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Article

Assessing the driving forces for future housing design

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ABSTRACT

The COVID-19 pandemic has underscored the imperative for housing to adapt to various factors, such as spatial, functional, climatic, and aesthetic considerations. The pandemic has transformed the dynamics between occupants and their living environments, influencing how different age groups interact with dwelling spaces, as well as impacting work, learning, healthcare access, and services. Urban life dynamics, especially in metropolitan areas, have undergone significant shifts due to social, cultural, technological, environmental, and economic factors. These changes, propelled by urbanization, demographic changes, evolving social structures, challenges in housing accessibility, and the rapid advancement of communication technologies, demand innovative approaches to housing design and programming. This study aims to identify future housing design trends and tendencies within this evolving context. Using a systematic literature review methodology, the study analyzed 87 articles published between 2010 and 2023, selected from digital databases according to predetermined criteria. Through meta-synthesis, STEEP analysis, and Shannon entropy assessments, the study identified 21 megatrends and 72 driving forces across the social, technological, environmental, economic, and political dimensions of housing design. The findings lay the groundwork for future housing innovations and sustainability, contributing to a wider discourse and enabling the generation of foresight model scenarios for housing design. Identifying these trends is crucial for creating functional, flexible, and sustainable living spaces that are suitable for the changing lifestyles and needs of individuals.

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INTRODUCTION

Metropolitan systems, covering only 3% of the Earth's surface, accommodate 55% of the human population (Guida & Natale, 2021). By 2050, it is projected that approximately 70% of the population will reside in urban areas, with the number of megacities—each housing 10 million or more individuals—expected to increase rapidly (United Nations, 2018). Additionally, cities are responsible for about 60% of greenhouse gas emissions and 70% of solid waste, consuming roughly 70% of the global energy supply (Guida & Natale, 2021).

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The livability and urban quality of cities face significant challenges due to the impacts of climate change and environmental degradation, migration patterns, demographic shifts, global pandemics, and health risks. Despite these challenges, cities continue to be pivotal as financial, technological, and cultural centers of communities. For the majority of the world's population, the definition of cities as spaces for living, working, and leisure is being reimagined. This redefinition process is transforming aspects such as livability, connectivity, sustainability, health, and well-being from mere targets into fundamental expectations among occupants regarding urban amenities.

Particularly, the rapid population growth and densification faced by cities are making multi-unit housing a common form of accommodation worldwide. In this context, urban housing is directly linked to emerging problems for the future of cities and plays a crucial role in their capacity to cope with this new reality. However, the inability of existing structures to fully meet even today's needs heightens the uncertainty of their capacity to adapt to future lifestyles.

Housing is a broad term used to describe any kind of dwelling, residence, or shelter intended for living (Chey, 2018). Fundamentally, housing responds to the human need for shelter and establishes deep, meaningful relationships with the individuals living within it and the surrounding built environment. Besides serving as a private living space, housing also functions as a center in the social and cultural context, reflecting the social structure of the community. The characteristics that make housing the starting and ending point of people's everyday lives distinguish it from other architectural structures. Dwellings are directly affected by various changes in daily life, and these changes, in turn, trigger social and physical transformations in housing. Therefore, researching the future and identifying parameters that could significantly influence the design of both cities and housing emerges as a critical solution in this field.

Environmental indicators, known as "megatrends," support design processes and their relationship with the built environment through innovative approaches. Megatrends are broad changes that slowly emerge and have long-lasting effects, covering society, economics, politics, and technology. These changes are influential in the emergence of specific trends and behavioral patterns. Recognizing megatrends is important for understanding the directions of change and developing strategies for the future. While megatrends have a global impact over decades, the trends influenced by megatrends are observed in shorter durations and specific regions (Kalaitzi et al., 2021). Trends are expansive, slow-moving forces and patterns that typically impact society globally over several years, encompassing phenomena observable in the present, such as population aging, the shift towards digital technology, and the trend towards mobile living (Saritas & Smith, 2011). Trends are shaped by driving forces—forces, uncertainties, and factors capable of instigating or directing change. A defining feature of driving forces is their inherent level of uncertainty, which significantly influences the future adaptation capabilities and outcomes for individuals or organizations. Whether a driving force is deemed positive or negative can engender divergent futures, fostering change patterns in opposite directions (Saritas & Smith, 2011).

This study aims to identify megatrends and trends that will shape the future of housing design. The main goal of the research is to raise awareness of the topic by identifying the driving forces capable of yielding innovative and progressive solutions. Furthermore, it contributes theoretically to the literature by providing a comprehensive list of megatrends and drivers that will impact design.

Housing studies are a pivotal research domain within the architecture discipline. Yet, these studies often focus on the present or current situation and examine the historical context. The lack of a comprehensive field of study addressing the future dynamics and trends shaping housing is notable. To enable work in such a field, this study identifies the guiding concepts most frequently encountered in the literature as "driving forces" through systematic literature review, meta-synthesis methods, and STEEP analysis themes. The findings have been statistically assessed using the SPSS program. This analysis has culminated in a list of trends related to the social, technological, environmental, economic, and political dimensions of housing.

This paper promotes interdisciplinary knowledge production. The findings enable professionals and researchers working in housing to deeply explore the implications of the identified drivers and develop alternative scenarios. The outcomes of the study lay the groundwork for a future-oriented foresight model, presenting alternative projections for the future of housing design and planning when considered together with ongoing studies.

BACKGROUND

In today's world, a paradigmatic transformation process has begun, triggered by the convergence of four fundamental trends in the social, technological, and environmental fields. The effects of changes in social structure, demographic shifts, digital transformation, and global environmental challenges are becoming increasingly visible in urban development and housing trends.

Changes in social structure involve the evolution of social norms, roles, and interactions. They characterize a shift towards more fluid, inclusive, and interconnected social paradigms. Traditional boundaries that define social hierarchies and classifications are becoming increasingly permeable, leading to the emergence of a more egalitarian and network-based society. At the same time, expansions in demographic structure are reshaping the global population. This trend includes a wide range, from aging populations in certain countries to the contrast of younger demographics in others, urbanization, and migration patterns. The integration of digital technology into all areas of social and economic life, along with the widespread adoption of digital technologies such as artificial intelligence, the Internet of Things, and blockchain, is creating opportunities for innovation, efficiency, and connectivity. At the same time, it also presents challenges related to privacy, cybersecurity, and the digital divide.

Environmental challenges threaten the sustainability of life, requiring urgent and globally coordinated solutions. The "Earth Overshoot Day," marking when humanity's demand exceeds Earth's capacity to regenerate resources within a year, fell on August 2, 2023 (Global Footprint Network, 2023). This indicates humanity used the year's supply of resources 151 days early, exceeding what the planet can regenerate in a year. The need to provide a livable planet for future generations has become more evident than ever. Sustainability has expanded to encompass not only environmental protection but also all innovative approaches that will reduce human impact.

In understanding and guiding the ongoing transformations, three fundamental concepts emerge as crucial: Society 5.0 and Human-Centric Design, Industry 5.0 and Innovability, and Sustainability and Ecological Transition.

Society 5.0 and Human-Centric Design

Society 5.0 is a societal transformation model defined as a "Smart Society" or "Super Smart Society," which is more human-oriented than our current information society, shaped by the accumulation of past eras and approved by Japan's Science, Technology, and Innovation Council in 2016 (Keidanren, 2018). It aims at a societal structure where technological innovations contribute not only to economic growth but also to social welfare and sustainability. The model aims to create new values where technology will eliminate social inequalities regardless of age, gender, language, or geographical location, and provide personalized products and services that focus on individual needs (Fukuyama, 2018). Society 5.0 focuses on using new technologies to support personal development and remove physical, administrative, and social barriers, anticipating developments in technological fields such as innovative strategies for an aging population, integration of cyber and physical worlds, effective solutions to environmental problems, and the Internet of Things, which will benefit society (Keidanren, 2018).

Human-centered design complements Society 5.0 with solutions to ensure that technological progress serves to enhance human well-being and social resilience. It follows an iterative process to respond to user needs, understand behaviors and experiences, and ensure user satisfaction. The synergy of these two concepts expects technology integration into architecture to contribute not only to functionality but also to the creation of environments that are comfortable, intuitive, inclusive, accessible, and personalized through technology. It represents a transformation towards a smarter architecture that enhances the human experience, promoting efficiency and sustainability.

Industry 5.0 and Innovability

Today marks a new era defined by the rapid development of digital technologies such as artificial intelligence, the Internet of Things, cloud computing, big data, robotics, and 3D printing. Advances in information and communication technologies have sparked a fully digitized industrial revolution known as Industry 4.0 since 2011, initially in Germany. This revolution has made production processes smart by connecting machines and devices, minimizing human intervention, and maximizing automation. Big data and machine learning have increased production efficiency. This transformation has enabled autonomous decision-making processes based on information and facilitated the flow of intelligence between devices (Lu, 2017; Maddikunta et al., 2022).

Industry 5.0 is a global concept that integrates human creativity and critical thinking skills with technology, extending the automation-oriented approach of Industry 4.0. It supports a symbiotic relationship between humans and machines. While monotonous and repetitive tasks are automated through robots and machines, tasks requiring planning and strategy development are left to human control. This new relationship transforms production processes into a more personalized, environmentally sensitive, socially centered, and flexible structure (Maddikunta et al., 2022; Nahavandi, 2019).

The vulnerability of advancing technologies to the environment and initiatives aimed at developing the built environment reveal a contradictory relationship in efforts to protect the planet. "Innovability" refers to this delicate balance between innovation and sustainability. The concept emphasizes the practice of creating new ideas, products, or methods that enable change to be sustainable in the long term. In this era dominated by environmental, social, and economic emergencies, humanity must continue to shape its future by consciously using resources taken from nature (innovation) while being aware of these resources' limitations (sustainability) (Sposito & Scalisi, 2023).

