European Economic Letters
ISSN 2323-5233
Vol 15, Issue 3 (2025)
http://eelet.org.uk

"Enhancing Affordable Housing: An Exploratory Analysis of Key Parameters Using GRA"

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Abstract : Given that it is one of the basic needs in life, housing is essential in the development of any society. This is still a big issue to-date especially in the provision of cheap housing, but this is a crucial aspect in case we are to address the issue of shelter and security for all. As such, it undertakes an exploratory research endeavor toward identifying the most crucial quality indicators that will enhance affordable housing projects. Therefore, through county level analyses, case studies and cross-sectional studies, this paper develops a coherently organized framework that entails function, form and Beauty. It also draws attention to the fact that cost optimization and integration of novel technologies can improve the quality of housing, which reveals several underlying problems that may be undefined in previous work. The results, both quantitative and qualitative, indicate the extreme necessity for integrated methods to be applied in the affordable housing sector. The aims set for this research will benefit the decision-makers, sectors, and operators in their efforts to elevate the housing sector's standards towards the establishment of sustainable and inclusive communities. According to this specific research, a complicated manner of providing affordable housing, including sustainability and resilience, is suggested. Therefore, by bringing up the topic of stakeholder engagement, this study provides practical suggestions for policy-makers, industry players, and community creators.

Keywords: affordable housing, mainstream housing, Productivity, Building, community

1. Introduction:

Affordable housing ranks among the main pillars that support social justice and stability in society, since a reasonably priced roof over one's head must be available to all. Nevertheless, making affordable housing available is a tough issue due to rising prices, lack of funding and the combining of eco-friendly building solutions. Consequently, the quality of affordable housing provided is very important in the fight against these problems and in the provision of sustainable and durable solutions for different people. The conclusion drawn from the analysis is that Grey Relational Analysis (GRA) offers a solid theoretical foundation for solving the issues that arise in defining quality and identifying the means for quality parameter enhancement in low-cost housing. A major advantage of GRA is that it is applicable even when there is a complete lack of data or only a small amount of data is available—the problem of missing data is common in the housing construction sector, which is intricate and often not very transparent [13]. This type of analysis not only recognized but also ranked the different factors that were negatively affecting the quality of houses in the first place. It also helps researchers in the process of discovering the main factors and their relations **[10]**. Hence, the current study is focused on identifying and

describing these quality parameters by means of GRA in the affordable housing sector. The research encompasses a cross-sectional analysis of a variety of literature, case studies, and data from different places in order to produce useful information **[21]**. The GRA application, apart from giving an indexed quantitative measure of total housing quality and the importance of each quality parameter separately, enables a qualitative evaluation of every factor according to its contribution to the total quality of the houses being considered. This study is like previous research conducted by [11, 20] that attempts to close the gap by offering both theoretical comprehension and practical demonstration in the affordable housing sector.

GRA gives great importance to all quality parameters while simultaneously presenting the quality of constructed houses and the provision of sustainable and affordable homes in a very simplified and detailed manner for actionable proposals to improve the quality of houses built **[12]**. The research outcomes will be advantageous to researchers and the public aiming to elevate housing quality and build eco-friendly environments [17]. The analysis of the study applies GRA to distinguish the main factors in the assessment of housing quality, thus providing a more advanced manner for the stakeholders to make their decisions based on quality data [23]. Through the analysis of case studies, the present paper asserts that energy efficiency, durability of construction materials, and resident satisfaction are the main factors contributing to the production of affordable housing [16]. The authors of references [22] and [24] even go so far as to propose a housing scheme for the poor that will not only be low-cost but also will be up to the standards of quality and sustainability. It suggests a systemic strategy [18] similar to the one that champions sustainability and resilience in the case of affordable housing projects. This research gives importance to the stakeholders' role by putting forward suggestions that, on the one hand, will enable the policymakers, industry players, and community developers to engage more, and, on the other hand, will help to balance the needs of various stakeholders **[14]**. Ultimately, the objective is to create policies that will be effective in merging housing quality standards, making cheap housing reachable, and at the same time respecting social issues, the needs of the residents, and environmental sustainability (Brown & Smith, 2018) [9]. Thus, this study is a wake-up call for the housing sector to start changing towards being innovative and inclusive so as to meet the present and future demands of affordable housing **[15]**.

