Sürdürülebilir Mühendislik Uygulamaları veTeknolojik Gelişmeler Dergisi
Journal of Sustainable Engineering Applications and Technological Developments
2025, 8(1): 61-76

Konut Tasarımında Minimalizmi Yeniden Tanımlamak: NLP ve Çok Ölçekli Kriterler ile M1-M13 Değerlendirme Modeli

Redefining Minimalism in Housing: Introducing the M1-13 Evaluation Framework via NLP and Multi-Scale Criteria

Duygu Yıldız[1*], İlkim Markoç[2]

[1*] *Yildiz Technical University*, Department of Architecture, Istanbul,Turkey
[2] Yildiz Technical University, Department of Architecture, Istanbul,Turkey

ÖZET

Bu çalışma, mimari minimalizmi yalnızca estetik bir tercih olarak değil; konut tasarımında verimlilik, kullanıcı memnuniyeti ve kültürel sürekliliği odağına alan çok katmanlı bir stratejik yaklaşım olarak yeniden tanımlamaktadır. Bu kapsamda geliştirilen "M1-M13 Minimalist Konut Tasarım Kriterleri", minimalizmi biçimsel boyutların ötesinde değerlendirerek, tasarım süreçlerinin ölçülebilir, karşılaştırılabilir ve veri temelli bir çerçevede analiz edilmesini mümkün kılmaktadır. Örneğin, M2 kriteri kullanıcı refahına, M5 enerji verimliliğine ve M10 modüler üretime odaklanmaktadır.

Araştırma kapsamında Amerika, Kanada, Birleşik Krallık, Hindistan ve Portekiz'den seçilen yedi çağdaş konut projesinin mimari anlatıları, doğal dil işleme (NLP) teknikleri kullanılarak incelenmiştir. Doğal dil işleme (NLP) teknikleri, projelere ait metinlerde hangi tasarım temalarının ne sıklıkla ve ne derinlikte işlendiğini tespit etmek amacıyla kullanılmıştır. Her projeye ait yaklaşık 1500-2000 kelimelik metin kümesi BoW, TF-IDF ve kavramsal eşleşme analizleri ile değerlendirilmiş; tematik yoğunluklar, önceden tanımlanmış anahtar kelime kümeleri aracılığıyla M1-M13 kriterleriyle eşleştirilmiştir.

Bulgular, UDAAN ve Platforms for Life projelerinin özellikle modüler üretim, fonksiyonel esneklik ve teknik yalınlık gibi kriterlerde yüksek temsiliyete sahip olduğunu; buna karşın Adro ve Park Hill projelerinde kültürel bağlamın güçlü ancak teknik verimliliğin sınırlı düzeyde temsil edildiğini ortaya koymaktadır. Ayrıca, tasarımda şeffaflık, müdahale kolaylığı ve kültürel süreklilik gibi sosyal sürdürülebilirlik odaklı kriterlerin pek çok projede düşük düzeyde kaldığı görülmüştür.

Çalışmanın teorik katkısı, minimalizmin yalnızca "az" ilkesiyle tanımlanamayacağını; bunun yerine sadeleştirilmiş ve çok yönlü karar stratejilerinin bir ifadesi olarak ele alınması gerektiğini savunmaktadır. Mimarlıkta nadiren kullanılan NLP teknikleri, bu çalışmada mimari metinlerin nesnel biçimde analiz edilmesini sağlayarak değerlendirme süreçlerine yeni bir yaklaşım sunmaktadır. Bu model, akademik araştırmaların ötesinde, tasarım yarışmaları, sosyal konut politikaları ve planlama süreçlerinde karar destek aracı olarak pratik bir potansiyele sahiptir.

Anahtar Kelimeler: "Minimalist konut tasarımı", "Tasarım değerlendirme kriterleri", "Doğal dil işleme (NLP)", "Mimari metin analizi", "Konut üretimi"

ABSTRACT

This study redefines architectural minimalism in contemporary housing not as a visual trend, but as a strategic and multi-layered design approach. It highlights how minimalism can support project efficiency, enhance user satisfaction, and maintain cultural continuity throughout the entire life cycle of housing projects. In this context, the "M1-M13 Minimalist Housing Design Criteria" have been developed to extend beyond the formal dimensions of minimalism and enable the evaluation of design processes within a measurable, comparable, and data-driven framework. For example, M2 relates to user well-being, M5 to energy efficiency, and M10 to modular construction.

Başvuru: 31.05.2025 Revizyon Talebi: 12.05.2025 Son Revizyon: 14.05.2025 Kabul: 15.06.2025
Doi: 10.51764/smutgd.1707768

[1*] Duygu Yıldız,Yildiz Technical University;duygu.yildiz2@std.yildiz.edu.tr;ORCID: 0009-0004-8097-2797
[2]İlkim Markoç, Yildiz Technical University; ilkim@yildiz.edu.tr; ORCID: 0000-0002-7805-1153

The architectural narratives of seven housing projects from the U.S., U.K., Canada, India, and Portugal were analyzed using Natural Language Processing (NLP) techniques. Natural Language Processing (NLP) methods were used to analyze architectural texts, helping identify how frequently and deeply specific design themes, such as flexibility or sustainability, are emphasized in project descriptions. The study utilized Natural Language Processing (NLP) techniques, including Bag of Words (BoW), Term Frequency-Inverse Document Frequency (TF-IDF), and conceptual keyword matching, to analyze a text corpus of approximately 1500-2000 words per project. These techniques identified how often and how deeply specific design themes appeared in the texts. Thematic densities were then mapped to the M1-M13 criteria using predefined keyword clusters, and each project was scored on a 0-6 scale for comparative visualization.

The findings indicate that UDAAN and Platforms for Life exhibit high representation particularly in criteria such as modular construction, functional flexibility, and technical simplicity. In contrast, Adro and Park Hill demonstrate strong cultural contextuality, but limited technical efficiency. Moreover, several projects showed low levels of representation in socially sustainable criteria such as transparency in design, ease of intervention, and cultural continuity. Theoretical contributions of this study argue that minimalism cannot be defined solely by the principle of "less" but must be reconsidered as the expression of simplified, multi-dimensional decision-making strategies. At the methodological level, the study utilizes the analytical potential of natural language processing techniques, rarely employed in architectural research, to evaluate architectural narratives through a data-based approach, thereby enhancing the objectivity of architectural critique. Practically, the M1-M13 criteria serve as an applicable, modular, and replicable decision support tool for architectural education, design competitions, public housing policies, and sustainable urbanization strategies.

Keywords: "Minimalist housing design", "Design evaluation criteria", "Natural language processing (NLP)", "Architectural narrative analysis", "Housing production"

1. INTRODUCTION

The dynamics of neoliberal urbanization, coupled with factors such as rising population density and spatial expansion, have rendered the development of more holistic evaluation frameworks for the social, environmental, and economic sustainability of housing production imperative (Marrero et al., 2024; Markoc, 2012). This study argues that minimalism in housing must be redefined not simply as a stylistic or aesthetic expression but as a strategic, multi-dimensional design paradigm that intersects with sustainability, user agency, and cultural continuity. In this context, the discipline of architecture is being reexamined not only through formal aesthetics or design language but also through multidimensional criteria such as production processes, spatial quality, energy efficiency, and sensitivity to local context (Kumar et al., 2025). Architectural minimalism plays a central role in this transformation. It offers a paradigm that combines simplified aesthetics, lean production methods, adaptable user behavior, and environmental efficiency (Blackburn et al., 2024).

Initially conceptualized through the modernist principle of "Less is More," minimalism has evolved in the 21st century from a purely visual inclination into a strategic tool extending from building technologies to principles of social justice. Particularly in the context of housing production, minimalism is increasingly viewed as a multidimensional response capable of offering both economic accessibility and environmental efficiency at the structural scale in the face of crises such as population pressure, limited land supply, socioeconomic inequality, and climate change (Kallis, 2023, Markoc, 2018). However, realizing this potential requires reconceptualizing minimalism beyond its formal boundaries by approaching it through a lens that emphasizes functionality, construction-oriented logic, and user-centered thinking.