Sustainability and Ecological Transition

Human activities have increasingly exerted pressure on the structure and functioning of nature, transforming the once resilient and robust natural environment into a delicate and vulnerable state. Global developments such as wars, migrations, and pandemics have brought the complex relationship between the development of the built environment and the desire to protect the planet back onto the agenda. It has revealed that sustainable development practices require not only protective measures but also broader, more inclusive, and innovative strategies (Sposito & Scalisi, 2023).

Focusing on the efficient use of resources under sustainability practices simplifies the complexity of the wider ecological crisis. This simplification leads to underestimating the seriousness of environmental emergencies and the comprehensive strategies needed to address them. Fundamental changes and comprehensive transformations are needed to increase the resilience of society in the face of ecological crises, climate change, and depleting resources. The concept of "transition" as a new dimension of sustainability has come up for discussion. Transition refers to the movement of initiatives that seek to increase the resilience of communities. This resilience is defined as the capacity of a community to maintain its functions in the face of challenges such as economic crises and ecological disasters (Pour La Solidarité, 2023).

Ecological transition refers to the comprehensive process of moving towards sustainable and environmentally friendly ways of living, working, and organizing communities. EU Member States often define a new sustainable development under the concept of "Ecological Transition," especially concerning 2030 Agenda targets.

The ecological transition theme is clearly defined in the European Green Deal, approved in 2020 by the European Commission, which targets making the EU climate-neutral by 2050. The ecological transition is also the basic model of Italy's National Recovery and Resilience Plan (Errante, 2022). In the context of the European Green Deal and Italy's National Recovery and Resilience Plan, the ecological transition aims to align economic growth and environmental sustainability by promoting energy transition (energy efficiency, preference for renewable energies), industrial transition (local production of recyclable goods within a circular economy perspective), and agricultural-food transition (replacement of industrial agriculture with organic farming) (Pour La Solidarité, 2023). The ecological transition process requires a global paradigm shift towards circular economies and the use of renewable energy, supporting a more resilient and equitable global society.

MATERIAL AND METHODS

This study employs a quantitative methodology combining systematic literature review, meta-synthesis, and Shannon entropy to objectively assess current and emerging trends in residential design. By minimizing subjective bias and grounding the analysis in statistical rigor, this approach ensures the scalability and replicability of the findings, thereby enhancing the credibility and trustworthiness of the research. However, it is important to recognize that findings from quantitative data run the risk of overgeneralization and may not accurately reflect emerging trends. Nevertheless, this study presents a balanced view that highlights both the strengths and potential limitations of the quantitative approach, aiming to standardize the process of gathering information from the literature and make knowledge extraction efficient.

This study begins with a literature review to identify possible future trends in the built environment. The review allows for the selection of keywords that frame the study. Based on the chosen keywords, a systematic approach relying on content analysis is employed to thoroughly investigate the relevant literature and establish conceptual relationships. The steps of the methodologies are presented in Figure 1.

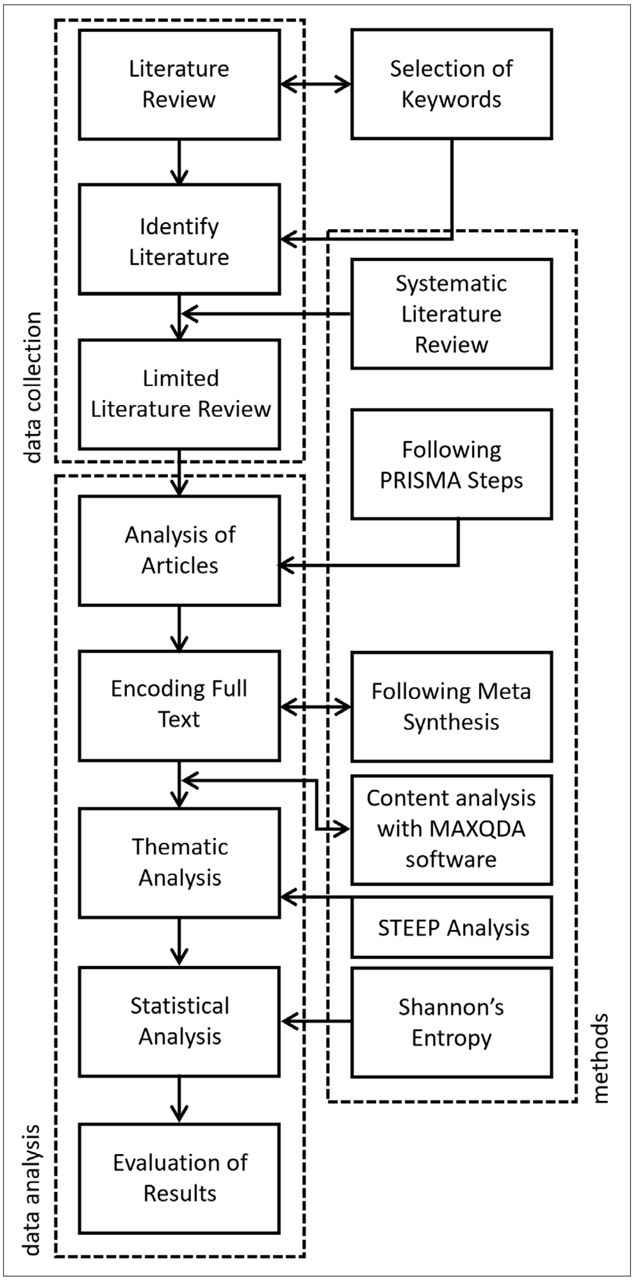

Figure 1. The structure of the research methodology.

Systematic literature review is a rigorous, verifiable, and repeatable research method that summarizes large datasets by following predetermined review steps (Petticrew & Roberts, 2006). The review process defined by Denyer & Tranfield (2009) consists of five steps: (1) identifying the research question, (2) identifying relevant literature, (3) selecting and evaluating studies, (4) analyzing and synthesizing, and finally, (5) reporting and utilizing the findings. The in-depth analysis after the systematic review is conducted through the meta-synthesis method. This method involves integrating and evaluating the findings obtained from the systematic review using qualitative analysis techniques (Yılmaz, 2021).

This paper follows the PRISMA (Preferred Reporting Items for Systematic Reviews) guidelines to increase the reliability and validity of the research. PRISMA is a research protocol that provides a 27-item checklist and evaluation flowchart (Moher et al., 2015; Yılmaz, 2021). The quality and reliability of the selected articles as a result of the systematic review have been examined through a critical appraisal using the Critical Appraisal Skills Programme. The CASP guideline guides researchers through the quality assessment process based on a predetermined set of 10 criteria (CASP, 2018).

The full texts of the selected articles were coded using Maxqda software. The coding was converted into statistical data using the frequency distribution technique and then categorized using predetermined thematic analysis techniques. For thematic analysis, the "STEEP" framework is utilized to identify the social, technological, environmental, economic, and political dimensions of the research (Fahey & Narayanan, 1986; Szigeti et al., 2011) (Figure 2). Frequency distribution is the main technique used in evaluating the findings obtained through systematic review and meta-synthesis steps. However, within the scope of this research, frequency distribution alone is not sufficient to determine the importance of each trend and its impact on the study. Therefore, the Shannon entropy technique is employed to enable a more comprehensive assessment in the formation of the set of driving forces. Statistical data were analyzed using SPSS and Excel programs.

Defining the Research Question

The research was conducted to identify new developments and controversial concepts in the field of architecture and housing design. In this context, it seeks to answer the following questions to uncover the dynamics and potential trends that will shape the future of housing design:

Q1: What are the megatrends shaping the future of housing design?

Q2: What are the trends shaping the future of housing design?

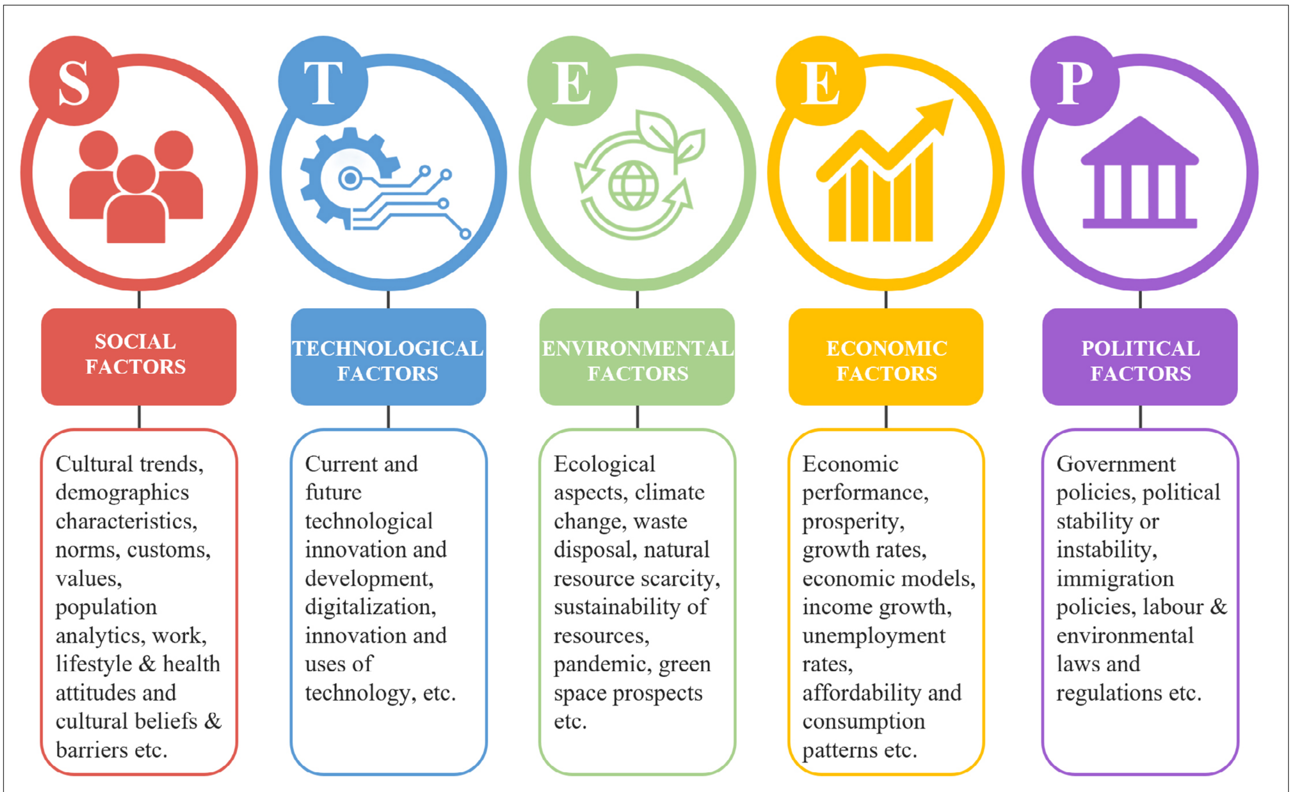

Figure 2. STEEP dimensions.

