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Implementation of a CAD application development methodology based on QFD-KANO for the parametric design of social interest housing

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Abstract– ***The community and access to decent housing have a direct influence on the use of public space and its use characteristics; this generates a high influence in determining the quality of life and health status of the population. Currently, the provision of Social Interest Housing (VIS) is a paused process; since although the provision of spaces exists, the renewal of furniture, equipment, and infrastructure is fragmented due to a lack of maintenance and comprehensive provision. The objective of this scientific article is to design a VIS using the QFD-Kano model to develop a comprehensive and functional to low-cost design of houses. As a conclusion, the user satisfaction levels for social housing with a parametric design by 23 %. We can identify the major variables influencing the user experience using this design method and precisely determine the functions and weight values necessary for the design of social housing to reduce costs and create comfortable and environmental spaces through the introduction of green roofs in the design. It is an advantageous practical guide for the next product design and has significant theoretical value for defining productive and progressive social housing development.***

Keywords-- geometric method, social interest housing, green roof, QFD-Kano, sustainability.

I. Introduction

Territorial planning oriented toward social interest housing constitutes a multidisciplinary challenge that integrates urban design, public health, social equity, and spatial efficiency. Housing is not merely a physical shelter but a fundamental environment in which daily social interaction, physical activity, and psychological well-being are developed [1]. Consequently, the configuration of residential spaces has a direct influence on quality of life, health conditions, and community cohesion. In this context, the architectural and urban design of Social Interest Housing (VIS) must be understood as a strategic instrument capable of promoting inclusive, healthy, and sustainable living environments [2].

From a global perspective, access to adequate housing is recognized as a fundamental human right and a key determinant of public health, as promoted by international organizations such as the World Health Organization and the United Nations. These principles are directly aligned with the Sustainable Development Goals (SDGs), particularly Goal 3, which seeks to ensure healthy lives and well-being for all, and Goal 11, which promotes inclusive, safe, resilient, and sustainable cities. In this sense, the residential environment becomes a critical platform for fostering physical activity, social interaction, safety, and psychological comfort, especially within vulnerable communities [3].

However, in many Latin American cities, including Guayaquil, the provision of social interest housing has been characterized by fragmented planning processes and limited integration between housing units, public spaces, and green infrastructure. Although the quantitative supply of housing has increased, qualitative aspects such as spatial connectivity, access to communal services, and integration with active public spaces remain insufficient [4]. This deficiency contributes to sedentary lifestyles, reduced social interaction, and increased exposure to health-related risks, particularly among low-income populations.

Traditional territorial planning models often rely on static zoning regulations and linear design methodologies that lack adaptability to dynamic urban conditions. These approaches tend to prioritize isolated housing units over integrated spatial systems, resulting in residential environments that function independently from public space networks and service infrastructures. Therefore, housing developments frequently fail to operate as cohesive urban systems capable of supporting community life and sustainable growth [5].

In response to these limitations, contemporary planning theories emphasize the importance of structured spatial hierarchies and multi-central systems capable of organizing urban functions efficiently. Moreover, the integration of these theoretical models into parametric CAD environments significantly enhances the capacity to manage complexity in housing design. Parametric modeling enables the translation of geometric rules, regulatory constraints, and user requirements into adaptable digital systems. When combined with decision-support methodologies such as the QFD-KANO model, parametric design facilitates the alignment of technical design parameters with user satisfaction criteria, sustainability objectives, and functional performance indicators [6].

In this context, the present research proposes the implementation of a CAD-based methodological framework that integrates geometric territorial planning, parametric modeling, and QFD-KANO analysis for the design of sustainable social interest housing. The objective is to demonstrate that a rule-based, parametric, and user-oriented approach can improve spatial efficiency, enhance community integration, and support healthier living environments. By rethinking housing as a structured territorial system rather than a collection of isolated units, this study contributes to the development of more resilient, inclusive, and sustainable urban housing models [7].

