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Comprehensive Quality Aspects of Affordable Housing Construction in India

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ABSTRACT: ***Working from home has become a reality for many as a consequence of the long-term impacts of the Covid-19 outbreak, and the importance of owning a home has become much more significant for several families. In 2022, affordable housing will be critical to maintaining the trend of home sales. However, the contemporary real estate market offers affordable housing that is generally marked by unstable tenure, tiny size, unsanitary conditions, and a lack of infrastructure. In India, the lack of quality housing has caused several issues, including policy failure, bylaw violations, housing shortage, and increased low-quality housing. The interaction of these elements has resulted in substandard house design and construction, lowering overall housing quality. End-users (homeowners) are subjected to unscheduled maintenance and repairs. The current lack of quality in existing housing, along with the increasing demand for new housing, emphasizes the necessity for strict quality management standards in the housing industry. Customers that are happy with their purchases are believed to constitute the industry's backbone. Homebuilders have realized that their capacity to accurately estimate the desirability of their housing units, as well as the level of service they provide, is critical to their financial viability. For a construction project to be successful, it is critical to translate customer needs into engineering terminology for new construction design. The concept of QFD has been successfully utilized in the manufacturing sector, but its benefits in construction have yet to be completely appreciated. To ensure that the owner's project requirements are met with the completed building, quality function deployment can efficiently integrate the project phases through design, construction, and operations and maintenance. In this paper, the overall quality determinants and characteristics of affordable housing in India will be identified. The QFD method is being utilized to enhance the quality of affordable housing projects. The House-of-quality was created to meet the demands of clients. As a result, developers will be able to better manage resources to provide improvements that are tailored to the demands and expectations of their clients.***

KEYWORDS: ***Affordable Housing, Quality Improvement, Quality function deployment, Housing design quality, Quality indicators, Quality standards in housing.***

INTRODUCTION

The goal of the Affordable Housing Collective agenda is to improve the sector's efficiency at a low cost while retaining safety, quality, and basic amenities [1]. The demand for low-cost homes is at an all-time high, but India has struggled with the supply side of the equation [2], [3]. However, the contemporary real estate market offers affordable housing that is generally marked by unstable tenure, tiny size, unsanitary conditions, and a lack of infrastructure. Because of the current lack of quality in existing housing and the large demand for new housing, strict quality management measures in the housing sector are required [4]. The contemporary real estate market offers affordable housing that is generally marked by unstable tenure, tiny size, unsanitary conditions, and a lack of infrastructure.

In India, the lack of quality housing has resulted in many issues, including policy failure, bylaw violations, housing shortage, and increased low-quality housing [5], [6]. The interaction of these elements has resulted in substandard house design and construction, lowering overall housing quality. End-users (homeowners) are subjected to unscheduled maintenance and repairs. The current lack of quality in existing housing, along with the increasing demand for new housing, emphasizes the necessity for strict quality management standards in the housing industry. Customers that are happy with their purchases are believed to constitute the industry's backbone [7]. Homebuilders have realized that their capacity to accurately estimate the desirability of their housing units, as well as the level of service they provide, is critical to their financial viability. Affordability includes not only the cost of purchasing a property but also the expenditures of operating and maintenance [2], [8]. Identification of building performance attributes as per user requirements to improve user satisfaction at an affordable price is an essential step to bringing in "affordability" in Indian Housing Stock [9].

This paper aims "to identify the aspects of Quality in affordable housing and prioritize the quality parameters of affordable housing construction in India". In this paper, "Quality is defined as all the attributes by which Affordable Housing is measured. These include design; built; innovative; socio-economic; cost-saving; and environmental attributes".