This study responds to this need by developing an original evaluation criteria set designed to quantify architectural narratives using quantitative methods. To operationalize this redefinition, the study introduces a new evaluation framework, the M1-M13 Minimalist Housing Design Criteria. These thirteen criteria extend beyond formal aesthetics and cover ecological (M5: energy efficiency), technological (M10: modularity), and user-centered (M2: well-being) dimensions. The model enables a structured, comparative analysis of architectural narratives in contemporary housing. The "M1-M13 Minimalist Housing Design Criteria" encompass thirteen core domains including production efficiency, technical simplicity, functional flexibility, modularity, energy efficiency, user well-being, and contextual sensitivity. The criteria are grounded in theoretical foundations and were subsequently applied to the architectural texts of seven contemporary housing projects using natural language processing (NLP) techniques.

Given the interpretive nature of architectural discourse, Natural Language Processing (NLP) techniques such as BoW and TF-IDF are employed to quantify design-related language across project narratives. These computational methods offer a novel way to assess the thematic weight and conceptual recurrence of minimalist principles across diverse projects. One of the key contributions of this study is the integration of an NLP-based thematic clustering approach into architectural evaluation processes. Architect statements, project narratives, and promotional texts, often overlooked in architectural literature, are utilized here as primary data sources. Each project was associated with a text corpus of approximately 1500-2000 words, analyzed through methods such as Bag of Words (BoW), Term Frequency-Inverse Document Frequency (TF-IDF), and contextual importance metrics. By transcending subjective interpretations, this method offers a systematic, replicable, and comparable scoring model, thereby proposing a distinctive analytical framework. By bridging computational linguistics with architectural theory, the study contributes to a growing interdisciplinary effort that treats design as both a conceptual and data-driven practice. The seven housing projects analyzed in this study were selected from the United States, the United Kingdom, India, Canada, and Portugal. These projects were assessed with consideration for geographical diversity and sociocultural context. The NLP-based analysis process examined each project's architectural narrative within the framework of the M1-M13 criteria and identified their strengths and weaknesses in terms of minimalist approaches. The research design is presented in Table 1.

Table 1 Research Design

Stage	Content
1.Problem Definition	The relationship between production efficiency, environmental sustainability, and user well-being in minimalist housing design is examined through architectural narratives.
2.Theoretical Background	Concepts such as minimalism, sustainability, technical simplicity, project life cycle efficiency, and cultural context are structured through an extensive literature review.
3. Development of the Criteria Set	Thirteen conceptual categories (M1-M13) derived from the literature are defined, and keyword clusters are constructed for each criterion.
4.Project Selection	Seven contemporary, accessible, and well-documented housing projects based on architectural texts are selected from five different countries.
5. Data Collection	Promotional texts, architect interviews, project brochures, and technical reports are compiled in .pdf/.docx formats.
6. Data Analysis	- Text corpora of approximately 1500-2000 words are compiled for each project. - Punctuation, special characters, and stop words are removed. Lemmatization is applied to reduce words to their base forms. - Conceptual matches are performed between the texts and the defined keyword sets for each criterion. - Term frequencies and contextual significance are calculated using TF-IDF and Bag of Words (BoW) analysis. - Based on match frequency, contextual placement, and content depth, each criterion is scored on a 0-6 scale. - The scores for each project according to the M1-M13 criteria are presented in a heatmap matrix. - Strengths and weaknesses, thematic intensities, and discursive gaps of each project are analyzed and contextualized with the relevant literature.
7.Original Contribution	The method offers theoretical and practical suggestions regarding its potential applications in architectural research.

This multi-layered research design not only ensures methodological consistency but also enables the systematic structuring and justification of the theoretical foundation of the M1-M13 evaluation criteria set. By proposing an innovative approach to architectural assessment, the study offers a comprehensive analysis on both theoretical and practical levels through the quantification of architectural narratives articulated by project authors. The developed M1-M13 criteria set functions as an applicable, modular, and scalable decision support tool, suitable not only for academic research but also for architectural competitions, public housing initiatives, sustainable development policies, and architectural education. In this context, the following section presents the theoretical background of the study and elaborates the conceptual foundations of minimalism in relation to its historical evolution, interdisciplinary dimensions, and conceptual expansions.

The broader aim is to inform architectural education, design competitions, and public housing policy by offering a replicable and scalable decision support framework. The M1-M13 criteria model is intended not only as a

theoretical construct but also as a practical tool for evaluating and guiding minimalist housing strategies in real-world contexts. Thematic density refers to the frequency and contextual clustering of key concepts related to each criterion in architectural texts. Conceptual matching denotes the alignment of narrative expressions with predefined design keywords.

2. MINIMALISM AND HOUSING DESIGN

2.1.Minimalism

Minimalism is not only an approach to formal simplification but also a way of living and thinking. This approach encompasses a wide range of domains, from consumption habits to spatial organization, from production methods to patterns of social interaction. At its core lies the principle of orienting toward the essential and eliminating all unnecessary elements. In the architectural context, this approach was epitomized by Mies van der Rohe's well-known dictum "Less is more," and has been recognized as one of the most refined interpretations of modernist design (Rulli, 2007). This principle is grounded in a design philosophy that prioritizes functional integrity over decorative aesthetics. The origins of minimalism can be traced through cultural bridges built between Eastern Zen philosophy and Western Bauhaus modernism. The phrase "Form follows function," coined by Louis Sullivan in the late 19th century, sought to transform not only architectural form but also patterns of living (Freidin, 2021). Concepts such as light, void, simplicity, and tranquility play a central role in the spatial experience of minimalism, while natural materials, plain surfaces, and geometric clarity embody its physical expression (Heikkilä & Hautamäki, 2024).

Minimalism extends beyond the physical environment to deeply influence individual psychology and collective behavioral patterns. Kang et al. (2021) define minimalism as a behavior pattern directly related to personal well-being, proposing that simplification supports a more meaningful life by reducing environmental and mental burdens. Accordingly, minimalism should not merely be regarded as a design preference, but rather as a holistic approach encompassing the interaction between individual, society, and environment.

2.2. Minimalist Approach in Architecture

Within the architectural discipline, minimalism has evolved into a comprehensive strategy that extends beyond design into construction, usage, and maintenance processes. Intentionally preserved voids, the directional use of natural light, a preference for raw materials, and the avoidance of ornamentation are among the fundamental principles of this approach. These principles contribute not only to aesthetic goals but also to critical areas such as environmental sustainability, cost-effectiveness, and user experience (Lucchi, 2023). Carvajal-Arango et al. (2019) demonstrate that the integration of lean construction principles into architectural design processes yields positive outcomes in terms of energy efficiency, material optimization, and operational sustainability. Accordingly, minimalism in architecture represents not only a formal simplification but also a strategic choice at the production and environmental levels. This approach is particularly relevant for large-scale projects such as public spaces and social housing developments. In this context, minimalism both enhances efficiency in project life cycle processes and enables meaningful architectural outcomes.

2.3. Minimalist Design in Housing Production

Neoliberal urbanization policies not only amplify urban land speculation but also further hinder access to housing due to social inequalities, economic vulnerabilities, and environmental threats (Ertürk & Markoç, 2025). Consequently, housing production has shifted from merely fulfilling the need for shelter toward becoming a multi-dimensional tool for addressing resource management, quality of life, and cultural continuity (Markoç & Çınar, 2018). This transformation pushes architectural practice toward more integrated and strategic approaches, positioning minimalism not just as an aesthetic choice but as a paradigm capable of responding to various urban challenges. In this regard, minimalist housing design has the potential to serve as an alternative model to address structural issues arising from neoliberal urban policies such as limited land supply, rising construction costs, and accessibility constraints (Markoç & Çınar, 2017). In dense urban contexts, open-plan layouts, multifunctional furniture, compact living spaces, and modular systems can offer effective solutions to spatial and social constraints. According to Ertürk and Markoç (2025), increasing population pressure and spatial constraints have heightened the demand for housing typologies that can deliver maximum functionality within minimal space.