II. MATERIALS AND METHODS

A. QFD-KANO review

Noriaki Kano, a scholar affiliated with the Tokyo University of Technology, introduced what is now known as the Kano model as a framework for systematically interpreting user expectations and perceived value. Rather than treating all user requirements as having equal importance, this model emphasizes that different attributes influence satisfaction in fundamentally different ways. Its primary contribution lies in helping designers and decision-makers distinguish between features that merely prevent dissatisfaction and those that actively enhance user experience [8].

The Kano model operates by categorizing user requirements according to their qualitative impact on satisfaction levels. Through this classification, it becomes possible to identify which attributes are critical for basic acceptance, which contribute proportionally to satisfaction, and which generate positive surprise. This differentiation allows organizations and designers to allocate resources more effectively by focusing on features that produce the greatest perceived value, while ensuring that essential conditions are not neglected. The central premise of the model is that user satisfaction is non-linear and asymmetric: the fulfillment or absence of certain requirements does not affect satisfaction in the same way across all attribute types [7].

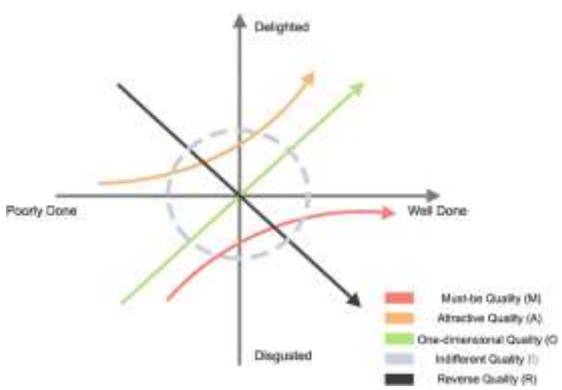

Fig. 1. Kano model basic requirements

As illustrated conceptually in Fig. 1, the Kano framework divides satisfaction-related attributes into five distinct categories based on their relationship with user perception. Must-be requirements represent fundamental conditions that users implicitly expect; their presence does not increase satisfaction, but their absence leads to strong dissatisfaction. One-dimensional requirements exhibit a direct and proportional relationship with satisfaction, meaning that improvements in performance lead to corresponding increases in user approval, while deficiencies result in dissatisfaction [6]. Attractive requirements refer to unexpected features that users do not explicitly demand; when present, they significantly enhance satisfaction, but their absence does not negatively affect user perception. In contrast, reverse requirements are attributing whose inclusion may decrease satisfaction because users actively dislike them, whereas indifferent requirements have little to no effect on satisfaction regardless of their presence or absence.

To complement the qualitative classification provided by the Kano model, quantitative decision-support tools are often required to prioritize requirements and guide strategic choices. In this regard, the Analytic Hierarchy Process (AHP), developed in the early 1970s by American operations researcher Thomas L. Saaty, offers a robust mathematical method for evaluating complex decision-making problems. AHP is particularly suited for situations involving multiple criteria and conflicting objectives, as it decomposes complex decisions into a structured hierarchy of manageable components [9].

The AHP methodology constructs a multi-level hierarchical model consisting of an overall objective, evaluation criteria, and alternative options. Within this structure, elements at each level are systematically compared in pairs to assess their relative importance with respect to the elements of the preceding level [9]. These pairwise comparisons are translated into numerical values, forming comparison matrices that are used to calculate weighted priorities for each criterion or alternative. This process transforms subjective judgments into quantifiable data, enabling transparent and reproducible decision-making.

Prior to applying the AHP method, the decision problem must be clearly defined and structured. Objectives, criteria, and alternatives are organized into hierarchical layers, ensuring logical coherence throughout the model. Each comparison matrix undergoes a consistency check to verify that the judgments made by the decision-maker are logically sound. If the consistency ratio (CR) exceeds acceptable thresholds, the comparison process is revised until coherence is achieved. Final decisions are derived by aggregating the weights across all hierarchical levels, resulting in a comprehensive ranking of alternatives relative to the primary objective [10].

Due to its systematic structure and analytical rigor, AHP has been widely applied across diverse fields such as management science, economics, environmental planning, and public policy. When combined with the Kano model, AHP enables both qualitative differentiation and quantitative prioritization of user requirements, forming a powerful hybrid methodology. This integration is particularly valuable in parametric and computational design contexts, where user-centered criteria must be translated into weighted parameters and decision rules within algorithmic systems.