LITERATURE REVIEW

Affordable Housing

Housing units that are affordable for persons with incomes below the average household income are referred to as affordable housing [4]. In India, low-cost housing is available for low-income individuals, middle-income individuals, and economically disadvantaged individuals (urban areas). Housing affordability is a big issue in developing countries such as India, where the majority of the population is unable to purchase homes due to high market prices. India, the world's third-largest developing economy, occupies a unique position in Asia. With a focus on business and national prosperity, the current government is eager to implement reforms that are crucial to recovering growth. As India strives for long-term growth, the real estate industry will play an increasingly important role. The country's real estate demand is expected to be fueled by rapid urbanization and increased occupier demand. At the start of 2012, the Government of India (GOI) anticipated a housing shortfall of around 18.78 million units, with 95 percent of them falling into the EWS - (Economically Weaker Sections) and LIG - (Low Income Group) categories. Furthermore, the country's overall urban housing deficit is estimated to reach about 30 million people by 2022 [3]. To accomplish its campaign commitment of "Housing for All by 2022," the Indian government confronts an immense task of providing more than 2 crore dwellings by 2022, which amounts to more than 3 million units per year [3]. Which, the government has taken several steps to make the affordable housing market profitable for both private developers and homeowners.

Housing Conditions in India:

However, quality criteria for dwelling areas and adjacent outdoor spaces have not been met to an acceptable degree in low-cost housing [10]. Many hastily financed social housing projects have finally been turned over and put to use. As a result, these projects that lack infrastructural services and social infrastructure disclose weaknesses in design, construction, and administration, with serious long-term repercussions for customers [11]. According to the 2011

Census of India, 73.3 percent of residences in metropolitan cities are rated as "excellent," compared to 68.0 percent in non-metropolitan class I cities. 67.7% of these houses are in good condition, 32.7 percent are livable, and 2.6 percent are decaying. [9], [11], [12] highlighted the importance of the identification of user requirements as one of the key parameters to improve the building performance during its operational phase. Three important factors are used to define affordable housing, i.e. income level, dwelling unit size, and affordability [7].

Housing Quality Assessment Tools:

According to [13], King Hammurabi of Babylon brought the concept of product quality and livability into the construction business in 1780 B.C. by declaring: ".....if a builder built a house for someone and did not construct it properly, and the house which he built fell in and killed its owner, then that builder shall be put to death." If it kills the owner's son, the builder's son will be put to death". As a result, worries about quality in the construction business date back centuries. Housing quality is a broad phrase that incorporates a wide range of factors and has both an objective and subjective component. The objective dimension includes a variety of important features, such as the type of home, the number of rooms, the presence of amenities, and the quality of the dwelling. User traits that contribute to distinct needs, desires, and expectations are included in the subjective dimension [14]. In a nutshell, housing quality criteria are housing conditions such as the physical environment's qualities and the characteristics of its users. The term "affordable housing" refers to a large range of individuals who live in a variety of settings and earn low to moderate incomes [15]. The cost of housing varies depending on who you ask and where you live.

The following are examples of different housing quality assessment tools used in different countries:

1. HQI – United Kingdom
2. DQI – United Kingdom gen
3. CONQUAS - Singapore
4. QLASSIC – Malaysia
5. QUALITEL – France
6. SEL Method – Switzerland
7. MC.FEUP – Portugal

Quality Function Deployment (QFD)

Quality function deployment (QFD) is a method for changing user expectations into design quality, deploying functions forming quality, deploying strategies for attaining design quality into subsystems and components, and lastly to specific aspects of the manufacturing process. Quality Function Deployment (QFD) has been used as a benchmarking technique for affordable housing technologies [16], [17]. The case example of technologies backed by the Government of India for the "Housing for All" Mission has been taken up for the improvement of the framework and benchmarking. Improving the quality of one's products is crucial for business owners. QFD is used to establish procedures for new product design and development, including quality management. Quality – Function - Deployment improves a product or service's performance by tailoring it to the needs of the customer. It may enable the creators of these products to see cost savings as a result of it [18]. Japan pioneered the concept of QFD in the late 1960s. After WWII, Japanese companies used to copy and replicate product development; however, they decided to change their strategy to one based on innovation. The

Japan Society of Quality Control created a research committee in 1978 to focus on Quality Function Deployment (QFD) [17].