Defining the Relevant Literature

The literature review focused on current studies conducted between 2010 and 2023. Searches were made in the Scopus and Web of Science digital databases, covering the "title/abstract/keywords" fields. Keywords were selected in pairs to closely relate to the research topic. Since the concepts of "housing" and "dwelling" were the main research subjects of the study, they formed the first group of words. The second group of keywords, identified as a result of the literature review, includes "driving forces, driving factor, and indicator"; "forecasting, foresight, backcasting, and scenario"; "ecology, ecological transition, sustainable transition, and environmental transition"; "society 5.0, human-centered, future society, next generations, and smart society"; "innovation, innovability, sustainability, sustainable innovation, and sustainable creativity." The Boolean Logic technique was used to determine the relationship between keyword groups, combining words with "OR" and "AND" connectors to narrow down the search (Figure 3).

Publications to be examined in the systematic review were limited to those related to the field of architecture and housing, published in peer-reviewed journals, in English, and compatible with at least one of the STEEP headings. These criteria define the scope of the subject areas the research will focus on and enhance the scientific validity of the study.

Study Selection and Evaluation

The PRISMA flowchart process is delineated in Figure 4. A total of 5304 articles were found in the initial database search. After the removal of 803 duplicates, the remaining articles underwent keyword-based scrutiny. Publications irrelevant to the discipline of architecture were excluded due to keyword limitations. Subsequently, title and abstract assessments were conducted on the remaining 3444 articles. The elimination of articles was based on certain criteria: (1) articles that contain keywords in the title or abstract but do not examine the concept of housing; (2) studies that use the keyword "housing" due to the examined case study but are not related to the discipline of architecture; (3) detailed studies that address the subject from a specific/single perspective, despite being related to the keywords; (4) studies related to the keywords and the field of architecture but are limited by geographical restrictions. Thus, 49 out of the remaining 282 articles were inaccessible, culminating in 233 articles progressing to the full-text review phase. Upon comprehensive text evaluation, 98 articles evidencing a linkage between the future and housing, and fulfilling the thematic research criteria were identified. Based on CASP's 10-step criteria, 87 articles scoring higher than 6/10 were selected for full reading and conceptual coding in the meta-synthesis.

RESULTS

Analysis of Resources

Figure 5 shows the distribution of 87 arcticles by years. There has been an increase in the number of studies since 2019. The most significant increase occurred in 2021, which

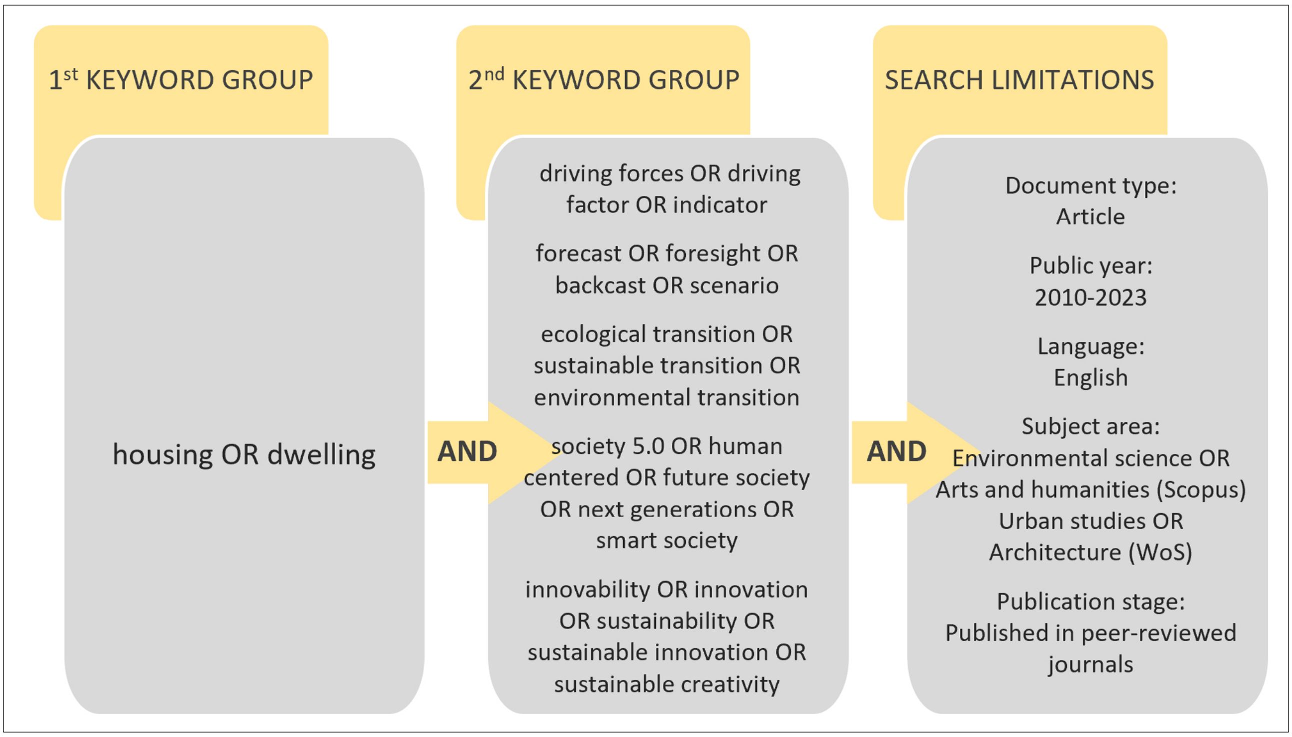

Figure 3. Keyword combination and search limitations for data collection.

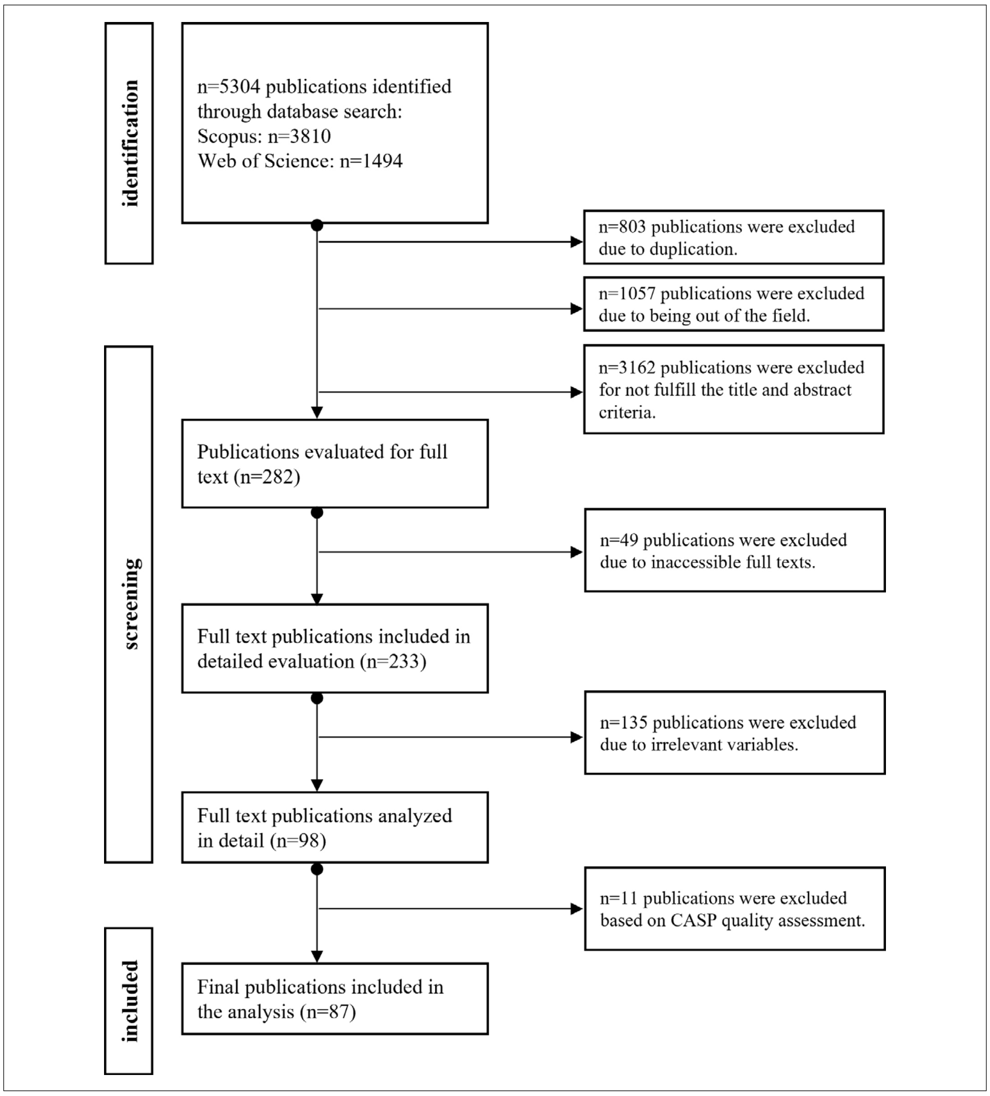

Figure 4. PRISMA flowchart.