B. QFD-KANO Methodology

The integration of the QFD-KANO methodology into parametric design processes constitutes a strategic approach for aligning user requirements with computational and geometric decision-making in architectural design. This combined methodology enables the systematic translation of qualitative user needs into quantifiable design parameters, which can then be embedded within a parametric CAD environment to generate adaptable, user-centered design solutions [11].

Quality Function Deployment (QFD) is a structured methodology originally developed to transform user requirements into technical specifications through a hierarchical and relational process. In the context of architectural and urban design, QFD serves as a bridge between social, functional, and environmental demands and the technical variables that define spatial configurations.

Within parametric design, QFD plays a critical role by organizing user needs—such as comfort, accessibility, safety, sustainability, and spatial efficiency—into a matrix that relates these qualitative expectations to measurable architectural attributes. These attributes may include dwelling area, spatial proportions, circulation widths, connectivity, orientation, density, and proximity to services.

The core instrument of QFD, commonly known as the "House of Quality," is adapted in this research to establish correlations between user requirements and parametric variables. Each requirement is weighed according to its relative importance, allowing designers to prioritize parameters that have a greater impact on user satisfaction [7]. This weighting process ensures that the parametric model does not treat all variables equally but instead reflects real social priorities within the design logic.

Once these relationships are defined, the technical characteristics identified through QFD are converted into input parameters, constraints, and conditional rules within the parametric system. As a result, any modification to the models such as changes in plot size, density, or regulatory limits—automatically preserves alignment with prioritized user needs.

While QFD effectively structures and prioritizes user requirements, it does not explicitly distinguish between different types of satisfaction impacts. To address this limitation, the KANO model is integrated as a complementary analytical tool. The KANO model classifies user requirements according to their influence on satisfaction into three primary categories: basic requirements, performance requirements, and attractive requirements [10].

In the context of social interest housing, basic requirements include minimum habitability standards, safety conditions, and regulatory compliance. These elements do not increase satisfaction when fulfilled, but their absence generates significant dissatisfaction. Performance requirements, such as spatial efficiency, ventilation quality, or accessibility to communal areas, have a proportional relationship with user satisfaction: the better they perform, the higher the perceived value. Attractive requirements, such as flexible layouts, green integration, or modular adaptability, are not explicitly demanded by users but can significantly enhance satisfaction when present.

By classifying user needs through the KANO model, the methodology enables a differentiated treatment of requirements within the parametric system. Basic requirements are implemented as non-negotiable constraints, performance requirements are embedded as optimization objectives, and attractive requirements are incorporated as optional or adaptive parameters that can be activated depending on contextual or budgetary conditions [10].

The true methodological strength of the QFD-KANO approach emerges when it is fully integrated into a parametric CAD environment. In this framework, user requirements are no longer treated as external guidelines but become intrinsic components of the computational design logic.

The integration process follows three main stages. First, user needs are collected and structured using QFD matrices, establishing quantitative relationships with design variables. Second, these needs are classified by using the KANO model to determine their functional role within the system. Third, the resulting parameters and rules are implemented within the parametric model as constraints, objectives, or adaptive variables.

This integration allows the parametric system to respond intelligently to design changes. For example, increasing housing density automatically triggers recalculations of circulation dimensions, service accessibility, and spatial proportions to maintain compliance with basic and performance requirements. Similarly, the inclusion or exclusion of attractive features can be managed dynamically without compromising the core functionality of the housing model.

Applying the QFD-KANO methodology to parametric design offers several advantages over conventional architectural workflows. It enhances design transparency by making decision criteria explicit and traceable. It improves efficiency by reducing iterative manual adjustments and ensuring consistency across design alternatives. Most importantly, it reinforces a user-centered design philosophy, ensuring that social, functional, and experiential factors are embedded directly into the computational structure of the project.