QFD is implemented in the early stage of the design process to ensure that the customer's preferences are integrated into the final product. The following are the four phases of a Comprehensive QFD:

(1) Product Planning (House of Quality) translates client demands or needs into product technical requirements to achieve them.

(2) Product design is the process of converting technical requirements into significant component attributes or systems.

(3) Process planning specifies the main process activities needed to achieve significant component attributes.

(4) Production Planning/Process Control: To keep operations under control, this part creates process control plans, maintenance plans, and training plans, among other things.

The QFD methodology entails the creation of one or more quality tables, which are matrices. The "House-of-Quality" is the name of the first matrix (HoQ). The customer's demands (VoC) are on the left side of the House-of-quality matrix, and the technical solution to achieving the requirements is on the right [16], [19].

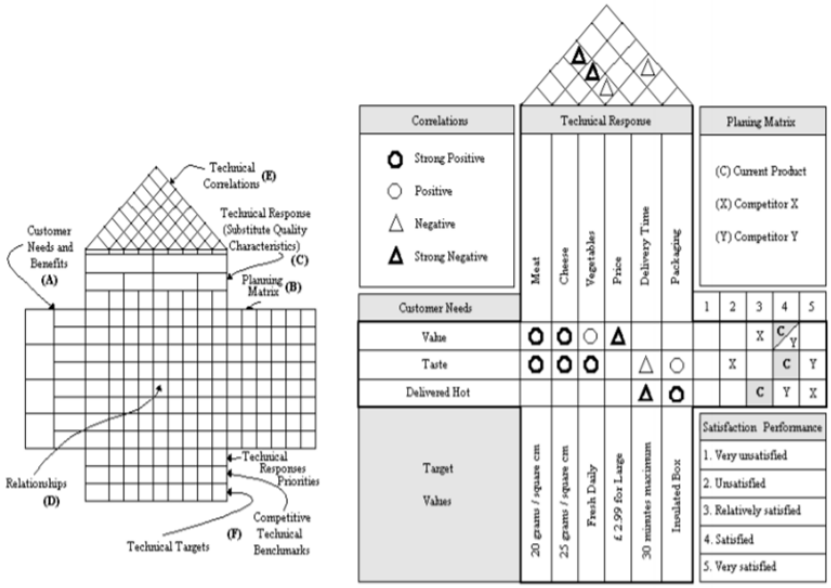

Figure 1: The House-of-quality [19]

Objective

1. To develop an understanding of affordable housing in detail to identify the parameters to define affordable housing in India.
2. To identify the aspects of Quality in Affordable Housing and access the quality of existing affordable housing in India.
3. To identify the needs of the customers in affordable housing quality and to apply a tool to prioritize the quality parameters.
4. To recommend the findings from the study to guide professionals and future research.

Scope

- The finding of the study could be used to smoothen the decision-making for the Affordable housing sector for quality improvement.
- The study will develop solutions for improvement in the quality level and guide professionals and future research
- This study will demonstrate the implementation of Quality Function Deployment in the construction industry for improving the quality of the projects
- Identifying quality characteristics and making recommendations in the form of a framework or procedure for evaluating and improving the quality of affordable housing

Limitation

- Limited access to case study sites due to the COVID-19 pandemic scenario.
- The study shall be limited to assessing construction quality through visual inspection, the quality of structural design/ detailing may not be possible to assess

Research Methodology

- Objective 1 outcome have arrived based on the literature review. It gives the overall idea about affordable housing, its definition, current scenario, trends in India, its bottlenecks, and analyses the factors for quality of affordable housing through literature review shortlisting
- Objective 2 will identify the various quality parameters of affordable housing construction through various housing quality assessment tools and will shortlist some parameters from that for the research and will access the quality of existing affordable housing identified in India through case studies
- Objective 3 quality function deployment tools and techniques and their application in the construction industry will be studied and will be applied in affordable housing. The input for the HoQ-house-of-quality developed in this stage will be through collecting real data from a case study and questionnaire survey of the selected parameters.
- Objective 4 gives the outcome of the research and solutions for the quality improvement, where recommendation framework and inferences will be generated to guide professionals and for future research.