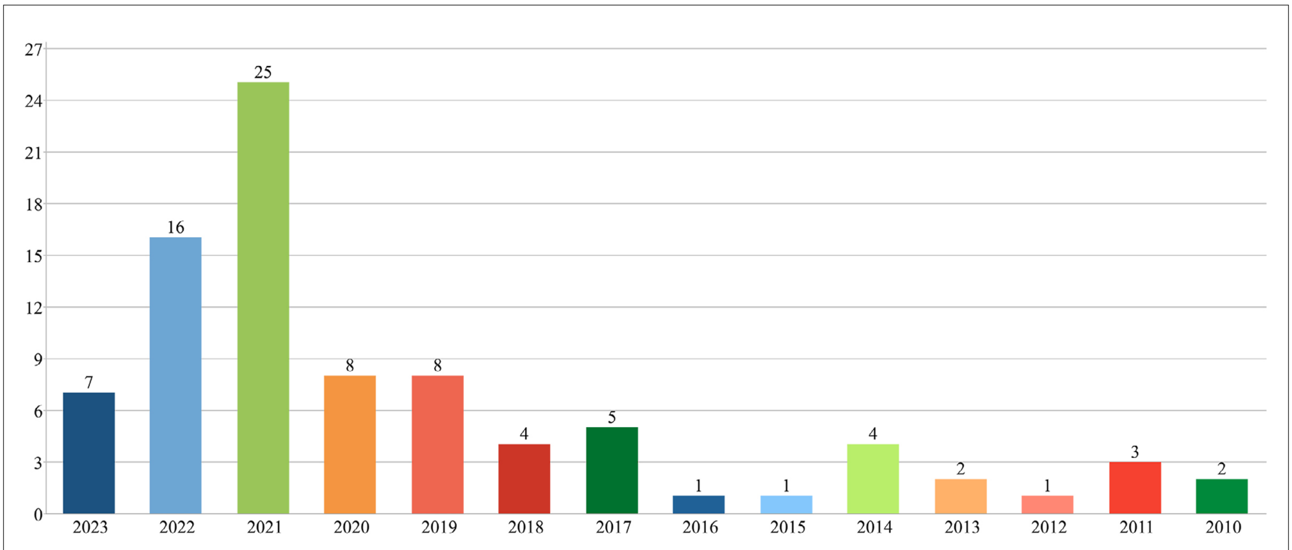

Figure 5. Number of articles based on year.

accounted for 28.74% of the total publications, followed by the year 2022 with 18.39%. Articles published in the first two months of 2023 were included in the study, and their relatively high rate of 8.05% indicates that research in the field will continue throughout the year.

The analyzed studies indicate that sustainability was a prominent theme before the year 2015. Between 2015 and 2019, there was a shift in focus towards technological subjects such as artificial intelligence, big data, and augmented reality. The increase in the number of articles in 2021 could be attributed to the COVID-19 pandemic. During the pandemic, mandatory lockdowns necessitated a reevaluation of the functionality and design of living spaces. Research revealed a growing interest in alternative uses of residential areas, indicating the increasing importance of flexible and multifunctional living spaces as homes and workplaces become more interconnected. The recent surge in publication numbers suggests extensive discussions on innovative concepts in housing design.

Analysis of Data

In the 87 articles examined, parameters that could affect the future of housing design and trends that can be classified as "driving forces" whose effects can be observed today were extracted as conceptual codes. These codes were determined through an inductive approach without a predefined categorization or framework. Driving forces reflecting the same or similar trends were consolidated under a single code to optimize the number of codes. The classification of driving forces followed a two-stage grouping process: (1) grouping under five main factors - social, technological, environmental, economic, and political - within the framework of STEEP analysis, (2) driving forces with similar themes and impacts were further divided into more detailed categories as megatrends under these factors. Frequency analysis was applied to the driving forces according to their thematic distribution based on the frequency of occurrence in the articles. As a result of the analysis, 5 factors, 21 megatrends, and 72 driving forces were identified with a frequency of 933 in total (Table 1).

Table 1. Frequency distribution of factors.

Factors	Megatrends	D.Forces	Frequency
Social	5	21	378
Technological	5	17	163
Environmental	5	16	224
Economic	3	10	103
Political	3	8	65
Sum.	***21***	***72***	***933***

Synthesis of Data

The megatrends and driving forces related to the social factor reveal the needs associated with modern society's urban lifestyles (Figure 6). The megatrend of Changes in Social Awareness (*f*:95) encompasses main themes such as environmental awareness, social interaction, and participation. Spatial Demand-Driven Changes (*f*:90) and Demographic and Cultural Changes (*f*:80) megatrends highlight the balance between individuals' spatial needs and privacy expectations and the changes in social structure and culture, drawing attention to shifts in family structures and the increasing importance of individual rights. The megatrend of Changes in Consumer Behavior (*f*:63) describes multidimensional changes experienced by society through driving forces like shared consumption habits and digitalization. Collective Living Changes (*f*:50) focus on the trends related to the need to create community and the dynamics of living together. This analysis comprehensively examines the wide spectrum of social factors that will shape the future of housing design and their detailed impacts on society.

Technology is creating important paradigm shifts in today's architectural field. The megatrend of Data and Sensor-Based Communication Technologies (*f*:50) enriches interactions and experiences by establishing data-driven and interactive bridges between daily life and the physical environment. Digital Fabrication and Automation (*f*:36) and Smart Living Technologies (*f*:32) megatrends focus respectively on the digitalization of architectural production and the increase in automation within homes, while Integrated Digital Experiences Technologies (*f*:32) highlight the digital transformation in life and work processes. Despite its lower frequency distribution, the Green Technologies (*f*:13) megatrend stands out due to its emphasis on sustainability and eco-friendly innovations (Figure 7).

The environmental factor determines current design parameters and trends through themes such as climate change and adaptation, energy and resource management, urban planning, and land use. The megatrend of Climate Change and Adaptation (*f*:66) refers to global environmental challenges, while Energy and Resource Management (*f*:47) and Urban Planning and Land Use (*f*:47) megatrends focus on the efficient management of natural resources, urban area densification strategies, optimal land use, and the valuation of green and open space demands for the sustainability of living spaces. Although the frequency distribution of Efficiency and Sustainability (*f*:37) and Environmental Impact and Pollution (*f*:27) megatrends are relatively low, their impact is significant due to their focus on energy and resource efficiency and the built environment's effects on the natural habitat. Environmental megatrends highlight strategies for enhancing sustainability, reducing carbon footprint, and conserving natural resources. The close frequency distribution of the megatrends indicates the

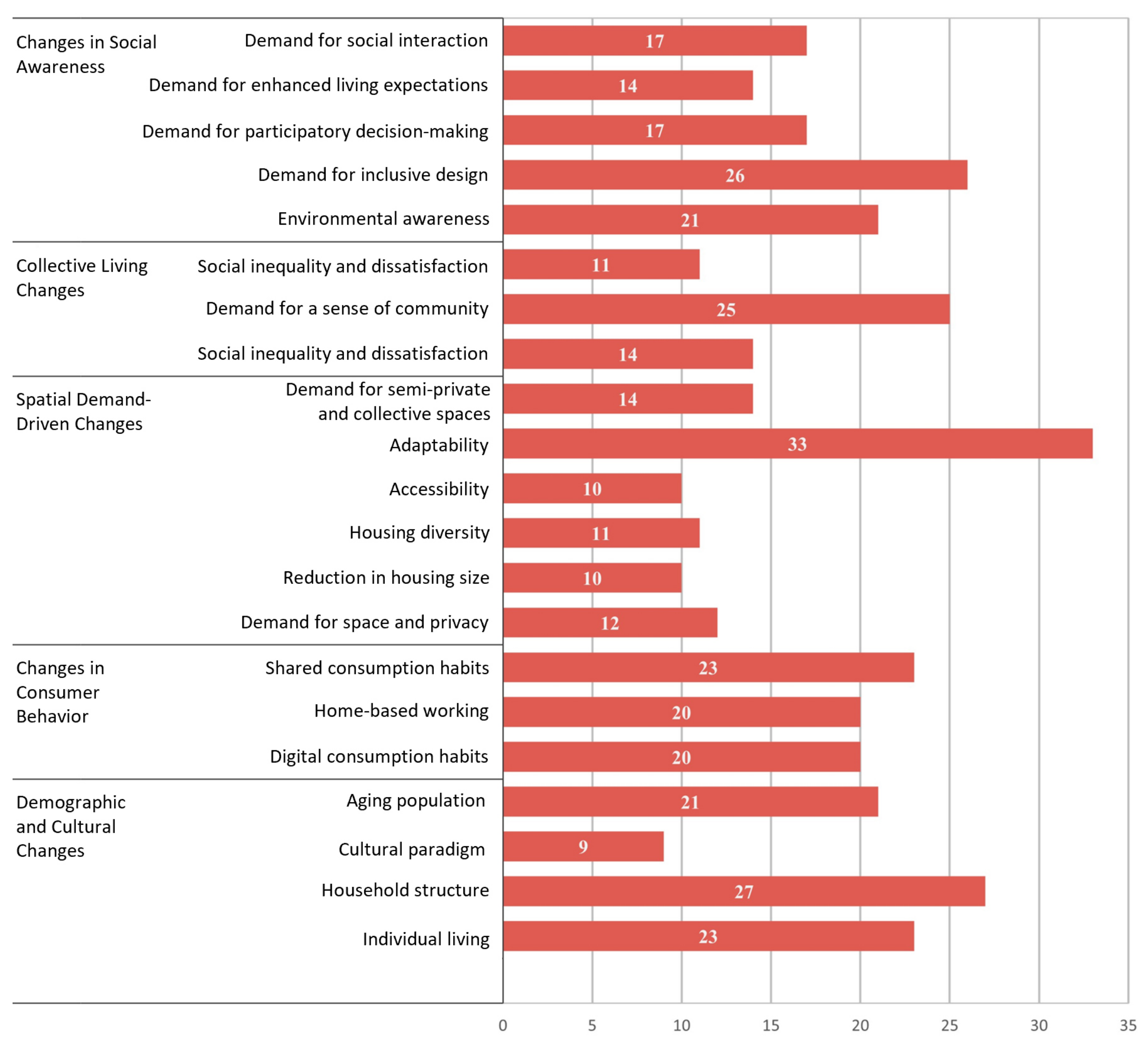

Figure 6. The frequency of each driving forces of social factors.

necessity of considering and integrating parameters to form a comprehensive strategy (Figure 8).