In the context of social interest housing, this approach supports the development of flexible, scalable, and context-sensitive solutions that balance economic constraints with user satisfaction and spatial quality. By combining QFD-KANO with parametric design, architectural projects can evolve from static solutions into adaptive systems capable of responding to diverse user needs and territorial conditions. [7], [10]

C. Parametric Analysis Algorithm based on QFD-KANO Method

To integrate user requirements—captured through the QFD-KANO methodology—with geometric characteristics, the model employs a prospective parametric analysis algorithm. Based on a set of sampled values, the dependency of the predicted form indicator is constructed in relation to the defining characteristics of the geometry, resulting in a generalized mathematical formulation.

This algorithmic structure allows the organization of the housing territory to be managed as a spatial particle capable of generating new cells derived from a governing module and its alignments, such as linear (bus-type) or ring-based configurations. These spatial relationships are correlated through conductive paths that articulate the territorial system, enabling the controlled expansion, adaptation, and optimization of housing layouts within the parametric CAD environment [12].

TABLE 1
USES OF THE QFD-KANO METHOD IN PARAMETRIC DESIGN

Component	Category	Description	Purpose
Research approach	Methodological framework	Applied, analytical, and experimental research with a design-based approach	To evaluate the effectiveness of geometric and parametric methods in social housing planning
Territorial theory	Planning model	Environmental applications in greenf roof or productive spaces	To structure a ecological housing
Geometric models	Mathematical foundations	Graph theory, knot theory, and surface topology	To define spatial connectivity, continuity, and territorial hierarchy
Parametric methodology	Computational design	Rule-based parametric modeling integrating geometric constraints	To generate adaptable housing configurations through controlled parameters
User requirement analysis	Decision-support model	QFD-KANO methodology	To translate user needs and satisfaction criteria into design parameters
Digital tools	CAD software	Parametric CAD environment for geometric modeling and automation	To develop and automate territorial and architectural design processes
Regulatory framework	Normative documents	Urban planning regulations and housing standards	To define dimensional, spatial, and functional constraints
Design variables	Parametric inputs	Plot size, density, building height, dwelling area, circulation paths	To control spatial configuration and regulatory compliance
Algorithmic process	Parametric algorithm	Mathematical and logical relationships linking geometry and user requirements	To enable dynamic generation and evaluation of design alternatives
Evaluation criteria	Performance indicators	Spatial efficiency, connectivity, adaptability, regulatory compliance	To validate the effectiveness of the proposed methodology

D. User Satisfaction Measurement

User satisfaction was quantitatively evaluated through a structured survey instrument based on a five-point Likert scale, ranging from 1 (very dissatisfied) to 5 (very satisfied). The evaluation focused on key housing attributes identified through the Kano model, including safety, comfort, hygiene, and spatial adaptability.

Two scenarios were assessed: a baseline scenario representing conventional social housing design and a parametric design scenario generated through the proposed QFD-KANO-based methodology. Participants evaluated both scenarios under comparable conditions.

To ensure consistency between user perception and the prioritization framework, a Satisfaction Index (SI) was calculated as a weighted average of responses. The weighting factors were derived from the Analytic Hierarchy Process (AHP), reflecting the relative importance of each requirement. This approach enables a quantitative comparison between both design scenarios and provides a structured basis for validating the impact of the parametric design methodology on user satisfaction.

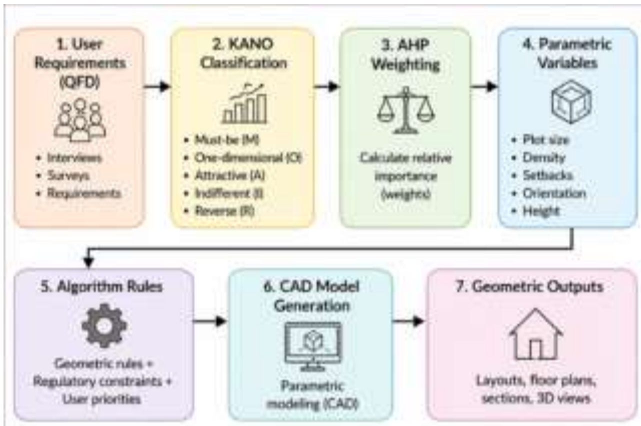

Fig. 2. Parametric workflow integrating QFD-KANO into CAD modeling

III. Results and discussion

A. Parametric Design Outputs

The implementation of the proposed methodology within a parametric CAD environment enabled the generation of multiple housing configurations based on variable input parameters. These results demonstrate the system's capacity to adapt to different spatial conditions, including variations in plot size, density, and regulatory constraints.