AFFORDABLE QUALITY PARAMETERS – (SHORTLISTED CRITERIA)

After a literature review from almost 15 sources, the parameters that are to be appraised for the application are selected. The 10 parameters have been selected from four main categories namely technological, sociological, economical, and environmental. They are as follows

(1) Technological

(A) INNOVATIVENESS: is the ability to use new processes or ideas to bring value to affordable housing programs. To qualify for affordable housing, the following conditions must be met.

(B) DESIGN OPTIMISATION: This is the process of designing for maximum utility. Affordable housing proposals evaluated using this metric are anticipated to meet any or all of the following criteria.

(C) PERFORMANCE: This is the ability of the affordable housing scheme's structural framework and engineering services to be stable and in excellent working order.

(2) Sociological

(A) SOCIAL INCLUSIVENESS: This is the extent to which any Affordable housing program promotes access to a job, school, healthcare, food, and so on.

(B) SECURITY/CRIME CONTROL: This is the ability of an affordable housing program to promote the security of its residents, their properties, and so on.

(3) Economical

(A) USE OF MATERIAL: This is the ability of the affordable housing project to reduce costs while maintaining quality in the building materials specified for its construction.

(B) ENERGY OPTIMISATION: This is the ability of an affordable housing plan to reduce the cost of energy used by residents.

(4) Environmental

(A) HEALTH AND SAFETY: This is the Affordable housing scheme's ability to ensure good and acceptable health and safety for its residents.

(B) WASTE DISPOSAL: This is the ability to dispose of unwanted garbage from any Affordable housing scheme.

(C) TRANSPORTATION: This is the ability of an affordable housing scheme to build strong, efficient, and low-cost community linkages with the rest of the neighborhood.

Table: 1 Affordable housing comprehensive demanded qualities; (source: author)

S.N	CATEGORY	REQUIREMENTS	DESCRIPTION
1	**Technological**	Innovativeness	To Explore new techniques or idea in contributing to added value to affordable housing scheme
		Design optimisation	To achieve optimal utility through design
		Performance	To have its structural framework and engineering services stable
2	**Sociological**	Social inclusiveness	To fosters access to job, school, healthcare, food etc
		Security/crime control	To foster security of the inhabitants, their properties etc
3	**Economical**	Use of material	To achieve cost reduction without compromising quality in the specification of the building materials for its construction
		Energy optimisation	To reduce the cost of energy being used by the inhabitants
4	**Environmental**	Health and safety	To maintain good and adequate healthy and safety environment for the inhabitants
		Waste disposal	
		Transportation	To establish strong,efficient and cheap commune links between itself and the rest of the world-

FRAMEWORK FOR AFFORDABLE HOUSING

When it comes to the construction of house-of-quality (HoQ), Figure 2 shows the complete QFD chart developed. The QFD-based design is obtained through the following steps. The first one is filling the needs of customers and technical characteristics. All the customer requirements summarized in the final list of parameters classification 'were put into "customer requirement" or the "What's" and the "Engineering requirements" or the "How's" columns of HoQ. This step is to translate the Customer Requirement into relevant Technical Requirements based on guidelines and literature review.