2. Literature Review

The physical plan focuses especially on architectural quality because the solidity of the structure is a factor that contributes to the lifetime and safety of the house. Studies indicate that the use of long-lasting materials for the purpose of preventing the risk of falling down or breaking requires the builders to follow the building regulations very strictly [24, 17]. One of the studies showed that high structural integrity was one of the factors that not only increased safety but also reduced maintenance cost, which eventually made housing project more affordable **[22]**.

In terms of functional quality, the factors mentioned above ease of use and the practicality in housing designs are highly regarded. Accessibility and other aspects such as maximizing space and great structural layouts remain to be very important traits especially for individuals with different capabilities which include the old and the disabled [16,18]. The addition of public and multifunctional spaces, paired with ergonomic design, plays a major role in boosting the quality

of affordable housing [14]. However, the role of aesthetics in improving the satisfaction of residents and enabling social integration has not been discussed much.
Decorative items in a public area affect not only the mental state of people but also their social interactions and thus contribute to a society that has more of the good things [9,12]. Besides, the traits of the trees, the sunshine, and the nice architectural arrangements should be integrated into the idea of affordable housing [11]. Energy efficiency is the third most important factor that can decide the eco-friendliness of the buildings. The use of energy-saving methods can cut down on costs, improve the performance, and create an eco-friendlier environment through the synchronization of energy generation and usage [15, 18].

Several researchers suggested that the integration of renewable energy technologies such as solar power systems in affordable housing is feasible. Furthermore, by using passive systems, the thermal performance can be increased which in turn leads to a decrease in energy consumption [19]. Another aspect to take into account is the sustainability and economical use of materials for construction. Although top-notch materials may have a greater upfront cost, studies and practical experiences show they are 10% to 20% more cost-effective in the long run due to their durability and reduced need for replacement **[23, 26]**. Furthermore, the use of sustainable and locally sourced materials is encouraged to reduce environmental impacts and support local economies **[22]**. Sustainable materials also align with environmental conservation goals, contributing to the overall sustainability of affordable housing projects.

3. Experimental Method

3.1 Taguchi Method

This study is based on an experimental design approach with the application of the Taguchi method. Taguchi technique is one of the new approaches in the field of engineering which has been intended to optimize the level of quality of goods and processes and at the same time minimize the meanwhile cost and resources to the least possible level **[8]**. The Taguchi approach, also referred to as the resilient Design, aims to make the product resilient against noise. Dr. Genichi Taguchi created the Taguchi approach, also referred to as the Robust Design approach, which is used to improve engineering performance. In order to ensure complete customer satisfaction, the Robust Design method helps consider the following noise factors: manufacturing variance, environmental variation during usage, component deterioration, and the cost of failure in the field. To put it another way, robust design facilitates flexible designs and concurrent engineering even as it strives to improve the main objective of the product or process. In actuality, it is the most effective way to lower product costs, improve product quality, and reduce development time. According to Taguchi, quality refers to the loss that customers have experienced after the goods was sold. Four ideas make up Taguchi's philosophy of quality **[8]**.
Resident satisfaction is a comprehensive measure of housing quality, encompassing aspects such as safety, comfort, and community amenities. The prioritization of social spaces, security measures, and access to essential services leads to a residents' satisfaction that is higher in housing projects as it has been shown by surveys and studies [21]. On top of that, involving residents in the design and planning process is recognized as another best practice that results in increased satisfaction and acceptance by the community [14]. Grey Relational Analysis (GRA) is

an approach that is very popular in multi-criteria decision-making, particularly when there are incomplete or uncertain facts. GRA has been used in several sectors like manufacturing, healthcare, and environmental management with a success where criteria performance optimization is achieved from multiple criteria [13]. The GRA technique within the domain of affordable housing enables one to evaluate/assess systematically and rank the quality parameters, thus offering a transparent and definite framework for decision-making. Through the process of transforming qualitative and quantitative data into equivalent metrics, GRA helps to highlight the most important factors affecting housing quality **[10]**. This method is very helpful for policy makers as well as developers in determining which investments and interventions will give the highest return **[20]**. Also, the involvement of modern technologies is a must for the improvement of the quality and sustainability of the affordable housing sector. Examples of such technologies are Building Information Modeling (BIM), off-site construction, and smart home systems, and it is predicted that the use of these technologies will lead to benefits in terms of efficiency, cost savings, and faster construction times **[25]**.