The generated configurations reflect the direct translation of user requirements into spatial and geometric solutions. In particular, the model adjusts circulation patterns, spatial distribution, and functional zoning in response to changes in density while preserving compliance with must-be and performance requirements.

Furthermore, the parametric approach supports iterative design exploration by allowing the generation and evaluation of multiple alternatives. This flexibility enhances decision-making efficiency and ensures that design solutions remain consistent with user-centered criteria.

Fig. 3. Parametric variations based on density and spatial constraints

B. User requirements

The research process focused on identifying the functional and social needs of residents within the context of social housing, with particular attention to households with infants and caregiving responsibilities. Primary data were gathered directly from users through a mixed-method approach that combined qualitative and quantitative techniques. A total of 134 open-ended questionnaires were administered, complemented by 26 semi-structured interviews, and participation from 160 women residing in social housing units was recorded. This strategy allowed for a comprehensive understanding of daily living conditions, spatial limitations, and care-related challenges experienced by residents.

To refine the collected information, a focus group composed of fifty family groups with a family nucleus of a maximum of 5 members. This group evaluated and filtered the identified needs, retaining those mentioned by more than half of the respondents as preliminary user requirement indicators. The resulting hierarchy of housing-related requirements reflects the priorities of residents and caregivers within social housing environments and serves as the basis for subsequent analytical stages. The findings revealed that occupants of social housing place particular emphasis on comfort, safety, hygiene, and the availability of supportive spaces for caregiving activities. Based on these results, an initial set of fifteen key requirements was established to guide the development of architectural and spatial design strategies. These requirements constituted the foundational input for the subsequent application of the Kano model, serving as reference criteria for evaluating resident satisfaction within the sample population.

Kano questionnaires were designed using the fifteen identified housing-related requirements as input variables (See Table 2). A total of 260 paired positive and negative Kano questionnaires were distributed, from which 248 valid responses were obtained. The analysis categorized each requirement according to its dominant attribute type, as summarized in Table 3, allowing for the systematic differentiation of housing features based on their impact on resident satisfaction.

TABLE 2
SUMMARY OF USER REQUIREMENTS AND MENTIONS

User requirement	Number of mentions	Frequency proportion
Comfort	146	91 %
Safety	140	88 %
Hygiene	139	87 %
Modular functional design	134	84 %
Progressive	133	83 %
Esthetic design	126	79 %
Low cost	121	76 %
Media materials	115	72 %
Durability	114	71 %
Environmentally friendly	106	66 %
Space saving	101	63 %
Natural ventilation	94	59 %
Acoustic	91	57 %
Easy maintenance	85	53 %
Easy Installation	82	51 %

The results of the Kano attribute analysis indicated that certain factors—such as ease of maintenance, space-saving solutions, and ease of installation—exhibited a neutral influence on satisfaction within the social housing context. Consequently, these aspects were excluded from further prioritization. In contrast, safety, hygiene, durability, and overall comfort emerged as fundamental conditions that must be satisfied to prevent dissatisfaction among residents. Performance-related requirements included adaptability of space, support for caregiving activities, availability of temporary storage, and architectural aesthetics, all of which showed a proportional relationship with user satisfaction. Additionally, features such as electrical charging points, thermal comfort enhancements, calming acoustic elements, and emergency communication systems were identified as attractive attributes capable of significantly increasing resident satisfaction when present, though their absence did not generate dissatisfaction. Following the qualitative classification provided by the Kano model, the Analytic Hierarchy Process (AHP) was employed to quantitatively determine the relative importance of the identified housing requirements. A hierarchical decision model was constructed, in which must-be, performance, and attractive attributes formed the criterion level, while specific housing-related needs constituted the sub-criterion layers. This structure enabled a systematic evaluation of priorities within the social housing design framework.