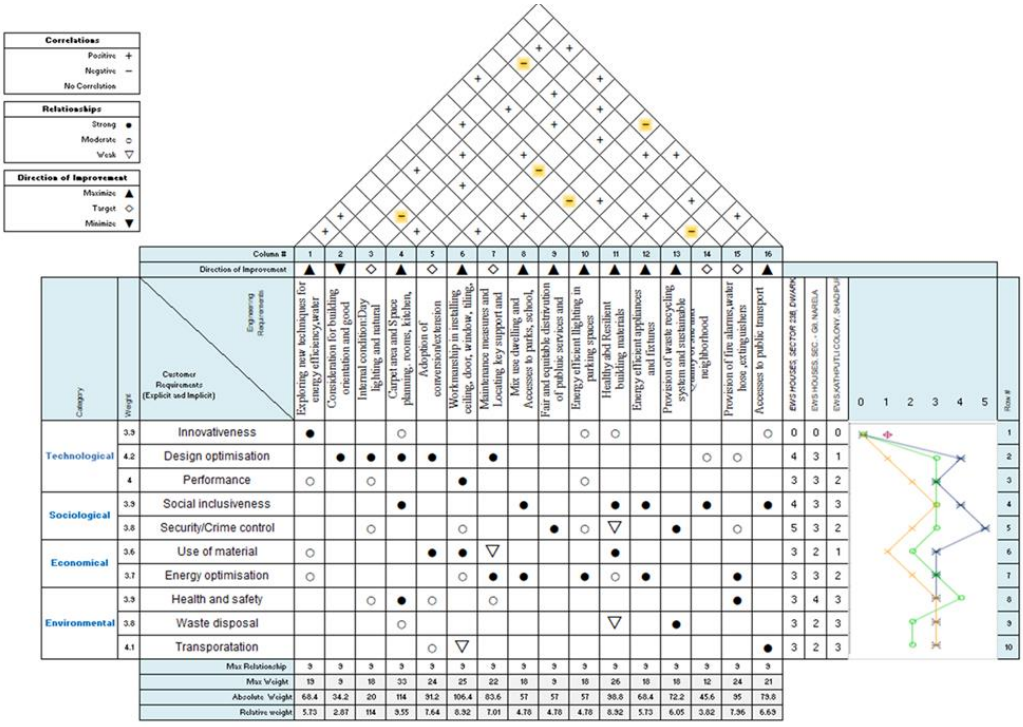

Figure 2: Complete QFD Chart - (Source: Author)

The cornerstone of the QFD methodology is the relationship matrix. The relationship between the intended quality and the technical criteria is depicted in this matrix. The values of the relationship matrix are determined on a three-point ordinal scale ("weak," "medium," and "strong"). A correlation value expresses how well a design specification serves the aim of a given desired quality criteria. For example, we can see that design optimization is strongly related to conversion/extension adoption. This matrix shows how the design specifications support each other to identify the bottlenecks. In this investigation, a three-point scale was used, in which "+" represents a strong positive correlation, blank represents no correlation while "-" represents a negative correlation., For example, we can see the workmanship in installing area have a strong correlation with maintenance measures and likewise.

MATERIALS AND METHODS

A 5-point Likert scale was employed in this study. On a 5-point importance scale, stakeholders in affordable housing were asked to rank the questionnaire items.

1 = not important,
2 = slightly important,
3 = moderately important,

4 = important, and
5 = extremely important.

The data collected from the questionnaire survey were analyzed using the RII method. The target population for this study is architects, planners, builders, developers, contractors, sub-contractors, and homeowners in Delhi NCR.

Questionnaire Survey Data Analysis

The survey was then conducted for 1 month among 50 stakeholders, overall, 36 responses were got Table 2 shows the Questionnaire survey data analysis and Relative Importance Index calculation. Figure 3 shows the Questionnaire survey Relative Importance Index Graph that indicates the breakup of the 4 criteria. It is found that design optimization is given much importance.