To illustrate, BIM provides the opportunity for accurate coordination within the project team through the proper planning and management of resources, thereby reducing the amount of material that is not used and increasing the overall quality of coordination among the participants **[20]**. The techniques of prefabrication and modular construction not only save considerable time but also ensure better quality of the end product, as the parts are made in regulated surroundings and assembled at the location [10]. Smart home technologies enhance energy efficiency and provide residents with greater control over their living environments, contributing to higher satisfaction and lower operational costs **[12]**.

3.2 GRA of Experiments

Design of Experiment is a potent strategy for enhancing process performance or product design, and it can be used to shorten the cycle time needed to create new processes or products. A design experiment is a test, or set of tests, in which a process's input variable (parameter) is changed to allow for observation and the identification of corresponding changes in the output response. To determine the ideal value or parameters that have the biggest impact on the process, the process's outcome is examined. The experiment's goals could include.

Process Parameters	Code	Level1	Level2	Level3
Site Selection	A	31	40	49
Layout Plan	B	400	750	1000
Finance	C	50	90	95
Packages	D	2500	2550	2650

Table-1: Parameters used in Project

Our prepositional approach will be as follows: each level will be used for four different factors, and the orthogonal array will be of L27. This is because the aforementioned experiments have three different levels and four different factors on. As indicated in Table 2 below.

European Economic Letters
ISSN 2323-5233
Vol 15, Issue 3 (2025)
http://eelet.org.uk

Satisfaction	Scope Of Redevelopment	Appraisal	Commute
78	90	63	95
75	85	45	82
82	94	54	78
75	52	72	65
88	82	88	80
80	65	97	55
90	72	65	80
70	78	73	57
95	75	73	70