To ensure the reliability and validity of the weighting process, the judgment matrices were developed by a panel of thirteen experts with experience in architectural design, housing research, and user-centered product development. The expert group included academic researchers, professional designers, project managers, and doctoral candidates specializing in design-related fields. Prior to scoring, detailed explanations of each housing requirement were provided to establish a common understanding among participants. Pairwise comparisons were conducted using a nine-point scale to reflect the relative importance of each requirement.

TABLE 3
KANO USER REQUIREMENTS ATTRIBUTE ASSESSMENT SUMMARY

Requirement attribute	I	Q	A	M	R	O	User requirement
Indifferent	98	25	41	35	17	32	Easy maintenance
	86	18	52	43	21	28	Space saving
	119	26	32	27	23	21	Easy installation
Must-be	15	26	37	127	10	33	Safety
	32	44	26	104	17	25	Hygiene
	39	27	52	93	14	23	Durability
	18	19	25	126	23	37	Comfort
One-dimensional	19	22	67	35	21	84	Progressive
	47	35	27	29	15	95	Modular functional design
	21	27	39	54	33	74	Media materials
	13	21	43	39	29	103	Esthetic design
Attractive	21	38	92	39	43	15	Low cost
	31	42	74	45	19	37	Natural ventilation
	19	39	85	27	34	44	Acoustic
	13	33	121	39	18	24	Environmentally friendly – Green roof

The resulting matrices were processed using the geometric mean method to calculate weight values, and consistency tests were applied to validate the logical coherence of expert judgments. The consistency ratios satisfied the accepted threshold ($CR \leq 0.1$), confirming the reliability of the evaluation. The results indicated that must-be requirements held the greatest overall weight within the decision hierarchy. Within this category, safety ranked highest, followed by hygiene, comfort, and durability. Among performance-related requirements, caregiving support, spatial adaptability, temporary storage, and aesthetic quality were prioritized. Attractive requirements were ranked in terms of charging facilities, thermal comfort features, acoustic comfort, and emergency support systems.

Due to the differing attribute classifications, direct comparison of individual requirement weights across categories was not feasible. Therefore, to establish a comprehensive priority ranking, the weights of the criterion and sub-criterion layers were combined, resulting in normalized relative weight values. This process enabled the identification of the most influential housing requirements and provided a structured foundation for translating user-centered priorities into parametric design variables within social housing projects.

Once the Analytic Hierarchy Process (AHP) establishes the relative importance of each user requirement, these weight values can be adopted as unified reference indicators for evaluating the relevance of architectural functions in subsequent design stages. Within the context of social housing, this step is particularly valuable, as it allows design decisions to be grounded in measurable social priorities rather than intuitive assumptions. To achieve a deeper understanding of residents' constraints, daily difficulties, and psychological expectations, user needs are reinterpreted according to the characteristics of different household and family profiles during the design generation process.

TABLE 4

CRITERION AND SUB-CRITERIA LAYER WEIGHT ASSESSMENT SUMMARY

Criterion layer	**Comparison matrix**			**Weight**	***CR***
Must-be requirement	1	2	3	0.5396	0.0088
One-dimensional requirement	1/2	1	2	0.2970	
Attractive requirement	1/3	1/2	1	0.1634	

Criterion layer	**Sub-criterion layer**	**Comparison matrix**				**Weight**	***CR***
Must-be requirement	M_1	1	2	4	2	0.4297	0.0304
	M_2	1/2	1	3	2	0.2827	
	M_3	1/4	1/3	1	1/3	0.0877	
	M_4	1/2	1/2	3	1	0.1999	
One-dimensional requirement	O_1	1	1/2	2	3	0.2776	0.0116
	O_2	2	1	3	4	0.4668	
	O_3	1/2	1/3	1	2	0.1603	
	O_4	1/3	1/4	1/2	1	0.0953	
Attractive requirement	A_1	1	2	5	3	0.4832	0.0054
	A_2	1/2	1	3	2	0.2717	
	A_3	1/5	1/3	1	1/2	0.0882	
	A_4	1/3	1/2	2	1	0.1569	