The economic factor focuses on the affordability and financial sustainability of living spaces. The megatrend of Housing Finance and Market Dynamics (*f*:58) highlights the transition to more flexible housing acquisition models over traditional purchasing methods, focusing on the capacity to meet users' needs. The Innovative Economic Models (*f*:24) megatrend emphasizes the rise of contemporary economic strategies, while Macroeconomic Indicators (*f*:21) focus on the effects of growth rates and general economic indicators on development trends. The findings reveal the significance of the economic factor's connection to the disciplines of architecture and urban planning at both macro and micro scales (Figure 9).

Under the heading of political factor, three megatrends have been identified: Urban Quality of Life Policies (*f*:24), Environmental and Sustainability Policies (*f*:24), and Economic and Social Policies (*f*:17). Urban Quality of Life Policies focus on policies aimed at enhancing residents' capacity to live within a community, Environmental and Sustainability Policies on the development of policies that preserve ecological balance and support sustainable development, and Economic and Social Policies on strategies to increase economic accessibility and social welfare. These megatrends demonstrate how political dimensions can create strategic changes in urban life, sustainability, and socio-economic development, and how they can shape advancements (Figure 10).

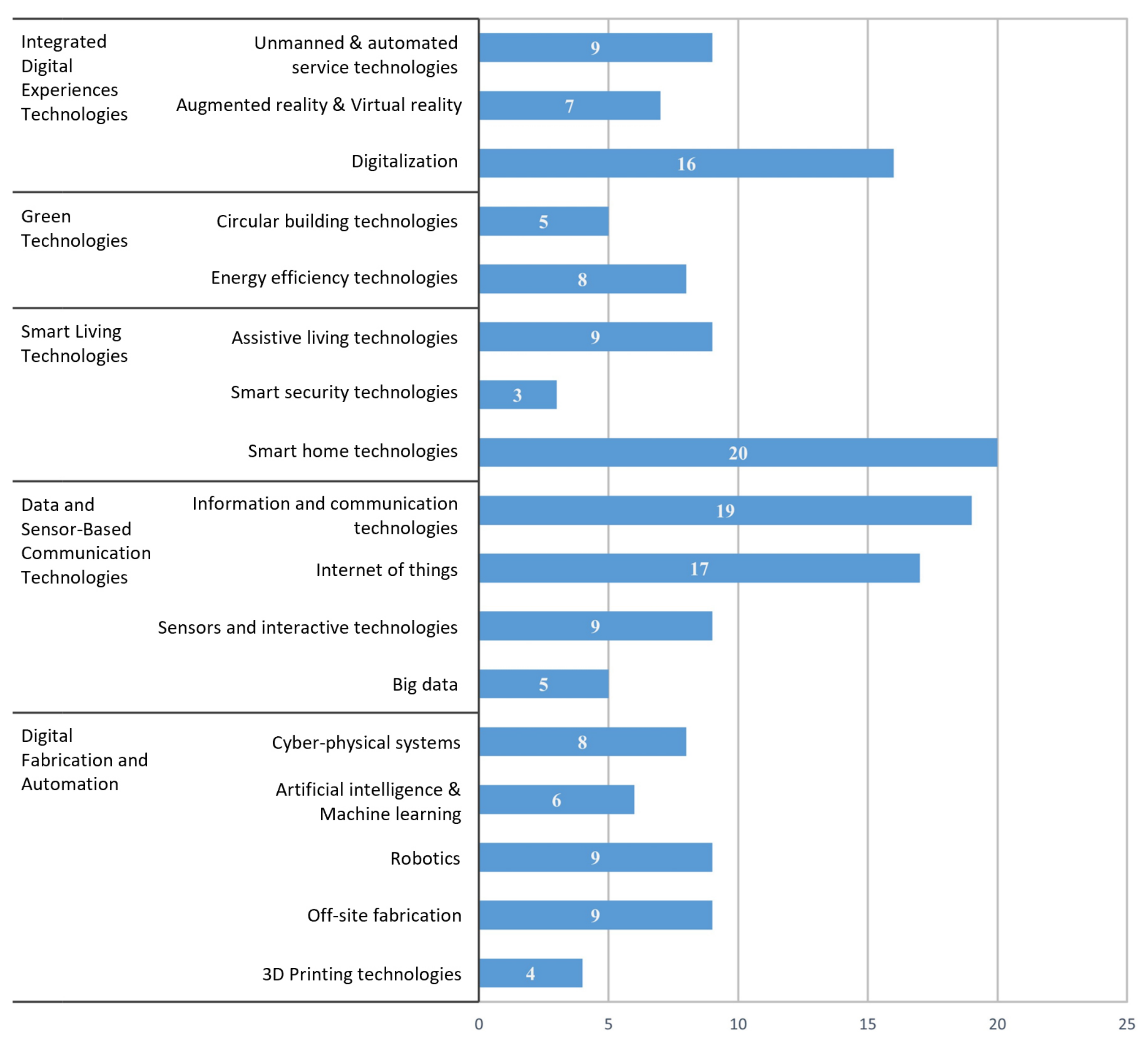

Figure 7. The frequency of each of the driving forces of the technological factors.

Synthesis of Results

The high frequency (f) values of the megatrends listed under the factors show that the driving forces are concentrated around certain themes and how deeply and comprehensively the analysis covers the subject under examination. However, this technique may be insufficient to evaluate the importance of driving forces. To overcome this deficiency, the Shannon entropy technique, one of the Multi-Attribute Decision Making methods, can be applied. Shannon entropy is widely used in information theory to measure uncertainty or complexity and is seen as an important alternative among objective weighting methods in MADM techniques. It is a useful metric for making informed inferences in situations of data insufficiency or uncertainty (Lotfi & Fallahnejad, 2010). The first step in Shannon entropy is to identify the examined data categories. The amount of insignificance of each driving force is calculated using Formula 1.

$$E_j = -k \sum_{i=1}^{m} P_{ij} ln(P_{ij}); \forall_j \qquad \text{(Formula 1)}$$

In the second stage, the importance weights of the driving forces are calculated using Formula 2.

$$W_j = \frac{E_j}{\sum_{i=1}^{m} E_j} ; \forall_j \qquad \text{(Formula 2)}$$

The column of importance weight (Wj) in the Shannon entropy technique quantitatively expresses the relative impact of each trend on the analyzed case or system. Driving forces with high entropy values indicate areas that should be prioritized in design processes, while those of medium and low importance offer ideas about specific strategies and innovative solutions that can be applied in housing designs.

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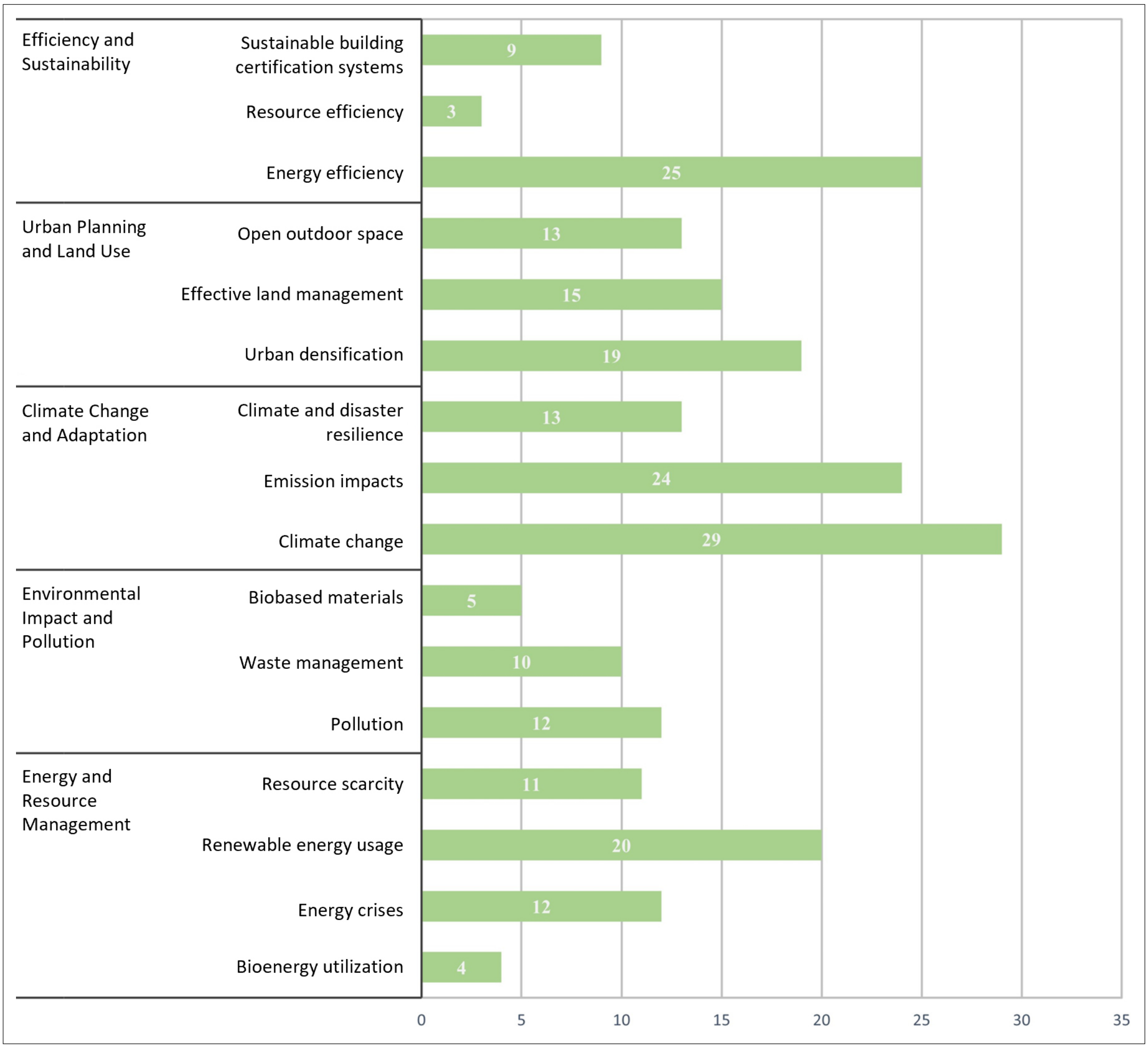

Figure 8. The frequency of each of the driving forces of the environmental factors.