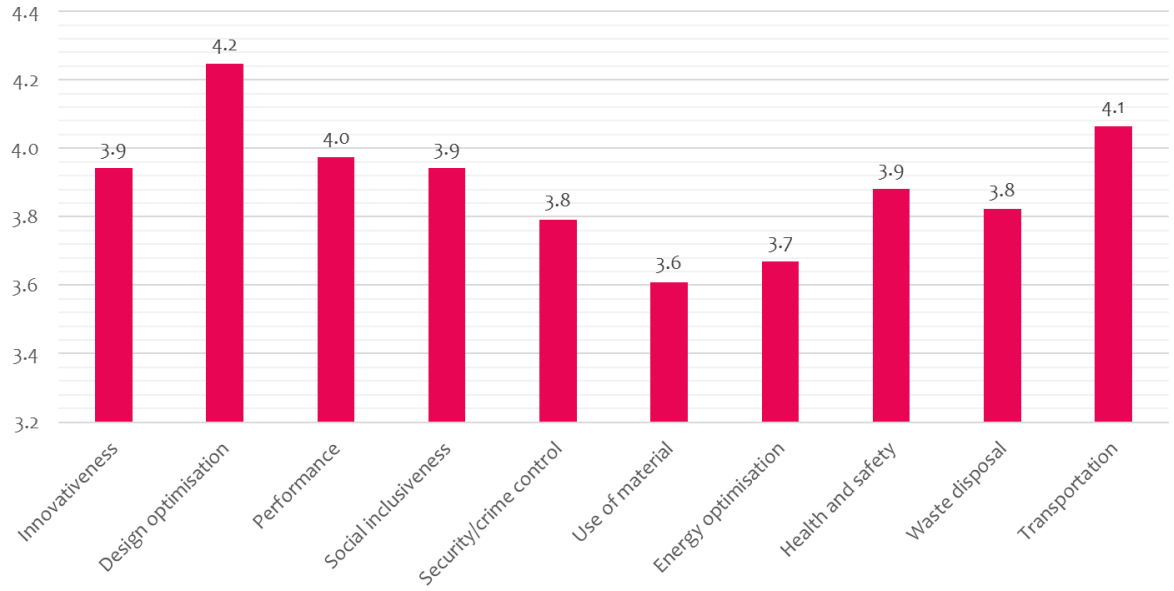

Figure 3: Figure showing relative index ranking graph (Source: Author)

The Construction of the HOQ

(1) Filling the customer requirements and Technical Characteristics: The final list of parameters classification was put into room A or the "demanded quality features" or the "planning or design matrix" or the "What's" column of the HoQ and the Room D is filled with the "Quality characteristics" or "Technical requirements" or the "How's". This step is to translate the Customer Requirement into relevant technical requirements based on (1) international guidelines, and (2) a review of the literature.

(2) Construction of the Relationship Matrix: This matrix represents the relationship between the desired quality and the technical requirements. The values of the relationship matrix are established using a 3-point ordinal scale (1="weak", 3= "medium", and 9= "strong"). This QFD-based approach employs a linear interval scale (1 = low, 3 = moderate, and 9 = high). A correlation value expresses how well a design specification serves the aim of a given desired quality criteria.

(3) Construction of the Correlation Matrix (Roof): This matrix or network depicts how the design requirements work together to identify bottlenecks and trade-offs. In this study, a

three-point scale was used, with "+" representing a strong positive correlation, "blank" representing no correlation, and "-" represents a negative correlation.

CASE STUDY

For the survey, 3 case studies were selected from the EWS category to study the quality of housing.

Case Study 1 - EWS Houses, Sector 23b, Dwarka
Case Study 2- EWS Houses, Sec. - G8, Narela
Case Study 3- Kathputli Colony, Shadipur

In the case of studies, the quality is analyzed through the affordable housing checklist made through the consideration opted for each of the 10 shortlisted parameters. The parameters have been weighted by the results obtained during the survey. Each case study has been studied from the site visit and videos available on the internet. The case studies have been ranked for each parameter on a zero to five scale and a weighted average has been taken through the data from the survey. The quality comparison has been done and has been used in HoQ for the prioritization matrix. Quality aspects of housing have been shortlisted through various quality assessment tools. The 3 case studies have been compared based on the 4 categories i.e. Environmental, Sociological, Technological, and Economical, and it is found that the EWS at sector 23b Dwarka is performing well in terms of quality attributes than the other 2 case studies.