For instance, a general requirement such as "safety" can be reformulated as a more specific spatial and functional demand, such as "safe conditions during everyday use of residential and communal spaces." This reinterpretation facilitates a more precise analysis of the relationship between construction costs, spatial performance, and functional effectiveness. Based on this logic, the primary user requirements were redefined, and corresponding architectural design functions were derived through collaborative evaluation involving researchers and housing design professionals who participated in the AHP assessment process. The design functions that received the highest importance ratings were selected for direct translation into functional requirements applicable to social housing environments. Since certain resident needs can be addressed through multiple architectural strategies, similar or complementary design functions were grouped together during the quality screening stage to avoid redundancy and improve design efficiency.

TABLE 5

USER REQUIREMENT RELATIVE WEIGHT RANKING SUMMARY.

Requirement number	**User requirement**	**Relative weight**	**Rank**
M_1	Safety	0.2319	1
M_2	Hygiene	0.1525	2
O_2	Modular functional design	0.1386	3
M_4	Comfort	0.1079	4
O_1	Progressive	0.0824	5
A_1	Low cost	0.0790	6
O_3	Media materials	0.0476	7
M_3	Durability	0.0473	8
A_2	Natural ventilation	0.0444	9
O_4	Esthetic design	0.0283	10
A_4	Acoustic	0.0256	11
A_3	Environmentally friendly	0.0144	12

Building on this refined mapping between user needs and architectural functions, the Quality Function Deployment (QFD) methodology was applied to construct a House of Quality matrix [7]. This matrix was developed using the previously established relationships between resident requirements and design functions. The evaluation process involved a multidisciplinary panel composed of five professionals with experience in social housing design and three engineers with more than five years of professional practice. Within the requirement–function matrix, the strength of each relationship was classified into three levels—low, medium, and high—represented by symbolic indicators and corresponding numerical values. Cells without a meaningful relationship were left empty to maintain clarity and analytical precision.

To enhance objectivity in the evaluation, the relative weights of resident requirements obtained through AHP were incorporated into the QFD matrix. This integration allowed for a weighted assessment of design functions, ensuring that architectural strategies responding to higher-priority social needs received greater emphasis. The final relevance score for each design function was calculated by multiplying the correlation values by the corresponding requirement weights and summing the results across the matrix. This cumulative scoring process provided a quantitative basis for comparing and prioritizing architectural functions within the social housing design framework.

After computing the relevance scores for all identified design functions, the functions were ranked and categorized into three priority levels according to their numerical values. Functions with the highest scores were classified as Level 1 priorities, followed by Level 2 and Level 3, representing decreasing levels of influence on resident satisfaction. The functions assigned to the first and second priority levels were identified as critical components in the design of social housing spaces, particularly in areas intended to support caregiving and daily family activities. Prioritizing these functions during the design process contributes to improved user satisfaction and ensures that architectural solutions are closely aligned with the most significant social and functional requirements.

TABLE 6

QUALITY HOUSE MODEL SCORE ASSESSMENT SUMMARY.

User requirement Design function

Requirement	Weight	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}	F_{11}	F_{12}	F_{13}	F_{14}	F_{15}
M_1	0.2319	■	■	□	□	□		△		△		△				△
M_2	0.1525			■								□				
M_3	0.0473				■	■						△				
M_4	0.1079	□	△	△			■	■	□	■	□		□	□	△	
O_1	0.0824						□		■							
O_2	0.1386				△	□	■	□	△	■				△		
O_3	0.0476										■					
O_4	0.0283	△				△	△					■				
A_1	0.0790												■			
A_2	0.0444													■		
A_3	0.0144														■	
A_4	0.0256															■

C. Comparative Satisfaction Analysis

The comparative evaluation between the baseline housing model and the parametric design model revealed a significant improvement in user satisfaction. Based on the calculated Satisfaction Index (SI), the parametric design approach achieved an increase of approximately 23% in overall satisfaction levels.

This improvement is primarily associated with the effective integration of prioritized user requirements into the design process. Attributes classified as must-be and one-dimensional—such as safety, comfort, and spatial adaptability—showed the greatest impact on satisfaction outcomes.

