being for residents.

Finally, the model presented in this article is part of contributions to environmental psychology from Latin America and it is directed to similar actual topics worked for different sciences and research groups, so it represents a fruitful theoretic and empirical research field (Bertoldo, Castro & Bousfield, 2013; Corral-Verdugo, Tapia-Fonllem, Ortiz-Valdez & Fraijo-Sing, 2013; da Silva & Soares, 2013; de Oliveira, Ardans-Bonifacino & Nöthen de Oliveira, 2013; Galli, Bolzan & Castellá, 2013; García-Landa & Montero, 2013; Guevara, 2013; Heyl, Moyano, & Cifuentes, 2013; Jakovcevic, Díaz-Marín, Moreno & Tonello, 2013; Olivos-Jara, Aragonés, Navarro-Carrascal, 2013; Páramo, 2013; Pereira, 2013; Pinheiro & Farias, 2013; Pol & Castrechini, 2013).

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