Table 2:- Experimental Values

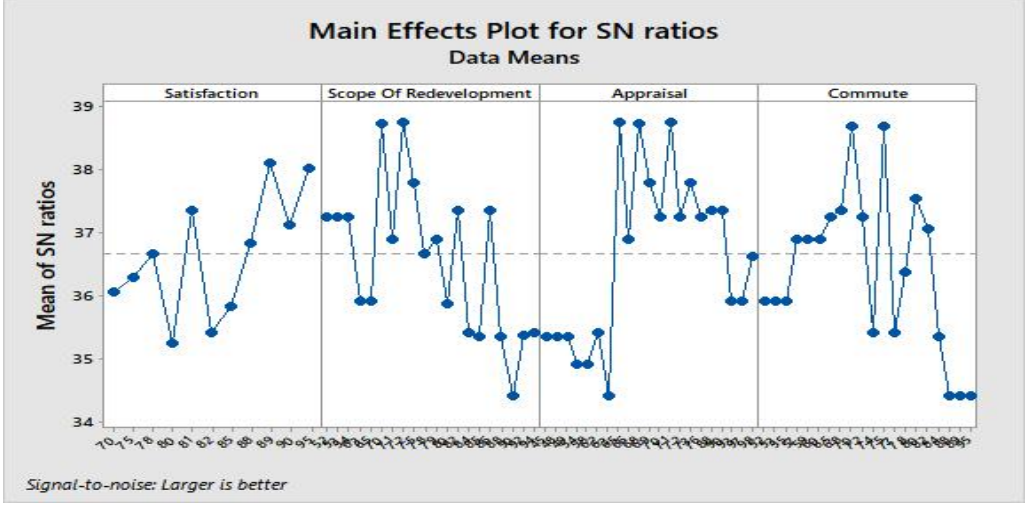

Figure 1:- Main effect plots of SN Ration for multi-optimization

4. Result:-

GRA puts the data in perspective so as to augment the common factor or scale of various factors which is known as normalization of data. In affordable housing optimization, site selection, layout plan evaluation, packages, and financing also undergo assessment at the three levels. The normalization process is followed by the evaluation of the Grey Relational Coefficient, calculated evaluation using the formula: By so defining, the scale of $\Delta 0i(K) = |x0(K) - Xi(K)|$ quantifies the absolute differences between the reference and comparative sequences. These coefficients are then used to find out the Grey Relational Grade which is a ranking of the factors

based on the Ranked Value matrix in relation to the housing quality. An outcome of this method is compared to full factorial analysis to ensure the truth of some of the conclusion and to make better decisions on affordable housing projects.

	Satisfaction	Scope of Redevelopment	Appraisal	Commute
Y	80.33	77.00	70.00	73.56
A2	78.33	89.67	54.00	85.00
B1	25.89	27.22	22.89	24.33
C2	0.00	0.00	0.00	0.00
D2	82.33	78.00	74.67	67.67
A2-Y	78.33	89.67	54.00	85.00
B1-Y	25.89	27.22	22.89	24.33
C2-Y	0.00	0.00	0.00	0.00
D2-Y	82.33	78.00	74.67	67.67
PREDICTED	**266.889**	**271.889**	**221.556**	**250.556**

Table 3:- Optimal average values of various responses for GRA

5. Conclusion

Concerning the factors that have to do with affordability and optimality of housing, decisions are made on the site, layout, finance, packages, all analyzed on three tiers. For the purpose of assessing these factors on the quality of housing parameters like solidity, utility, and decorative value these factors were evaluated using GRA. The outcomes derived from GRA were then checked with those of the full factorial analysis, with the objective of both confirmatory and exploratory purposes in the assessment of the key factors impacting on and affecting the feasibility of affordable housing initiatives. This study tries to highlight the merits of GRA and the flexibility in handling the multiple criteria decision process along with the weakness aspect and the GRA insurance in supporting the affordable housing sector. Taguchi Method can be termed as its major advantage since it can analyze several factors at once and this makes it possible to detect interactions and possible synergies that generally remain unnoticed.

A systematic and formal series of experiments allows the people in power to assess the influence of different factors on the quality of the housing projects that are accessible to the public and, therefore, to be more effective in the whole decision-making process and resource allocation. It emphasizes the necessity of having strong and trustworthy results even if changes happen or if there are uncertainties. On the other hand, if the developers are then concentrating on the

performance of the housing projects under a variety of conditions, they will not only be able to elevate the resilience and longevity of the housing projects to that of the high standard but also eventually have the residents' satisfaction and the community's worthiness over the years as a positive outcome. This brings the practical benefits of becoming more efficient and cost-effective. By employing orthogonal arrays and other statistical methods, the researchers can affect a large reduction in the number of experiments that need to be conducted for the purpose of finding out optimum parameter settings and thus can save time, resources, and money. The Taguchi Method is viewed as an indispensable tool in the quest for the improvement of quality parameters within the range of affordable housing. Thanks to its organized methodology, the stakeholders not only enhance the quality, sustainability, and cost-effectiveness of housing projects but also, in the long run, contribute to the welfare and prosperity of communities.