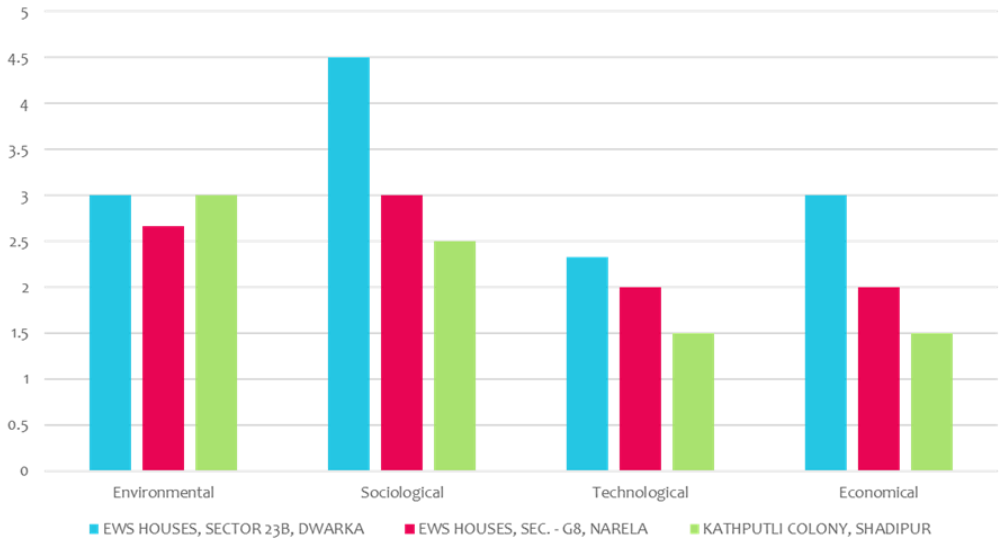

Figure 4: Quality Comparison of Case Studies on Environmental, Sociological, Technological and Economical Parameters; Source: Author

ANALYSIS

All of the matrices used for planning the assessment of existing product characteristics versus those of available standards are included in the analysis. This matrix has been altered to make the QFD approach suitable for low-income houses. Based on the current design, the matrix includes sections for each service as well as standard recommendations. In contrast to the usual HoQ, issues were put into the technical matrix to ensure that it was more than simply a wish list. The analysis was carried out using [20] methodology. The relative weights were then calculated.

Table 2: Showing the matrix with the technical characteristics, and it Relative weights

Technical Charecteristics	Max Weighht	Absolute weight	Relative weight	Rank
Carpet area and space planning	30	114	9.55	1
Workmanship	28	106.4	8.92	2
Resilent building materilas	26	98.8	8.28	3
Provision of fire safety equipments	25	95	7.96	4
Conversion/Extension facility	24	91.2	7.64	5
Maintenance measures	22	83.6	7.01	6
Lighting in parking space	21	79.8	6.69	7
Access to public transports	21	79.8	6.69	8
Waste recycling systems	19	72.2	6.05	9
Energy effiecient fixtures	18	68.4	5.73	10
Innovative Techniques	18	68.4	5.73	11
Day light and ventillation	17	64.6	5.41	12
Public service facility	15	57	4.78	13
Mix use dwelling	15	57	4.78	14
Quality of site and neighbourhood	12	45.6	3.82	15
Building orientation	9	34.2	2.87	16

(Source: Author)

The graph in Figure 5 shows the technical characters in order of prioritization. The five most important technical characteristics which need to be given importance for affordable housing quality were carpet area and Space planning of rooms, kitchen, bath, etc, Workmanship in installing ceiling, door, window, tiling, painting, plastering, plumbing work, and electric wiring, providing resilient building materials, provision of fires safety equipment's, and provision of conversion/extension facility.