From the perspective of sustainability, minimalist housing design provides environmental advantages such as reduced material consumption, the integration of energy-efficient systems, and a lower carbon footprint (Carvajal-Arango et al., 2019). However, the assumption that aesthetic simplicity directly equates to environmental sustainability must be critically reassessed. Visually minimalist structures may still generate significant carbon emissions or waste during construction. True sustainability, therefore, can only be achieved through life cycle

analysis and holistic design decisions (Perrucci & Baroud, 2020). Moreover, minimalist design holds significant value in terms of cultural sustainability (Sutantio et al., 2022). This concept includes not only the preservation of architectural heritage but also the continuity of lifestyles, collective memory, and value systems (Kaur, 2024). By reinterpreting local materials, traditional construction techniques, and regional architectural identities, minimalist design can symbolically bridge the past and the future. The integration of design and cultural identity observed in Scandinavian countries offers a powerful example of this potential. Similarly, in the context of Turkey, minimalist structures developed using local techniques can play a strategic role in balancing heritage conservation with contemporary needs (Oktay, 2020; Sarı Haksever & Markoç, 2020).

Minimalist housing offers flexibility not only at the physical level but also behaviorally and socially (Radogna & Kalhoefer, 2022). De Paris and Lopes (2018) emphasize that functional flexibility entails not only the transformability of spaces but also the creation of multifaceted experiential areas that can adapt to diverse lifestyles. Within this scope, modular systems, off-site construction methods, and digital fabrication tools enhance both production efficiency and user satisfaction (Molavi & Barral, 2016; Kamali & Hewage, 2017). For instance, modular systems such as expandable housing units or prefabricated wall panels can be easily adapted to different household sizes or local climatic conditions, illustrating the scalability and flexibility of minimalist solutions. Industrialized construction technologies in particular shorten construction time, reduce costs, and limit environmental impacts by minimizing waste generation (Du et al., 2023).

Another key dimension of minimalist housing production is its potential contribution to social sustainability. Planning decisions that prioritize shared spaces, communal areas supporting neighborhood relationships, and expandable modular units contribute to the formation of integrated living environments at the community scale (Vijayakumar et al., 2024). In this context, the success of minimalist housing should be evaluated not only in terms of spatial efficiency but also in its capacity to foster social cohesion and solidarity (Kang et al., 2021). For example, the provision of adaptable communal zones and expandable modules in social housing not only promotes neighborhood cohesion but also allows users to shape their environment over time.

Accordingly, minimalist housing design should be conceptualized as a holistic strategy, one that brings together formal simplicity, production efficiency, environmental performance, cultural continuity, and social adaptability within a unified architectural response. The effective implementation of this approach requires not only architectural practice but also a broader transformation toward simplification and transparency in urban policies, planning norms, and economic models. The following section will elaborate on the theoretical foundations and methodological justifications of the M1-M13 evaluation framework, followed by case analyses.

In practical terms, the M1-M13 model can be applied as a design evaluation tool during early project phases. For example, public housing competitions can integrate the criteria to assess not only spatial aesthetics but also contextual relevance, user needs, and long-term adaptability. Similarly, municipalities may utilize the model to shape urban development guidelines aligned with sustainability and inclusivity goals.

3. METHODOLOGY

3.1. Research Design

This study adopts a case analysis approach utilizing natural language processing (NLP) techniques to examine the multifaceted impact of minimalism in contemporary housing design. The foundation of the study lies in the M1-M13 Minimalist Housing Design Criteria Set, derived from interdisciplinary literature and structured to encompass dimensions ranging from aesthetics to production processes, energy efficiency to social sustainability. The research design was structured to enable architectural data to be analyzed not only visually but also through textual content.

In this context, architectural narrative forms such as architect statements, project briefs, and presentation documents were rendered measurable, and a text-based analytical model was developed beyond conventional observational interpretations. This approach allows the design tendencies of the projects to be evaluated not through their physical form but through the architect's discourse. This approach is especially valuable in architectural research, where discourse often shapes perception as much as physical form. By applying NLP techniques, the study transforms interpretive, language-based data into quantifiable indicators. This not only enhances the objectivity of architectural critique but also enables large-scale comparisons of projects based on their thematic priorities.

3.2. M1-M13 Minimalist Housing Design Criteria

The formulation of the M1-M13 Minimalist Housing Design Criteria is grounded in the necessity of establishing a comprehensive framework that encompasses not only the aesthetic qualities of minimalism but also its functional, environmental, social, and user-oriented dimensions. This study combines theory-driven foundations with

computational text analysis to develop an original and replicable evaluation model that translates abstract architectural ideals into measurable indicators. The development process of the criteria began with a systematic literature review spanning multiple disciplines, including architecture, sustainable construction, behavioral sciences, and urban studies. Accordingly, the criteria are not solely based on formal definitions of minimalism, but are informed by literature that emphasizes its pragmatic, environmental, and psychological implications in housing design.

In this regard, Cuadrado et al. (2015) and Carvajal-Arango et al. (2019) emphasize operational simplification and resource optimization in architectural production through the exclusion of non-value-adding processes (M1) and the promotion of lean construction principles (M8). The central role of user well-being (M2), mental clarity, and sensory comfort in minimalist environments is supported by the work of Kang, Martinez, and Johnson (2021), which frames minimalism as a behavioral and emotional model of well-being rather than merely an aesthetic sensibility. Criteria such as functional simplicity (M3), life-cycle-based design (M4), and environmental efficiency (M5) are derived from sustainability-oriented studies, including those by Sutantio et al. (2022) and Carvajal-Arango et al. (2019), which advocate for decision-making based on life-cycle assessments and low-carbon material strategies in housing design. The M6 criterion, centered on functional flexibility, is theoretically based on Radogna and Kalhoefer's (2022) work, which promotes spatial configurations and adaptable lifestyles oriented toward user-centric design in multilayered urban contexts. Criteria such as transparency in the design process (M7) and ease of intervention using low-tech strategies (M9) draw on findings by El-Husseiny and El-Setouhy (2022) and Markoc (2021), which underscore user participation and community engagement as essential components of sustainable practices, thus highlighting the social dimension of minimalism. The modularity and off-site construction criterion (M10) is derived from Kamali and Hewage (2017) and Molavi and Barral (2016), whose research emphasizes that prefabrication enhances construction speed, cost efficiency, environmental control, and waste reduction. Technological simplicity (M11), use of local materials (M12), and durability through ease of maintenance (M13) attribute significance to minimalism in terms of contextual sensitivity, resilience, and cultural sustainability. These criteria align with the holistic design frameworks advocated by Sutantio et al. (2022) and Carvajal-Arango et al. (2019), which highlight the necessity of integrating material choices, life-cycle approaches, and site-specific adaptations.

Unlike traditional assessment schemes in the literature that often prioritize visual or spatial form, the M1-M13 criteria set positions minimalism as a system of values and a set of operational strategies. Each criterion is articulated using discipline-specific terminology and is structured through thematic keyword clusters. This framework allows the application of Natural Language Processing (NLP) techniques to architectural narratives. Beyond increasing the objectivity of architectural critique, this approach enables large-scale comparative analyses through numerical metrics such as contextual richness, term frequency, and thematic co-occurrence. Each criterion is grounded in established literature across architecture, sustainability, production efficiency, and user-centered design. In this regard, the proposed evaluation framework encompasses both conceptual coherence and practical applicability. For instance, modularity (M10) and scalability are exemplified in prefabricated wall systems that can be adapted to varying plot sizes or household needs, supporting flexible implementation across diverse project contexts. Table 2 presents the theoretical foundation of the M1-M13 Minimalist Housing Design Criteria.