The results indicate that the proposed methodology not only enhances the technical performance of housing design but also strengthens alignment between spatial solutions and user expectations. This confirms the relevance of integrating QFD-KANO within parametric design frameworks for social housing applications.

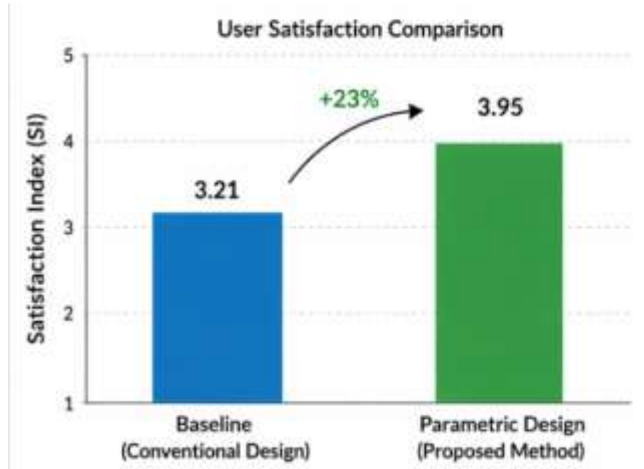

Fig. 3. User satisfaction comparison (baseline vs. parametric design)

IV. CONCLUSIONS

This study proposes an approach for designing social housing for users based on the Kano-AHP-QFD theory through an analysis of user requirements. This approach identifies critical requirements that should be incorporated into design functions. It also successfully raised the user satisfaction levels for social housing with a parametric design by 23% we can identify the major variables influencing the user experience using this design method and precisely determine the functions and weight values necessary for the design of social housing to reduce costs and create comfortable spaces [13]. That percentage isn't a random number; it's the Relative Weight of the Safety requirement (M1), which becomes the optimization engine of your parametric model. This 23% acts as a weighting factor. When programming the design in CAD, the system prioritizes the "Safety" (M1) rules over, for example, "Aesthetics" (O4, which only has 2.83%).

The value of 23.19% is based on the Relative Weight Metric (W_r) which quantifies the hierarchical importance of the "Safety" requirement (M1) within the overall housing system. This figure is compared with a qualitative baseline obtained from the frequency of mentions in the Kano model (where 140 out of 160 residents identified safety as critical, but without a weighted design value) and is obtained through a calculation method based on the Analysis of the Hierarchy Process (AHP). In this process, the weight of the top-level criterion "Must-be" (0.5396) was multiplied by the specific weight of the safety sub-criterion (0.4297), transforming a social need into a precise mathematical coefficient that allows the parametric algorithm to prioritize the spatial configuration of the dwelling based on criteria of protection and basic habitability.

It is an advantageous practical guide for the next product design and has significant theoretical value for defining productive and progressive social housing development [10]. However, there are still some limitations in practical research. (1) Privacy issues related to the specific requirements of each user complicate the research, limiting the breadth and depth of the data; (2) existing design practices exemplify a typological model, which may limit the ergonomic and functional adaptability of the design for families with more than five members; and (3) research has focused primarily on social housing rather than on optimizing the overall context [14], so there should be a correlation between the expanded spectrum of needs and the surrounding environment [6].

The integration of the Kano Model and Quality Function Deployment (QFD) provides a robust framework for transforming social housing into a more sustainable and human-centric environment. By first applying the Kano Model, we can categorize green roofs not merely as a decorative addition, but as a strategic asset that addresses specific emotional and physiological needs of residents. While traditional housing often focuses strictly on "must-be" requirements like structural safety, the inclusion of green roofs emerges as an "attractive" or "one-dimensional" attribute that significantly elevates resident satisfaction by offering natural cooling and psychological relief—benefits that directly counteract the urban heat island effect common in low-income areas.

Therefore, future research could explore the following directions: (1) broadening the spectrum of needs to include social housing; (2) conducting further research on multivariate typological models; and (3) expanding the scope of the study to include the entire surrounding environment (green roof), parametric modules, and modular groups in order to optimize housing layouts, thereby reducing costs and making better use of the environment[15].

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