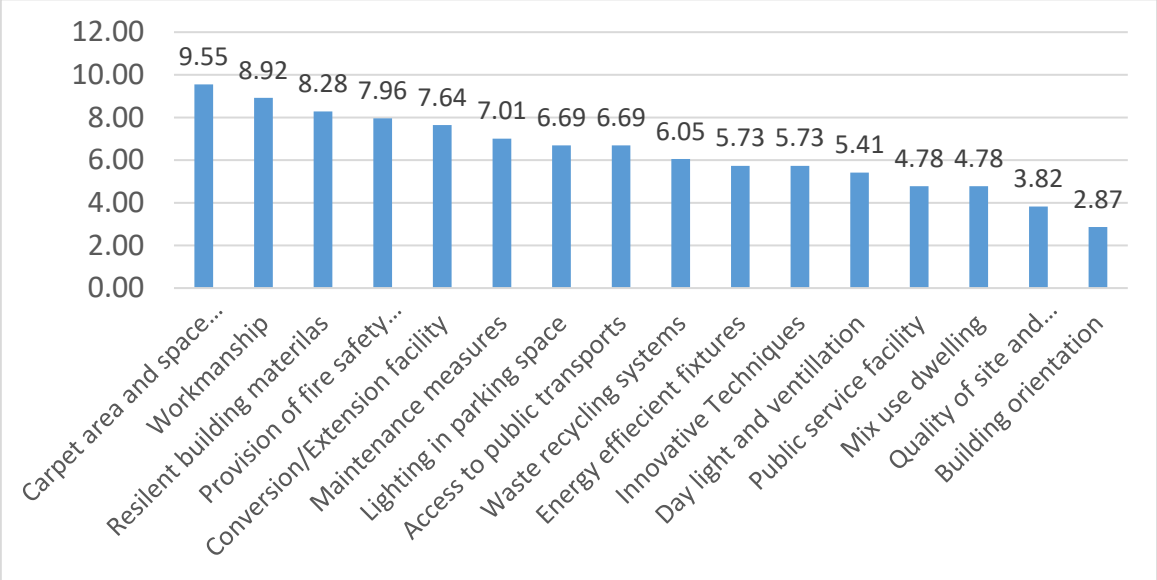

Figure 5: Prioritization chart of the technical characteristics; (Source: Author)

Here, a group of technical features was presented to meet the demands and their relationship with each of the agreed-upon customer criteria. For the next HoQ, the five most critical technical qualities were chosen. To meet the demands, a set of technical features was provided, and their link with each of the client criteria was agreed upon.

DISCUSSIONS

Based on the analysis, some of the ways by which developers can improve the quality of affordable housing development include employing a toolkit and coming up with fresh ideas. A minimal space requirement should be considered for the functions of rooms and other living spaces to be easily converted without incurring unjustified negative effects. A strategy on affordable housing should take into account the distance from employment, education, healthcare, food, social, recreational, and cultural venues. The greatest way to influence high-quality affordable housing is to engage in a complete design process from the start, ensuring an acceptable solution and the best value for money.

Every project is unique, catering to a variety of needs and circumstances. Technical and design guidelines can be helpful, but they do not guarantee quality. Guidelines and toolkits are just as vital as a solid design team, a passionate, committed client, and strong stakeholder involvement. Considering customers' requirements, the developer needs to have a strong emphasis on sustainability while keeping expenses reasonable. To keep the cost of maintenance and energy requirements low, innovative solutions, and energy-saving measures should be implemented.

CONCLUSION

The matrix developed in this study through case studies may be utilized by developers/designers as a system approach and decision-making/planning tool to add value to affordable housing projects by ensuring the quality of priority quality indicators. It is determined that improving prioritized quality parameters is the first step in improving the construction quality of affordable housing within a given time frame. Throughout the design process, this prioritization will be utilized as a guide keeping the emphasis on the customer's requirement. Practitioners can use the tool kit and prioritizing matrix for a successful output from affordable housing quality, and a continuous exercise with new components is required to identify the inadequacy of their programs. At each level of usage, the observed deficit or demand should be made the targeted aim for the next stage. As a consequence, rather than being a one-time event, the exercise's benefits are increasingly visible over time.

The toolbox highlighted the essential quality demands and weaknesses of the Indian affordable housing sector. However, the proposed toolkit in this research is based on the framework of four impact variables. Continuous evaluation is necessary for effective validation in the future. This research could help to accommodate any changes that may occur within the established parameters and criteria as a result of technological advancements, automation, regulatory changes, or other factors.

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