Table 2 Minimalist Housing Design Criteria.

Code	Minimalist Design Criterion	References
M1	Avoidance of non-value-added activities	Cuadrado et al. (2015); Carvajal-Arango et al. (2019)
M2	Focusing on basic user needs and enhancing human well-being	Kang, Martinez & Johnson (2021); Radogna & Kalhoefer (2022)
M3	Avoidance of uncertainty and functional complexity in design	Radogna & Kalhoefer (2022)
M4	Integration of simplification and optimization of construction time and life cycle	Carvajal-Arango et al. (2019); Sutantio et al. (2022)
M5	Reduction of resource use, carbon emissions, and construction waste through simplification of processes, materials, and spaces	Carvajal-Arango et al. (2019); Sutantio et al. (2022)
M6	Providing spatial diversity through functional flexibility	Radogna & Kalhoefer (2022)
M7	Increasing transparency and simplicity in the design process	El-Husseiny & El-Setouhy (2022)
M8	Lean thinking throughout all design, production, and disposal phases	Carvajal-Arango et al. (2019); Sutantio et al. (2022)
M9	Early identification and simple optimization of intervention-required points	El-Husseiny & El-Setouhy (2022)
M10	Use of modular and off-site construction to support construction time and	Molavi & Barral (2016); Kamali &

Code	Minimalist Design Criterion	References
	workflow	Hewage (2017)
M11	Enhancing design impact by minimizing the use of tools and technologies	Sutantio et al. (2022); Carvajal-Arango et al. (2019)
M12	Emphasis on locality (natural materials, cultural compatibility)	Sutantio et al. (2022)
M13	Durability and ease of maintenance	Carvajal-Arango et al. (2019)

This criteria set, which integrates theoretical paradigms with data-driven content analysis, serves as a modular, replicable, and scalable tool applicable across various fields such as architectural evaluation, policy development, and academic research. In this way, minimalism is redefined not as an abstract formal ideology, but as a concrete, measurable, and strategic design approach.

3.3. Data Collection and Case Selection

The sample analyzed in this research consists of seven mass housing projects built between 2012 and 2024, selected from diverse geographies including the United States, United Kingdom, India, Canada, and Portugal. The selection criteria were as follows: (i) the project must qualify as mass housing aimed at social, affordable, or mixed-income groups; (ii) accessibility to design documents, plans, interviews, and visual materials must be ensured; (iii) the project must align with principles of sustainability, functionality, and simplification; (iv) the availability of qualified textual data enabling an in-depth analysis based on the M1-M13 criteria. The selected projects are presented in Table 3.

Table 3 Projects analyzed in the study

Project Name	Year	City / Country	Architecture Firm	Functions
Via Verde	2012	New York, USA	Grimshaw Architects, Dattner Architects	Housing, commercial, health center, public green spaces
52 New Street	2021	Cambridge, USA	Just-A-Start, Rode Architects	Affordable housing, community room, commercial, gym
Park Hill Phase 2	2017	Sheffield, UK	Mikhail Riches	Housing, studios, student dormitory, offices
UDAAN	2018	Mumbai, India	Sameep Padora and Associates	Affordable housing, daycare, gym, commercial
Cité Angus II	2023	Montreal, Canada	Ædifica	Housing, commercial, public green spaces
Platforms for Life	2021	Vancouver, Canada	LWPAC, Intelligent City	Net-zero housing, education, health, urban farming, social spaces
Adro	2023	Lisbon, Portugal	MASSLAB	Affordable housing, commercial, public spaces

3.4. NLP Based Analyzing Process

This section outlines the process of converting qualitative architectural narratives into quantifiable data for analytical purposes.

-Text Corpus Construction and Preprocessing

The text corpus for each project was compiled from architectural narratives, promotional documents, interviews, and technical reports in PDF and DOCX formats. Each corpus comprised approximately 1,500 to 2,000 words. During preprocessing, all text was converted to lowercase. Then, punctuation marks, stop words, numerical data, and HTML codes were removed. Lastly, lemmatization was applied to reduce words to their root forms. This stage was executed using Python programming language with the support of the spaCy, NLTK, scikit-learn, pandas, and TextBlob libraries.

-Construction of Thematic Dictionaries and Conceptual Matching

For each of the M1-M13 design criteria, thematic keyword sets were constructed based on literature review. For

instance, the M5 (Energy and Resource Efficiency) criterion included terms such as energy-saving, solar, passive, and emission, while the M12 (Locality and Cultural Context) criterion featured terms like vernacular, local materials, and cultural continuity. Using these term clusters, conceptual matches within the texts were identified, and overlap maps were created for each criterion. These matches were implemented using regular expressions (Regex) via Python's re library. The complete list of key terms associated with each criterion is shown in Table 4.

Table 4 Minimalist Design Criteria and Associated Key Terms

Criteria	Key Terms
M1	efficiency, simplification, waste reduction, streamlined, optimization, eliminate steps, unnecessary process, non-value-added
M2	comfort, well-being, daylight, human scale, livability, health, accessibility, mental health, thermal comfort, social inclusion
M3	clarity, legibility, simplicity, clean lines, visual order, functional clarity, reduced complexity, uncluttered, minimal elements
M4	lifecycle, durability, maintenance, long-term use, adaptability over time, life-span, disassembly, cradle-to-cradle
M5	energy-saving, solar, thermal mass, passive design, low-carbon, emission reduction, renewable, insulation, green energy, reuse, embodied energy
M6	adaptable, convertible, flexible layout, multipurpose, hybrid space, reconfigurable, transformation, modular use
M7	stakeholder involvement, participation, co-design, transparency, community engagement, user feedback, inclusive process, consultation
M8	lean construction, lean thinking, process efficiency, just-in-time, minimal intervention, value-driven, streamlined workflow
M9	passive systems, self-regulation, intuitive solutions, straightforward repair, easy fix, low-tech intervention, modular upgrade
M10	prefabricated, modular, off-site, dry-construction, pods, panelized, factory-built, rapid assembly, plug-in units
M11	low-tech, simplified technology, user-friendly systems, minimum infrastructure, passive systems, reduced mechanical dependency
M12	local materials, vernacular, cultural context, indigenous, site-specific, regional identity, local climate, cultural continuity
M13	durability, robustness, low maintenance, weather resistance, material longevity, replaceability, resilient design, ease of upkeep

-Frequency and Contextual Relevance Analysis

Thematic intensity refers to how strongly a specific concept (e.g., user well-being) is emphasized across a text, while conceptual matching involves identifying semantically related terms within predefined clusters, ensuring both direct and indirect associations are captured. Using Bag of Words (BoW) and Term Frequency-Inverse Document Frequency (TF-IDF) vectorization techniques, each term's frequency and contextual distinctiveness within the documents were calculated. These analyses allowed for a quantifiable distribution of thematic intensity across each corpus. The implementation was carried out in Python using the CountVectorizer and TfidfVectorizer classes from the sklearn.feature_extraction.text module of the scikit-learn library.

-Thematic Coverage and Depth Scoring (0-6 Scale)

The keyword matches were evaluated not solely based on numerical frequency but also considering their contextual placement and conceptual depth within the texts. Accordingly, each criterion was scored on a 0-6 scale. Initial scoring was performed automatically via NLP algorithms. In edge cases (particularly between score levels 2 and 3), manual contextual verification was conducted by the authors to refine the scoring. This step minimized potential false positives or negatives and enhanced the reliability of the results.