Table 2 presents the importance weights calculated using the Shannon entropy technique for the driving forces associated with social factors. The analysis identifies adaptability, household structures, and the demand for inclusive design as the most significant driving forces. These are closely followed by the demand for a sense of community, individual living, and aging population. Especially, the megatrend of demographic and cultural changes highlights transformations in family structures and household dynamics, the place of the individual in society, the growing importance of individual rights and freedoms, and the diversity in forms of self-expression, drawing attention to changes in social values, norms, and beliefs.

Table 3 presents the importance weights calculated using the Shannon entropy technique for the driving forces under technological factors. The analysis reveals that interactive technology developments such as smart home technologies, information and communication technologies, and the Internet of Things are the most significant driving forces in the future of housing design. Digitalization and subsequent innovative trends highlight technologies that transform traditional lifestyles into ones compatible with modern needs, making living spaces smarter, more connected, and more efficient.

Table 4 presents the importance weights calculated using the Shannon entropy technique for the driving forces associated with environmental factors. The analysis highlights that discussions on climate change, energy efficiency, emission impacts, environmental sustainability, and reducing carbon footprints remain pertinent. Additionally, subsequent key

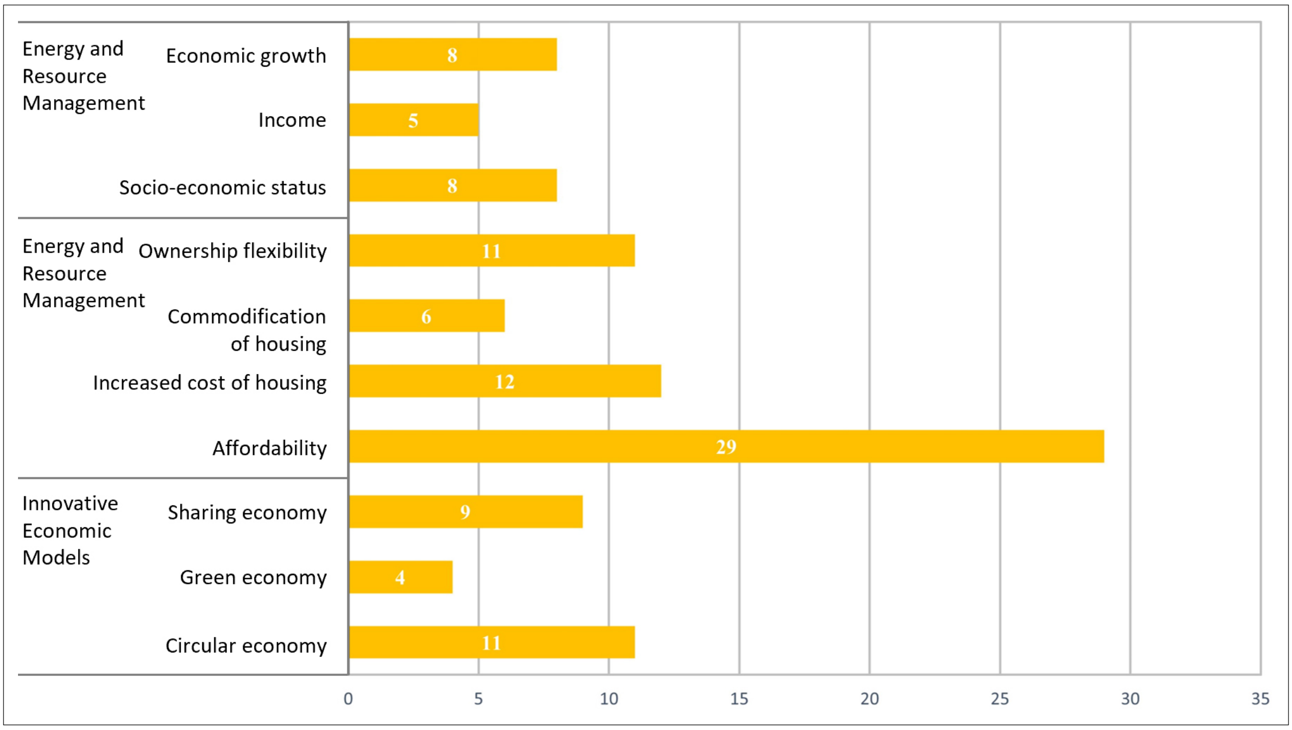

Figure 9. The frequency of each of the driving forces of the economic factors.

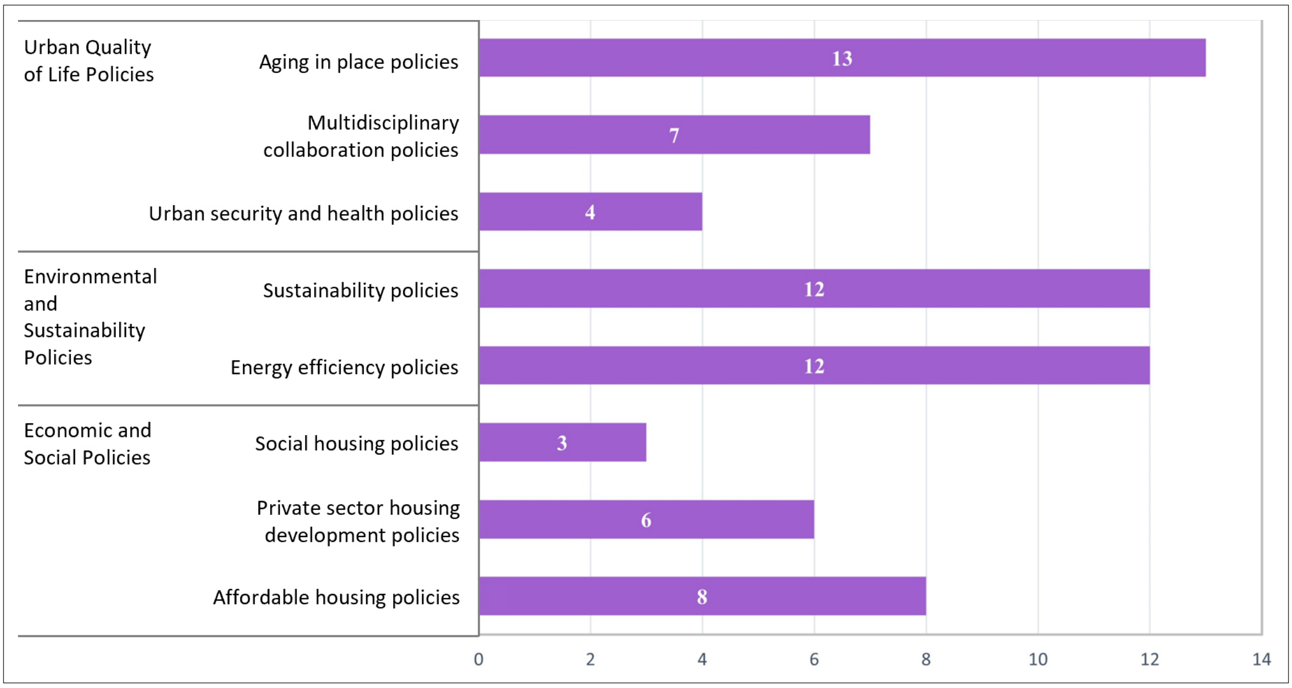

Figure 10. The frequency of each driving forces of political factors.

drivers such as the use of renewable energy usage, urban densification, and effective land management demonstrate that the quest for solutions to environmental challenges occupies a significant place in current debates.

Table 5 presents the importance weights calculated using the Shannon entropy technique for the driving forces associated with economic factors. The driving forces such as affordability and the increased costs of housing are high importance. Subsequent drivers such as ownership flexibility and the circular economy point to alternative methods of acquiring and utilizing housing, offering new perspectives on the current housing market dynamics. Findings indicate that economic factors have impacts on

Table 2. The calculated importance weights of social factors

Factors	Megatrends	Driving Forces	*f*	Ej	Wj	Rank
Social	Demographic and Cultural Changes	Individual living	23	-0.702	0,.053	5
		Household structure	27	-0.738	0.056	2
		Cultural paradigm	9	-0.492	0.037	13
		Aging population	21	-0.682	0.051	6
	Changes in Consumer Behavior	Digital consumption habits	20	-0.671	0.051	7
		Home-based working	20	-0.671	0.051	7
		Shared consumption habits	23	-0.702	0.053	5
	Spatial Demand-Driven Changes	Demand for space and privacy	12	-0.556	0.042	10
		Reduction in housing size	10	-0.516	0.039	12
		Housing diversity	11	-0.537	0.040	11
		Accessibility	10	-0.516	0.039	12
		Adaptability	33	-0.783	0.059	1
		Demand for semi-private and collective spaces	14	-0.591	0.045	9
	Collective Living Changes	Social inequality and dissatisfaction	14	-0.591	0.045	9
		Demand for a sense of community	25	-0.721	0.054	4
		Support for community well-being	11	-0.537	0.040	11
	Changes in Social Awareness	Environmental awareness	21	-0.682	0.051	6
		Demand for inclusive design	26	-0.730	0.055	3
		Demand for participatory decision-making	17	-0.634	0.048	8
		Demand for enhanced living expectations	14	-0.591	0.045	9
		Demand for social interaction	17	-0.634	0.048	8
		Sum.		***- 13.276***		

Table 3. The calculated importance weights of technological factors.