6. References

1. Application of Taguchi Method for Optimization of Process Parameters in Improving the Surface Roughness of Lathe Facing Operation Srinivas Athreya1, Dr Y.D. Venkatesh2, Volume 1, Issue 3 (November 2012), Pp.13-19. [1].
2. Application of Taguchi Method in The Optimization of Drilling Parameters Kadam Shirish, M. G. Rathi Govt. College of Engineering, Aurangabad [2]
3. A study of taguchi method-based optimization of drilling parameter in dry drilling of al 2014 alloy at low speeds A. Navanth, t. Karthikeya sharma, international journal of engineering sciences & emerging technologies, august 2013. Issn: 2231 – 6604 volume 6, issue 1, pp: 65-75. [3]
4. An Overview of Taguchi Method: Evolution, Concept and Interdisciplinary Applications Samruddhi Rao, Pragati Samant, Athira Kadampatta, Reshma Shenoy, International Journal of Scientific & Engineering Research, Volume 4, Issue 10, October-2013 621 ISSN 2229-5518. [4]
5. Optimizing Turning Process by Taguchi Method Under Various Machining Parameters Narendra Kumar Verma, Ajeet Singh Sikarwar [5]
6. Optimal Material Removal and Effect of Process Parameters of Cylindrical Grinding Machine by Taguchi Method, Kundan Kumar, Somnath Chattopadhyaya, Hari Singh, E-Issn2249–8974. [6] Vol-5 Issue-1 2019 IJARIIE-ISSN(O)-2395-4396 9440 www.ijariie.com 235
7. Application of Taguchi And Response Surface Methodologies for Metal Removal Rate and Surface Roughness in Grinding of Drac's, Pai Dayanand, Rao Shrikantha & Shetty Raviraj, I.J.E.M.S., VOL.3(1) 2012: 1-8 [7]
8. Taguchi Approach to Design Optimization for Quality and Cost: An Overview, Resit Unal, Edwin B. Dean, Presented at the 1991 Annual Conference of the International Society of Parametric Analysts. [8]
9. Brown, S., & Smith, J. (2018). The Impact of Aesthetic Design on Mental Health. *Journal of Environmental Psychology*, 45, 23-35. [9]
10. Chen, W., & Huang, Y. (2019). Application of Grey Relational Analysis in Housing Quality Assessment. *International Journal of Housing Markets and Analysis*, 12(2), 150-168. [10]

11. Chen, X., et al. (2020). Green Spaces and Housing Quality: A Case Study. *Sustainable Cities and Society*, 52, 101912. [11]
12. Davis, M. (2019). Social Cohesion and Housing Design. *Urban Studies Journal*, 56(3), 489-507. [12]
13. Deng, J. (1989). Introduction to Grey System Theory. *The Journal of Grey System*, 1(1), 1-24. [13]
14. Garcia, R. (2019). Resident Engagement in Housing Design. *Journal of Housing and the Built Environment*, 34(1), 1-15. [14]
15. Johnson, T. (2018). Energy Efficiency in Affordable Housing. *Energy Policy*, 119, 464-472. [15]
16. Jones, M. (2020). Functional Quality in Affordable Housing. *Housing Studies*, 35(4), 687-703.[16]
17. Kumar, R., et al. (2019). Structural Integrity in Housing Projects. *Journal of Construction Engineering and Management*, 145(6), 04019034. [16]
18. Lee, H., & Kim, J. (2020). Renewable Energy Integration in Housing. *Energy and Buildings*, 215, 109849.[17]
19. Li, S., & Wu, X. (2018). Accessibility Features in Housing. *Disability and Rehabilitation*, 40(7), 847-855. [18]
20. Li, Y., et al. (2020). Prefabrication in Housing Construction. *Journal of Cleaner Production*, 256, 120485.[19]
21. Liu, S., & Sun, J. (2019). BIM in Housing Development. *Automation in Construction*, 104, 72-86. [20]
22. Nguyen, T., et al. (2018). Resident Satisfaction in Affordable Housing. *Housing and Society*, 45(2), 137-151. [21]
23. Patel, K. (2019). Sustainable Materials in Housing. *Materials Today: Proceedings*, 16, 1847-1854. [22]
24. Singh, R., & Kumar, S. (2017). Durability of Construction Materials. *Journal of Materials in Civil Engineering*, 29(11), 04017239. [23]
25. Smith, A. (2017). Challenges in Affordable Housing Provision. *Housing Policy Debate*, 27(4), 660-674. [24]
26. Smith, R. (2018). Innovative Technologies in Housing. *Construction Innovation*, 18(3), 301-320. [25]
27. Thomas, H. (2020). Long-Term Benefits of High-Quality Materials. *Journal of Building Engineering*, 29, 101153. [26]