-Visualization

The scores obtained for each project under the M1-M13 criteria were compiled into a numerical matrix, forming the foundational dataset for thematic analysis. The matrix was structured along the project-criterion axes, enabling both project-wise and criterion-wise comparisons. The multidimensional dataset was then visualized using various techniques. In the first stage, radar charts were employed to depict each project's representational strength across the M1-M13 criteria. These visuals highlighted strong and weak thematic areas. In the second stage, a heatmap matrix encompassing all seven projects was produced, revealing thematic intensities and representational gaps across criteria. Visualization was conducted using Matplotlib and Tableau software. This methodological

framework allowed the integration of both qualitative and quantitative data into a single platform, ensuring a replicable and objective analysis of architectural narratives. The resulting visualizations not only served descriptive purposes but also functioned as tools for explanatory and comparative analysis, offering a robust foundation for the systematic evaluation of architectural discourse.

The evaluation model developed in this study can be adapted for use in design education studios, housing competition juries, and early-stage municipal project assessments. For example, by applying M1-M13 scores during preliminary reviews, stakeholders can prioritize projects that align not only with aesthetic expectations but also with long-term sustainability and user-centered design goals.

4.FINDINGS

Within the scope of this research, seven housing projects selected from diverse geographical and cultural contexts were analyzed using the M1-M13 Minimalist Design Criteria. The scoring was conducted on a 0-6 scale, with 78 identified as the highest cumulative score, serving as an objective reference point for cross-project comparisons. Criterion-based assessments revealed clear strengths and weaknesses of each project.

Located in New York, the Via Verde project demonstrated strong representation in lifecycle approach (M4), energy efficiency (M5), and user well-being (M2). The architectural narratives prominently emphasized passive strategies and comfort-oriented design. However, limited content was found regarding transparency in the design process (M7), formal clarity (M3), and technical simplicity (M11), while themes such as modularity and stakeholder participation were underrepresented.

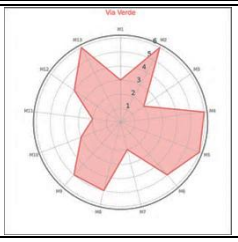
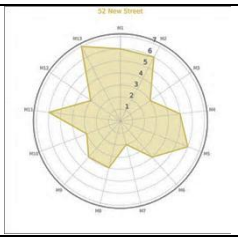
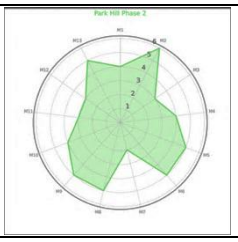
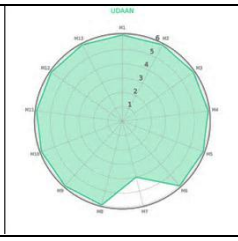
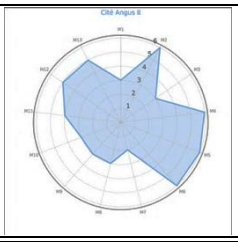
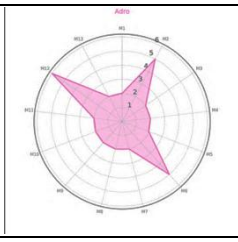
From the United Kingdom, the 52 New Street project clearly highlighted environmental strategies (M5), process simplification (M1), and low-tech solutions (M11), with explicit references to the Passive House certification. However, it lacked depth in cultural context (M12), modular systems (M10), and user engagement (M7). Similarly located in the UK, the Park Hill Phase 2 project stood out for its strong emphasis on user orientation (M2), spatial flexibility (M6), and repairability (M9). Yet, the project scored low in cultural continuity (M12), participatory processes (M7), and formal simplicity (M3). It also lacked narrative depth in production efficiency (M8).

India's UDAAN project exhibited the most holistic minimalist approach among all, with high scores across all criteria. Themes such as process efficiency (M1), modularity (M10), durability (M13), and the use of local materials were strongly articulated. Integration of low-tech systems (M11) was also evident. However, the content lacked sufficient emphasis on social participation (M7).

In Canada, the Cité Angus II project presented rich narratives around energy efficiency (M5), user satisfaction (M2), and spatial flexibility (M6). Nonetheless, it showed weaker representation in process management (M8), modular construction (M10), and technical simplification (M11). While integration with the local context (M12) was expressed with conceptual strength, content regarding transparency in the design process (M7) was limited.

The Platforms for Life project from Portugal demonstrated balanced and advanced representation across all criteria. In particular, it stood out in modularity (M10), user satisfaction (M2), and low-tech system integration (M11). Its narratives offered detailed and conceptually rich content on production processes and energy efficiency. However, discussion on cultural context (M12) was sparse, with little emphasis on themes like regional identity or local adaptation. Also located in Portugal, the Adro project focused on urban integration (M12) and spatial flexibility (M6), but exhibited weak representation in energy efficiency (M5), process simplicity (M8), and technical clarity (M11). The architectural narratives mainly revolved around formal design and the relationship with public space, with insufficient attention given to user-system interaction and project lifecycle strategies. This evaluation clearly demonstrates the systematic variation among projects in terms of their performance across the M1-M13 design criteria (Table 5).

Table 5 Evaluation of Projects According to Minimalist Design Criteria: Strengths, Weaknesses, and Radar Analysis

Project Name	Total Score	Strong Criteria	Weak Criteria	Commentary	Radar Graph
Via Verde	58	M2, M4, M5, M6, M8, M9, M13	M3, M7, M11	Strong in sustainability, user well-being, and lifecycle; weak in design transparency and simplicity.	
52 New Street	59	M1, M2, M5, M11, M13	M7, M10, M12	Highlights energy and process efficiency; lacks cultural context and user engagement.	
Park Hill Phase 2	54	M2, M5, M6, M8, M9, M13	M3, M7, M12	Strong user orientation and flexibility; weak cultural continuity and formal clarity.	
UDAAN	72	M1-M6, M8-M13	M7	High achievement across all criteria; only participation theme is underrepresented.	
Cité Angus II	56	M2, M4-M6, M11-M13	M1, M3, M7, M8, M10	Strong in energy and local context; weak in process and lean strategies.	
Platforms for Life	72	M1-M6, M7-M11, M13	M12	Balanced and comprehensive success; lacks content on cultural context.	
Adro	50	M2, M6, M12	M1, M4, M5, M7-M11, M13	Focused on urban integration and flexibility; lacking in energy performance and technical clarity.	

The M1-M13 criterion set provides a comprehensive and comparative framework for analyzing diverse housing strategies in relation to environmental, technical, cultural, and user-oriented dimensions. Notably, the criteria of modular construction systems (M10) and technical simplification (M11) were found to be represented at a high level only in the Platforms for Life and UDAAN projects. These two cases explicitly integrate industrialized construction techniques, the use of prefabricated elements, and strategies aimed at reducing mechanical

dependencies within their architectural narratives. In contrast, these criteria were either only marginally addressed or entirely absent in the design discourse of the other projects.

Regarding locality and cultural context (M12), the assessment shows that European projects, particularly Adro and Park Hill Phase 2, more strongly reference local architectural traditions, material selection, and regional identity. Conversely, projects from North America and Asia tend to reflect cultural continuity only through indirect expressions and display a lower level of thematic intensity. Thematic intensity in this context refers to the depth and frequency with which specific design themes are discussed or emphasized within architectural narratives, rather than their mere mention. This finding suggests that the project's relationship with its socio-cultural context can be as influential as its formal design content.