Factors	Megatrends	Driving Forces	*f*	Ej	Wj	Rank
Technological	Digital Fabrication and Automation	3D Printing technologies	4	-0.310	0.038	10
		Off-site fabrication	9	-0.492	0.061	5
		Robotics	9	-0.492	0.061	5
		Artificial intelligence & Machine learning	6	-0.401	0.050	8
		Cyber-physical systems	8	-0.466	0.058	6
	Data and Sensor-Based Communication Technologies	Big data	5	-0.360	0.045	9
		Sensors and interactive technologies	9	-0.492	0.061	5
		Internet of things	17	-0.634	0.078	3
		Information and communication technologies	19	-0.659	0.081	2
	Smart Living Technologies	Smart home technologies	20	-0.671	0.083	1
		Smart security technologies	3	-0.246	0.030	11
		Assistive living technologies	9	-0.492	0.061	5
	Green Technologies	Energy efficiency technologies	8	-0.466	0.058	6
		Circular building technologies	5	-0.360	0.045	9
	Integrated Digital Experiences Technologies	Digitalization	16	-0.621	0.077	4
		Augmented reality & Virtual reality	7	-0.436	0.054	7
		Unmanned & automated service technologies	9	-0.492	0.061	5
		Sum.		***-8.091***		

Table 4. The calculated importance weights of environmental factors.

Factors	Megatrends	Driving Forces	*f*	Ej	Wj	Rank
Environmental	Energy and Resource Management	Bioenergy utilization	4	-0.310	0.035	13
		Energy crises	12	-0.556	0.063	8
		Renewable energy usage	20	-0.671	0.076	4
		Resource scarcity	11	-0.537	0.061	9
	Environmental Impact and Pollution	Pollution	12	-0.556	0.063	8
		Waste management	10	-0.516	0.058	10
		Biobased materials	5	-0.360	0.041	12
	Climate Change and Adaptation	Climate change	29	-0.754	0.085	1
		Emission impacts	24	-0.712	0.080	3
		Climate and disaster resilience	13	-0.574	0.065	7
	Urban Planning and Land Use	Urban densification	19	-0.659	0.075	5
		Effective land management	15	-0.606	0.069	6
		Open outdoor space	13	-0.574	0.065	7
	Efficiency and Sustainability	Energy efficiency	25	-0.721	0.081	2
		Resource efficiency	3	-0.246	0.028	14
		Sustainable building certification systems	9	-0.492	0.056	11
		Sum.		***-8.846***		

Table 5. The calculated importance weights of economic factors.

Factors	Megatrends	Driving Forces	*f*	Ej	Wj	Rank
Economic	Innovative Economic Models	Circular economy	11	-0.537	0.110	3
		Green economy	4	-0.310	0.064	8
		Sharing economy	9	-0.492	0.101	4
	Housing Finance and Market Dynamics	Affordability	29	-0.754	0.155	1
		Increased cost of housing	12	-0.556	0.114	2
		Commodification of housing	6	-0.401	0.082	6
		Ownership flexibility	11	-0.537	0.110	3
	Macroeconomic Indicators	Economic growth	8	-0.466	0.095	5
		Income	5	-0.360	0.074	7
		Socio-economic status	8	-0.466	0.095	5
		Sum.		***-4.880***		

Table 6. The calculated importance weights of political factors.

Factors	Megatrends	Driving Forces	*f*	Ej	Wj	Rank
Political	Economic and Social Policies	Affordable housing policies	8	-0.466	0.131	3
		Private-sector housing development policies	6	-0.401	0.113	5
		Social housing policies	3	-0.246	0.069	7
	Environmental and Sustainability Policies	Energy efficiency policies	12	-0.556	0.157	2
		Sustainability policies	12	-0.556	0.157	2
	Urban Quality of Life Policies	Urban security and health policies	4	-0.310	0.088	6
		Multidisciplinary collaboration policies	7	-0.436	0.123	4
		Aging-in-place policies	13	-0.574	0.162	1
		Sum.		***-3.546***		

housing accessibility and sustainability, underscoring the need for the development of innovative approaches.

Table 6 presents the importance weights calculated using the Shannon entropy technique for the driving forces associated with political factors. Aging-in-place policies emerged as the most significant driving force in the last dimension analyzed. Subsequently, energy efficiency and sustainability policies were identified, providing strategic directions for minimizing environmental impacts and optimizing energy usage. Additionally, affordable housing policies underscore the urgent need to develop housing solutions that are both accessible and sustainable.

DISCUSSION

Digital transformation, human-centered development, and environmental awareness are reshaping cities, spaces, and people's lifestyles. Public and collective spaces, particularly housing, play a prominent role in these transformation processes by reinforcing the interaction between the social fabric and the built environment. The built environment is continuously evolving, extending beyond tangible and visible elements to include abstract components that provide social and environmental benefits (Sposito, 2022). These changes underscore the importance of adapting to spatial transformations and discovering effective new approaches and driving forces in housing design.

As discussed in this paper, housing is shaped by the combination of five dimensions: social, technological, economic, environmental, and political. Current studies often address only certain aspects of this complex structure and are generally limited to a narrow perspective (Bitterman & Shach-Pinsly, 2015; Colistra, 2019; Höjer et al., 2011; Iuorio et al., 2019; Jaouhari et al., 2019; Lojanica et al., 2018; Ma et al., 2022; Mete, 2022; Nikezić et al., 2021; Oorschot & Asselbergs, 2021; Wright et al., 2014; Xhelili et al., 2020; Zvěřinová et al., 2020). This paper aims to identify the driving forces effective in housing design, to provide a comprehensive overview of research gaps in the field, and to evaluate the current literature within a conceptual framework. A systematic literature review and meta-synthesis resulted in the identification of 21 megatrends and 72 driving forces, with a frequency distribution of 933, in the 87 articles examined.

A high frequency value (*f*) indicates that the examined concepts are focused on specific subjects, demonstrating substantial interest in these topics within the field. The findings of the article reveal that social, technological, and environmental dimensions have impacts on the future of housing design. Despite having fewer trends and frequencies compared to other factors, economic and political dimensions cannot be overlooked in a holistic analysis, as they can create significant driving forces. This situation shows that current studies are insufficient in understanding the effects of economic and political factors on housing design and that more comprehensive research is needed in these areas. In addition, existing housing studies mostly focus on statistical analysis based on quantitative data, highlighting the need for multidimensional discussions and conceptual and theoretical research.

Shannon's entropy was utilized in this study to measure the variability and unpredictability of different factors affecting housing design. High entropy values suggest areas with significant diversity in opinions or projections, indicating either evolving fields with no consensus or emerging trends that are not yet fully understood or agreed upon. The study identified several key trends, such as the increasing integration of smart home technologies and the growing importance of sustainability in housing design. These trends are not isolated phenomena; they reflect broader societal shifts towards a more interconnected and environmentally conscious world. For example, the emphasis on sustainability mirrors a global movement towards reducing carbon footprints and enhancing energy efficiency in response to climate change concerns. Similarly, the rise of smart technologies in housing underscores a societal tilt towards convenience, security, and connectivity.

The study's findings demonstrate that social factors will trigger significant changes not only in the built environment but also in the dynamics of social structure due to demands arising from changing lifestyles and intergenerational differences. The difficulties associated with individual living and the necessity of increasing the capacity to meet the needs of shrinking household sizes have been emphasized in the studies examined. In particular, the increase in the aging population and single-person households notably strengthens the need for new lifestyles (Lavikka & Paiho, 2023). The juxtaposition of concepts such as a sense of community and individualization, combined with the emergence of demands for inclusive design, underscores the need to prioritize diversity and accessibility, aiming to create livable and flexible spaces for everyone.

The driving forces in the context of technological factors point to innovations aimed at enriching everyday life interactions and experiences by creating data-driven and interactive spaces between the physical environment and the digital world. Innovative technologies have the potential to transform design processes, production techniques of the built environment, and end-user experiences. For instance, modular technologies offer off-site production opportunities to accelerate construction processes, reduce costs, and enhance building quality. The Internet of Things, sensors, and advanced communication technologies increase the intelligence of living spaces, making homes more connected and interactive. These technologies allow users to interact with their environment in smarter and more responsive ways, accelerating the functional evolution of housing while enhancing the mobility capacity of residents. Such transformations are leading to the widespread adoption of smart homes, which offer new models and methods of working that extend beyond mere technological progress and are oriented towards enhancing the daily life practices of users. This suggests that future housing designs will need to be highly adaptable to integrate new technologies that may not currently be at the forefront of design considerations. Therefore, technological advancements have the potential not only to reshape housing design but also to redefine building operations, alter how individuals interact with their living spaces, and influence how communities evolve.

The findings on environmental factors highlight the increasing importance of sustainable environmental management strategies and innovative solutions, which should play a role in housing design and urban planning practices. Articles show that unresolved issues, such as the environmental and energy crisis, biodiversity loss, natural resource depletion, global warming, and climate change, are persisting and intensifying. While the findings emphasize the effects of global climate change and the necessity of reducing carbon footprints, they also reveal the importance of prioritizing energy efficiency and sustainability principles in housing design. Design decisions that save energy and increase environmental awareness are expected to become foundational features of future housing. These approaches can support economic accessibility and ownership flexibility, adaptable to various socio-economic conditions, and contribute to the promotion of social equity for a broad range of users.

On the other hand, the growth of economies and the increase in income, along with changing consumption habits, could lead to a rise in demand for higher quality and technologically advanced housing that meets the lifestyles, desires, and demands of individuals and families. This situation can encourage an increase in housing diversity, leading to the emergence of various housing options that reflect cultural, social, and individual identities. However, viewing housing as an investment tool and economic value may lead to treating homes as goods or commodities in market conditions. This may lead to an increase in inequalities in housing access. In this context, adopting inclusive and participatory approaches in housing design and policies that center on environmental sustainability and social justice could form an effective response to both today's and future challenges.