Among the minimalist design criteria, transparency in the design process (M7) and ease of intervention (M9) received low scores across all analyzed projects. In most cases, architectural texts did not adequately address user participation, stakeholder dialogue, co-design processes, or the representation of low-tech systems. These results indicate that minimalism in the analyzed projects has primarily been interpreted through visual aesthetics or environmental benefit, while deeper dimensions such as social sustainability and process-oriented decision-making strategies have been largely overlooked. This imbalance underscores the need to expand the scope of minimalist housing design beyond environmental and visual efficiency. In future projects, embedding participatory design practices and stakeholder engagement into architectural narratives will be essential to fulfill the holistic vision of minimalism advocated in this study. Without such integration, minimalist discourse risks remaining reductive and disconnected from community-based value systems. These findings are visually represented in Figure 1, which presents a heatmap comparing the selected housing projects according to the M1-M13 Minimalist Design Criteria.

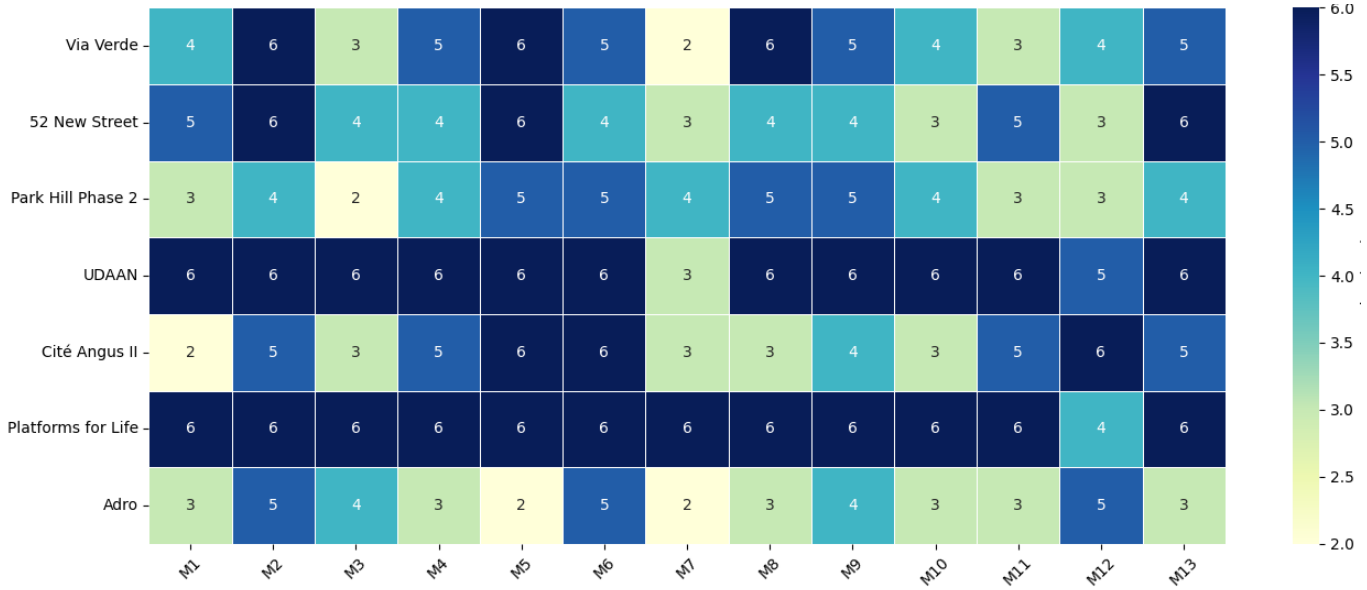


Figure 1 Heatmap of Project Evaluations According to the Minimalist Design Criteria

As observed in the heatmap (Figure 1), M7 and M9 criteria are consistently underrepresented across projects, reflecting limited emphasis on participatory design and ease of intervention. Natural language processing (NLP) analysis of the architectural narratives belonging to the selected housing projects revealed that the most frequently occurring terms were "daylight," "flexibility," "prefabricated," "modular," and "efficiency." This finding suggests that contemporary architectural discourse predominantly centers around concepts such as user satisfaction, functional flexibility, and modular production. In contrast, terms like "participation," "cultural continuity," and "repairability" were found to be only sparsely represented in the narratives. In this context, the NLP-based architectural narrative analysis method functions as an objective, reproducible, and digitally sustainable methodological tool that quantifies conceptual density within architectural discourse. These findings demonstrate the necessity of evaluating architectural projects not only in terms of aesthetics and environmental performance but also in relation to broader parameters such as simplicity across lifecycle phases, social participation, and construction strategies. These insights can be operationalized in architectural competitions, municipal housing guidelines, and design education studios. For instance, early-phase project evaluations may adopt the M1-M13 model to prioritize submissions that integrate lifecycle thinking, cultural continuity, and user adaptability. Such applications can help bridge the gap between architectural discourse and policy-making. The results presented here lay a robust analytical foundation for the theoretical and practical insights discussed in the subsequent sections of the study.

5.DISCUSSION

The natural language processing (NLP)-based textual analyses conducted in this study have revealed, in a comprehensive and multidimensional manner, how seven contemporary housing projects selected from different geographical and cultural contexts are positioned in relation to the M1-M13 Minimalist Design Criteria. The findings reveal meaningful distinctions in the projects' conceptual density, representational gaps, and theoretical orientations, based not on visual appearances but on the architectural narratives themselves, marking a significant departure from traditional evaluation approaches. Here, conceptual density refers to how often and deeply a theme is engaged within a project's narrative, while representational gaps denote the complete or partial absence of critical criteria in design discourse.

5.1. Comparison with the Literature

The NLP-based analysis results show that advanced construction strategies such as modular production (M10) and technological simplification (M11) were comprehensively represented only in the Platforms for Life and UDAAN projects. This aligns with Kamali and Hewage (2017) and Molavi and Barral (2016), who emphasize the environmental and operational efficiency offered by industrialized construction techniques. For instance, modularity (M10) in Platforms for Life is represented through the use of prefabricated, plug-in units, while technological simplicity (M11) involves reduced mechanical systems that rely on natural ventilation and passive lighting. In the remaining projects, modularity and simplified construction systems were either minimally represented or entirely absent from the architectural narratives. This indicates that architectural discourse continues to prioritize formal and aesthetic expressions, often sidelining construction technologies.

Similarly, the cultural contextuality criterion (M12) was found to be more strongly represented in European projects, which referenced local materials, architectural traditions, and regional identity more prominently. This finding resonates with the concept of "design-integrated cultural identity" as described by Kaur (2024) and Oktay (2020). In contrast, North American and Asian projects tended to reflect universality through formal design principles, with only indirect references to local specificity. Notably, the weak representation of cultural contextuality in a project from India, a country with strong local architectural heritage, is especially striking.

One of the most critical findings of this study is the consistently weak representation of design process transparency (M7) and ease of intervention (M9), both of which are closely linked to social sustainability. Themes such as user participation, simplified intervention, and low-tech accessibility, emphasized by El-Husseiny and El-Setouhy (2022), were found to be marginal both in architectural narratives and in actual design processes. This suggests that minimalism, as interpreted in the analyzed projects, is still largely constrained to environmental performance and aesthetic formalism, while deeper structural dimensions like social sustainability remain underdeveloped. Similarly, criteria such as the elimination of non-value-adding processes (M1) and the integration of lean thinking principles into production (M8), highlighted by Carvajal-Arango et al. (2019) and Cuadrado et al. (2015), were underrepresented in architectural texts.

The NLP analyses revealed that the most frequently occurring terms in the architectural narratives were "daylight," "flexibility," "prefabricated," "modular," and "efficiency." This suggests a strong discourse focus on user well-being (M2), functional flexibility (M6), and production efficiency (M1-M5), while more holistic social and cultural themes like "participation," "repairability," and "cultural continuity" remained marginal. In this context, the user well-being representation aligns with Kang et al. (2021), who connect minimalism with individual welfare and behavioral harmony. Overall, the M1-M13 Minimalist Design Criteria Set provides a robust evaluative framework that goes beyond aesthetics to encompass variables such as production processes, user experience, technical systems, and cultural adaptability. This multidimensional model not only supports the "strong minimalist thesis" advanced by Freidin (2021) but also operationalizes the conceptual frameworks proposed by Lucchi (2023) and Heikkilä & Hautamäki (2024) through architectural narrative analysis.

5.2. Theoretical and Methodological Contributions

The theoretical contribution of this study lies in its redefinition of architectural minimalism, not as a purely formal aesthetic, but as a strategic, multidimensional structural framework that incorporates production processes, lifecycle optimization, and user-centricity. By moving beyond paradigms such as Bauhaus, Wabi-Sabi, or Lagom, and integrating contemporary sustainability practices with industrialized building technologies, the study addresses a significant gap in the literature. The M1-M13 Minimalist Design Criteria Set not only offers a theoretical structure but also functions as a functional evaluation tool validated through empirical analysis. This study views minimalism not as mere "reduction" but as the synthesis of simplified multi-parameter decisions, integrating frequently overlooked concepts such as functionality, durability, ease of intervention, and contextual sensitivity into architectural theory. Thus, minimalism is repositioned not as a stylistic tendency, but as a systematic strategy

directly tied to measurable goals like social sustainability, production efficiency, and user satisfaction.

On the methodological front, this study transforms NLP techniques, rarely employed in architectural research, into a systematic approach for analyzing textual narratives. Through tools such as spaCy, TF-IDF, and contextual intensity mapping, architectural texts were evaluated via replicable, quantifiable methods instead of subjective interpretation. This provides an original analytical approach that renders design strategies legible through their textual representations. Particularly, the relationship between spatial minimalism and user well-being, as conceptualized by Kang et al. (2021), is tested in both conceptual and contextual terms within this study's project sample. In doing so, the psychological, behavioral, and social outputs of architectural design are made analyzable through narrative data.

The M1-M13 Minimalist Design Scale reconceptualizes architectural minimalism along the form-process-context axis and positions itself as an original tool enabling the quantitative measurement of multiple dimensions of minimalist practice. The study thus provides a theoretical grounding for viewing minimalism not just as a stylistic expression, but as a structured strategy for multidimensional design decision-making. Rather than restating architectural theory, the NLP-driven model allows researchers and practitioners to map conceptual focus and thematic gaps across diverse projects in a quantifiable way.

5.3. Practical Contributions

In addition to its theoretical depth, this study also offers significant guidance for practical implementation in the architectural field. The integration of the M1-M13 Minimalist Housing Design Criteria Set with the NLP-based analysis method transforms the model into a multidimensional decision-support tool applicable not only in academia but also in real-world planning and evaluation contexts. One of its primary practical contributions is the introduction of a criteria-based design guidance system. By translating abstract concepts into measurable parameters, the M1-M13 Criteria Set serves as a systematic guide from the early stages of the design process onward. This framework supports the objective interrogation of design content and the standardization of quality levels in architectural competitions, sustainable housing policies, and urban regeneration initiatives. It also enhances interdisciplinary accountability by enabling architects to document conceptual decisions transparently and measurably.

Moreover, the NLP-based thematic analysis method employed in this study moves architectural discourse beyond traditional interpretive approaches, allowing for the quantitative analysis of textual content. By treating architect statements, project descriptions, and promotional texts as primary data, the study replaces subjective evaluation models with reproducible, comparable, and objective outputs. This enables a clearer and more systematic analysis of the alignment, or misalignment, between architectural discourse and actual design actions. The model can be directly adapted into architectural studio coursework to assess student projects based on user-centric and ecological principles. Moreover, municipal planning departments may embed the criteria into affordable housing guidelines, enabling policymakers to screen proposals based on design clarity, lifecycle alignment, and social inclusion. In post-occupancy evaluation, the M1-M13 matrix can also guide community feedback assessments.

One of the key practical advantages of the M1-M13 model is its capacity to support objective, comparative analysis. Visualizations such as radar charts and heatmaps enable stakeholders, including jurors, municipalities, and policy-makers, to identify thematic strengths and gaps across housing projects with clarity. This enhances transparency and consistency in multi-criteria decision-making, particularly in high-stakes contexts. Moreover, the model provides a scalable and replicable framework suitable for guiding public policies focused on affordable, energy-efficient, and socially responsive housing. Its scalability allows it to be applied across diverse project sizes, while replicability ensures consistent evaluation across different geographic and cultural contexts, fostering a data-driven design culture within architectural practice.

6.CONCLUSION

This study redefines architectural minimalism not merely as an aesthetic preference, but as a multidimensional and measurable design paradigm. The developed M1-M13 Minimalist Housing Design Criteria offer a structured framework that extends architectural minimalism beyond formal aesthetics to encompass production efficiency, technical simplification, functional adaptability, and cultural continuity. By integrating natural language processing (NLP) techniques, the model enables a hybrid evaluation approach that combines qualitative depth with semi-quantitative analysis of architectural narratives from seven contemporary housing projects.

The analyses demonstrate that minimalism can be structured not only at the level of architectural products but also across the entire project life cycle, environmental strategies, and user-oriented design approaches. Projects that scored highly in criteria such as modular construction systems (M10), energy and resource efficiency (M5),

technical simplification (M11), and user well-being (M2) stand out as comprehensive examples that reflect the holistic potential of minimalism in contemporary architecture. On the other hand, low representation in criteria such as transparency in design (M7), sensitivity to cultural context (M12), and ease of intervention (M9) indicates that minimalism must also incorporate social and behavioral dimensions, beyond its physical manifestations.

On a theoretical level, the study repositions minimalism not as a strict interpretation of the "less is more" principle, but rather as a distilled expression of strategic design decision-making. The M1-M13 scale offers an objective and conceptual assessment model across the form-process-user triad in architectural theory, expanding the contemporary interpretation of minimalism in an interdisciplinary context. Methodologically, the study integrates NLP techniques, rarely applied in the field of architecture, into architectural text analysis, enabling designer statements to be analyzed in a data-driven and reproducible manner. The scoring based on thematic density and contextual correlation derived from architectural narratives provides a tangible and original evaluation tool for critical architectural theory. In this context, thematic density refers to the depth and recurrence of key design ideas in the text, while contextual correlation evaluates how well these ideas align with specific criteria clusters across different projects. Moreover, the M1-M13 criteria set holds the potential to serve as a modular, flexible, and scalable decision-support system for applications in architectural education, design competitions, housing policy, and urban regeneration practices. For instance, architectural schools may integrate the M1-M13 framework into studio evaluations; housing agencies could use it to assess design proposals in affordable housing calls; and municipalities might embed the model in planning guidelines to ensure lifecycle sustainability and user engagement. Here, modularity denotes the ability to adapt the criteria set based on context (e.g., public vs. private housing), while scalability reflects its potential to evaluate both small-scale units and large-scale urban development projects.

6.1. Limitations and Future Research

In addition to its contributions, the study also outlines several limitations to guide future research. First, all analyses were conducted based solely on textual architectural narratives. The absence of direct observation of physical outputs, user experiences, or project life cycle performance limited the capacity to evaluate user-centered criteria in real-world terms. Future studies would benefit from incorporating empirical data such as user feedback, post-occupancy satisfaction surveys, and on-site observations, thereby enhancing the internal validity of the scale. Second, the number and geographic diversity of analyzed projects were limited. While the sample represents countries like the USA, Canada, the UK, India, and Portugal, the architectural practices, local construction traditions, and socio-economic dynamics of the Global South remain underrepresented. In this respect, cross-cultural comparative studies could better illuminate the meaning and application of minimalist housing architecture in diverse socio-cultural contexts. A third limitation lies in the fact that the NLP algorithms used in this study were focused solely on textual analysis. In future research, integrating OCR-based visual recognition tools, plan-reading algorithms, or machine learning-supported models could facilitate a more layered and comprehensive architectural analysis that extends beyond textual data. Lastly, no simulation or pilot implementation has yet been conducted to explore how the M1-M13 criteria set could be directly used as a policy-making tool. Pilot implementations in collaboration with housing authorities or design competition juries could help validate the model's applicability and refine its operational criteria based on stakeholder feedback. The model's practical applicability in fields such as social housing, post-disaster reconstruction, and sustainable urban transformation needs to be tested through advanced fieldwork. These limitations simultaneously indicate areas for future development and offer new pathways for research, enabling the complex nature of minimalism to be explored and tested across multiple contexts and scales.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Author Contribution Statement

The article is a result of joint work by the authors, each of whom contributed equally.