Finally, this study has identified that political factors provide a guiding framework for housing design and planning, capable of implementing the trends mentioned above, as a significant finding. Political trends establish standards and regulations on strategic issues such as energy efficiency, sustainability, accessibility, and affordability. These political factors, directly related to economic, social, technological, and environmental dimensions, facilitate the holistic integration of factors through the creation of regulations and the support of social development. The political and economic dimensions possess complementary driving forces. These two factors need to be considered together for effective design and sustainable social development. The findings of this study indicate that the trends obtained through the analysis of STEEP factors support each other and should be evaluated by adopting a broader and more holistic approach that considers the dynamic interactions between factors in housing design and policies.

CONCLUSION

This research, based on megatrends and driving forces collected through a systematic literature review, constitutes the starting point for a comprehensive study to develop future scenarios specifically for the multi-family housing typology. At the same time, it also brings into question the opportunities and challenges that researchers and practitioners may encounter in terms of spatial and functional transformation in the future of housing design. By focusing on trends within a broad conceptual framework, the study offers the possibility to be prepared for the future in areas such as social unraveling, ecological degradation, economic imbalances, and digital transformation, to mitigate potential adverse effects, create a strategic roadmap, and produce effective solutions to changes. The results of the research aim to raise awareness in architectural research about adapting to major changes.

In the future of housing typology, developing fair and inclusive living spaces that can meet user expectations should be considered a priority research area. Designing affordable housing for diverse social groups and adopting an approach that supports social, economic, and technological equality can be effective in re-establishing social balance. Otherwise, the addition of technological inequality to existing economic inequalities may deepen social segmentation and widen the gap between countries and regions. Therefore, it is recommended that future research should detail flexible and versatile housing design parameters by considering user diversity and socio-economic factors.

A more holistic and in-depth analysis of environmental sustainability, economic justice, and technological opportunity equality is recommended. These three fundamental dimensions have direct impacts on social norms and the built environment. The discipline of architecture plays a critical role in maintaining social balances and optimizing user-space interactions, extending beyond physical spaces. In this context, it may be important to take strategic steps in housing design to meet the housing needs of every person, eliminate inequality, and promote housing diversity.

For future studies, it is recommended to analyze the identified megatrends and driving forces at more detailed geographic levels. Focused analyses, by revealing specialized needs and trends, can contribute to the development of regional and comprehensive future scenarios. Such an approach allows for the evaluation of alternatives and the discussion of desired futures. These analyses can be useful in determining the decisions to be made today and the policy steps to be taken to achieve desired futures.

In conclusion, this paper provides a comprehensive assessment of the megatrends and driving forces that will shape the future of housing design, offering theoretical and practical contributions to the discipline of architecture. Understanding and supporting these multilayered and dynamic trends require interdisciplinary collaboration and the prioritization of innovative regulation development by relevant policymakers. Architectural practice must adopt a holistic approach that encompasses the three dimensions of sustainability, including social and economic aspects, beyond just technological and environmental dimensions. With such an approach, architectural, urban planning, and policy development processes will gain the potential to create sustainable, livable, and resilient living spaces for future generations by developing accessible, flexible, and inclusive housing design strategies.

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REFERENCES

Bitterman, N., & Shach-Pinsly, D. (2015). Smart home – A challenge for architects and designers. Archit Sci Rev, 58(3), 266–274.

CASP. (2018). Critical Appraisal Skills Programme. https://casp-uk.net/casp-tools-checklists/

Chey, K. (2018). Multi-unit housing in urban cities. Taylor & Francis.

Colistra, J. (2019). Innovations in housing for smart cities. J Archit Eng, 25(4), 06019001.

Denyer, D., & Tranfield, D. (2009). Producing a systematic review. In D. Buchanan & A. Bryman (Ed.), The Sage Handbook of Organizational Research Methods (1st ed), pp. 671–689. Sage Publications.

Errante, L. (2022). Design opportunities towards the ecological transition of villages, cities, buildings and dwellings. In F. Calabrò, L. Della Spina, & M. J. P. Mantiñán (Ed.), New metropolitan perspectives, pp. 120–135). Springer.

Fahey, L., & Narayanan, V. K. (1986). Macroenvironmental analysis for strategic management. West Publishing Company.

Fukuyama, M. (2018). Society 5.0: Aiming for a new human-centered society. Japon Spotlight. https://www.jef.or.jp/journal/pdf/220th_Special_Article_02.pdf

Global Footprint Network. (2023). Earth overshoot day 2023 fell on August 2. https://overshoot.footprintnetwork.org/

Guida, C., & Natale, F. (2021). Ecological transition: Which transactions? TeMA J Land Use Mobil Environ, 14(1), 93–98.

Höjer, M., Gullberg, A., & Pettersson, R. (2011). Backcasting images of the future city – Time and space for sustainable development in Stockholm. Technol Forecast Soc Change, 78(5), 819–834.

Iuorio, O., Wallace, A., & Simpson, K. (2019). Prefabs in the North of England: Technological, environmental and social innovations. Sustainability, 11(14), 3884.

Jaouhari, S., Palacios-Garcia, E., Anvari-Moghaddam, A., & Bouabdallah, A. (2019). Integrated management of energy, wellbeing, and health in the next generation of smart homes. Sensors, 19(3), 481.

Kalaitzi, D., Matopoulos, A., Fornasiero, R., Sardesai, S., Barros, A. C., Balech, S., & Muerza, V. (2021). Megatrends and trends shaping supply chain innovation: A roadmap for research and innovation. In R. Fornasiero, S. Sardesai, A. C. Barros, & A. Matopoulos (Ed.), Next Generation Supply Chains, pp. 3–34. Springer.

Keidanren. (2018). Society 5.0: Co-creating the future. Japan Business Federation. https://www.keidanren.or.jp/en/policy/2018/095.html

Lavikka, R., & Paiho, S. (2023). Motivations and market solutions for flexible housing in Finland. J Housing Built Environ, 38(3), 1789–1818.

Lojanica, V., Colic-Damjanovic, V. M., & Jankovic, N. (2018). Housing of the future: Housing design of the Fourth Industrial Revolution. 5th International Symposium on Environment-Friendly Energies and Applications (EFEA), 2018, 1–4.

Lotfi, F. H., & Fallahnejad, R. (2010). Imprecise Shannon's entropy and nulti attribute decision making. Entropy, 12(1), 53–62.

Lu, Y. (2017). Industry 4.0: A survey on technologies, applications and open research issues. J Ind Inf Integr, 6, 1–10.

Ma, C., Guerra-Santin, O., & Mohammadi, M. (2022). Smart home modification design strategies for aging in place: A systematic review. J Housing Built Environ, 37(2), 625–651.

Maddikunta, P. K. R., Pham, Q. V., Prabadevi, B., Deepa, N., Dev, K., Gadekallu, T. R., Ruby, R., & Liyanage, M. (2022). Industry 5.0: A survey on enabling technologies and potential applications. J Ind Inf Integr, 26, 100257.

Mete, S. (2022). Towards degrowth housing development? Lessons from a scenario-based gaming session in the Oslo region. Local Environ, 27(4), 517–536.

Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., Stewart, L. A., & PRISMA-P Group. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Systematic Reviews, 4(1), 1–9.

Nahavandi, S. (2019). Industry 5.0 — A human-centric solution. Sustainability, 11(16), 4371.

Nikezić, A., Ristić Trajković, J., & Milovanović, A. (2021). Future housing identities: Designing in line with the contemporary sustainable urban lifestyle. Buildings, 11(1), 18.

Oorschot, L., & Asselbergs, T. (2021). New housing concepts: Modular, circular, biobased, reproducible, and affordable. Sustainability, 13(24), 13772.

Petticrew, M., & Roberts, H. (2006). Systematic reviews in the social sciences: A practical guide. Blackwell Publishing Ltd.

Pour La Solidarité. (2023). European observatory of transition: Definitions. https://www.transition-europe.eu/en

Saritas, O., & Smith, J. E. (2011). The big picture – Trends, drivers, wild cards, discontinuities and weak signals. Futures, 43(3), 292–312.

Sposito, C. (2022). Reflections and trajectories for interdisciplinary research on the digital transition. Agathón Int J Archit Art Des, 12, 2–13.

Sposito, C., & Scalisi, F. (2023). Reflections and trajectories for interdisciplinary research on the ecological transition. Agathón Int J Archit Art Des, 13, 3–18.

Szigeti, H., Messaadia, M., Majumdar, A., & Eynard, B. (2011). STEEP analysis as a tool for building technology roadmaps. In Internationale Challenges E-2011 Conference, Florence, Italy.

United Nations. (2018). World urbanization prospects: The 2018 revision. https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf

Wright, D., Buys, L., Vine, D., Xia, B., Skitmore, M., Drogemuller, R., Kennedy, R., & Li, M. (2014). EUTOPIA 75+: Exploratory futures scenarios for baby boomers' preferred living spaces. J Futures Stud, 19(2), 41–60.

Xhelili, A., Strube, R., Grossi, F., Zvěřinová, I., Taylor, T., Martinez-Juarez, P., Quiroga, S., Suárez, C., & Gjorgjev, D. (2020). A technological scenario for a healthier, more equitable and sustainable Europe in 2040: Citizen perceptions and policy implications. In J Environ Res Public Health, 17(1), 231.

Yılmaz, K. (2021). Sosyal bilimlerde ve eğitim bilimlerinde sistematik derleme, meta değerlendirme ve bibliyometrik analizler. MANAS Sosyal Araştırmalar Dergisi, 10(2), 1457–1490.

Zvěřinová, I., Máca, V., Ščasný, M., Strube, R., Marques, S., Dubová, D., Kryl, M., Craveiro, D., Taylor, T., Chiabai, A., & García de Jalón, S. (2020). How to achieve a healthier and more sustainable Europe by 2040 according to the public? Results of a five-country questionnaire survey. Int J Environ Res Public Health, 17(17), 6071.