REFERENCES

Blackburn, R., Leviston, Z., Walker, I., & Schram, A. (2024). Could a minimalist lifestyle reduce carbon emissions and improve wellbeing? A review of minimalism and other low consumption lifestyles. *Wiley Interdisciplinary Reviews: Climate Change, 15*(2), e865. https://doi.org/10.1002/wcc.865

Carvajal-Arango, D., Bahamón-Jaramillo, S., Aristizábal-Monsalve, P., Vásquez-Hernández, A., & Botero, L. F. B. (2019). Relationships between lean and sustainable construction: Positive impacts of lean practices over sustainability during construction phase. *Journal of Cleaner Production*, *234*, 1322-1337. https://doi.org/10.1016/j.jclepro.2019.05.216

Cuadrado, J., Zubizarreta, M., Rojí, E., García, H., & Larrauri, M. (2015). Sustainability-related decision making in industrial buildings: An AHP analysis. *Mathematical Problems in Engineering, 2015*(1), Article 157129. https://doi.org/10.1155/2015/157129

De Paris, S. R., & Lopes, C. N. L. (2018). Housing flexibility problem: Review of recent limitations and solutions. *Frontiers of Architectural Research, 7*(1), 80-91. https://doi.org/10.1016/j.foar.2017.11.004

Du, J., Zhang, J., Castro-Lacouture, D., & Hu, Y. (2023). Lean manufacturing applications in prefabricated construction projects. *Automation in Construction, 150*, 104790. https://doi.org/10.1016/j.autcon.2023.104790

El-Husseiny, M. A., & El-Setouhy, H. (2022). Sürdürülebilirlik yöntemi olarak düşük teknolojili inşaat modlarının canlandırılması. *Sürdürülebilirlik, 14*(21), 13762. https://doi.org/10.3390/su142113762

Ertürk, Ö. F., & Markoç, İ. (2025). Young adults' accessible and affordable housing challenge in Istanbul. *Eren Journal, 4*(6), 9-27.

Freidin, R. (2021). The strong minimalist thesis. *Philosophies, 6*(4), 97. https://doi.org/10.3390/philosophies6040097

Heikkilä, M., & Hautamäki, R. (2024). Restorative environmental experiences: Uncovering the invisible and visible attributes in Finnish forests and Japanese gardens - A literature review. *Journal of Environmental Planning and Management*, 1-22. https://doi.org/10.1080/09640568.2024.2418343

Kalhoefer, G., & Radogna, D. (2022). Environmental and technological flexibility for new housing needs. *VITRUVIO - International Journal of Architectural Technology and Sustainability, 7*(1), 30-45. https://doi.org/10.4995/vitruvio-ijats.2022.17461

Kallis, A. (2023). *The minimum dwelling revisited.*

Kamali, M., & Hewage, K. (2017). Development of performance criteria for sustainability evaluation of modular versus conventional construction methods. *Journal of Cleaner Production, 142*, 3592-3606. https://doi.org/10.1016/j.jclepro.2016.10.108

Kang, J., Martinez, C. M. J., & Johnson, C. (2021). Minimalism as a sustainable lifestyle: Its behavioral representations and contributions to emotional well-being. *Sustainable Production and Consumption, 27*, 802-813. https://doi.org/10.1016/j.spc.2021.02.001

Kaur, A. (2024). Minimalism: A game changer for industries. In *Sustainable Consumption Experience and Business Models in the Modern World* (pp. 125-143). 10.4018/978-1-6684-9277-2.ch006

Kumar, S., Sakagami, K., & Lee, H. P. (2025). Beyond sustainability: The role of regenerative design in optimizing indoor environmental quality. *Sustainability, 17*(6), 2342. https://doi.org/10.3390/su17062342

Lucchi, E. (2023). Energy and climatic performances of modern architecture: A complete overview of building physics implications. *Engineering Proceedings, 53*(1), 19. https://doi.org/10.3390/IOCBD2023-15203

Markoç, İ. (2012). Bursa'nın Kentsel Gelişimi ve Konut Üretimi, Ph.D. Thesis, Uludağ University, Bursa, Turkey.

Markoç, İ. (2018). Konut Kullanıcısı Hareketliliğinde Kalite ve Memnuniyet Değerlendirmesi: Sarıgöl Konut Dönüşüm Alanı. (Doctoral dissertation), Yıldız Technical University, Institute of Science, Istanbul, Turkey.

Markoç, İ., & Çınar, C. (2017). Reading housing satisfaction parameters over housing mobility in the redevelopment process: Sarıgöl, Istanbul, Turkey. *Cogent Social Sciences, 3*(1), 1-20. https://doi.org/10.1080/23311886.2017.1412915

Markoç, İ., & Çınar, C. (2018). Loss of social belonging, displacement and social exclusion in the neighbourhood:

Urban redevelopment in Sarıgöl, Istanbul, Turkey. *Megaron, 13*(2), 169-181. https://doi.org/10.5505/megaron.2017.97658

Markoc, Ilkim (2021). Poverty and Difficulties in Participation of Urban Social Life: Young Women in Istanbul. Journal of International Women's Studies, 22(9), 49-67.

Marrero, M., Rivero-Camacho, C., Martínez-Rocamora, A., Alba-Rodríguez, D., & Lucas-Ruiz, V. (2024). Holistic assessment of the economic, environmental, and social impact of building construction: Application to housing construction in Andalusia. *Journal of Cleaner Production, 434*, 140170. https://doi.org/10.1016/j.jclepro.2023.140170

Molavi, J., & Barral, D. L. (2016). A construction procurement method to achieve sustainability in modular construction. Procedia engineering, 145, 1362-1369. https://doi.org/10.1016/j.proeng.2016.04.201

Oktay, D. (2020). Towards sustainable habitats in Turkey: Challenges and prospects for the future. *Ekistics and The New Habitat, 80*(1), 3-10. https://doi.org/10.53910/26531313-E2020801436

Perrucci, D., & Baroud, H. (2020). A review of temporary housing management modeling: Trends in design strategies, optimization models, and decision-making methods. *Sustainability, 12*(24), 10388. https://doi.org/10.3390/su122410388

Rulli, D. (2007). Less is more: Ludwig Mies Van Der Rohe, glass houses and immigration. *Teaching History: A Journal of Methods, 32*(2), 92-97. https://doi.org/10.33043/TH.32.2.92-97

Sari Haksever, T., & Markoç, İ. (2020). Social Perception of the Green Roofs in contribution to Urban Sustainability: Istanbul. Journal of Developing Country Studies, 10(4). http://doi.org/10.7176/dcs/10-4-08

Sutantio, A., Anwar, N., Wiguna, I. P. A., & Suryani, E. (2022). Developing a model of sustainable construction for condominium projects in developing countries; case of Indonesia. GEOMATE Journal, 23(96), 85-94. https://doi.org/10.21660/2022.96.3319

Vijayakumar, A., Mahmood, M. N., Gurmu, A., Kamardeen, I., & Alam, S. (2024). Social sustainability assessment of road infrastructure: A systematic literature review. *Quality & Quantity, 58*(2), 1039-1069. https://doi.org/10.1007/s11135-023-01683-y