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POST-PANDEMIC URBAN RESIDENTIAL LIVING: ADAPTABILITY & FLEXIBILITY IN ARCHITECTURE IN LAHORE'S LOW-RISE APARTMENTS

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ABSTRACT
The COVID-19 pandemic has exposed the inadequacies of traditional architectural principles in low-rise apartment buildings, particularly in dense urban environments like Lahore. This research investigates whether contemporary architectural practices align with the principles of flexibility and adaptability necessary for habitable spaces in the post-pandemic "new normal." It explores how these designs impact the physical and mental health of residents while addressing the unique challenges presented by the pandemic.
Specifically, the study delves into how architectural layouts can support the adaptability required for remote working and learning at home, a need accentuated during the global health crisis. Through a comprehensive literature review and detailed analysis, the research examines critical health concerns, such as the effects of limited ventilation and poor indoor air quality in low-rise apartments, as well as the psychological toll of confined living spaces and social isolation.
Drawing on case studies and literature reviews, this research identifies emerging architectural principles and innovative design strategies that emphasize flexibility, connectivity, cultural inclusivity, sustainability, and functionality, with a strong focus on enhancing resident well-being. Ultimately, this study aims to provide insights into how low-rise apartment buildings in Lahore can evolve to better meet the needs of their inhabitants in a post-pandemic context.

Keywords:
Architectural Adaptability, Urban Residential Design, Post-Pandemic Living, Work-Study Home Dynamics

1. INTRODUCTION

In the post-pandemic era, urban living has undergone significant transformation, particularly in residential buildings (Peters & Halleran, 2020; RIBA, 2021). Changes in people's functional and psychological needs have reshaped the approach to residential design, emphasizing adaptability, comfort, and well-being (Asim & Shree, 2021; Duarte & Almeida, 2021). These shifts reflect an increasing demand for spaces that support remote work, promote physical health, and prioritize mental well-being, all while balancing functionality and aesthetics in densely populated urban environments (Yang et al., 2021; Hussain & Alsharif, 2023).
The COVID-19 pandemic has exposed significant inadequacies in the design of low-rise apartment buildings in Lahore, Pakistan, revealing that these structures are ill-equipped to meet the evolving demands of urban living. As residents adapt to remote work and increased time spent at home, the limitations of existing architectural practices have come into sharp focus. With approximately 9 million housing units backlogged in Pakistan and a growing urban population, the urgency for effective residential solutions has never been more pressing (World Bank, 2016; Mustafa, 2019). These buildings, constructed before the pandemic, remain in use today without providing the freedom of modification needed to cater to contemporary user needs.

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This trend is similarly reflected in Lahore, where the shift in lifestyles due to the pandemic has led to people spending significantly more time at home. Consequently, there has been a profound re-evaluation of architectural considerations in residential buildings to better address the changing functional and psychological needs of the population. Multi-unit apartment living has continued to dominate as the primary housing style in urban areas, driven by the increasing densification of cities worldwide, including Lahore (Rafique et al., 2024). The Government of Pakistan projects that vertical growth is necessary to accommodate the increasing population; however, this shift must not come at the expense of liveability and quality of life (Government of Pakistan, 2014). Instead, design strategies must ensure that low-rise apartments provide flexible, adaptable spaces fostering social interaction, mental well-being, and a connection to nature (Duarte & Almeida, 2021).

A critical issue lies in the architectural inflexibility of low-rise apartments. Unlike high-rise buildings, which often integrate communal spaces, dedicated work areas, and recreational facilities, low-rise apartments frequently lack such essential amenities (Fatima et al., 2021). This deficiency restricts residents' ability to adapt their living spaces for contemporary needs, leading to negative impacts on their mental and physical well-being. Research indicates that inadequate living conditions can exacerbate stress, anxiety, and other health issues, particularly during prolonged periods of confinement (Sampson et al., 2020).

Furthermore, the design of many low-rise apartments fails to incorporate vital elements that promote health and well-being. For instance, studies have shown that access to natural light, ventilation, and green spaces is critical for enhancing residents' quality of life (Kellert, 2015; Shahbaz & Zaidi, 2019). However, these features are often missing in Lahore's low-rise developments, where the lack of outdoor areas and poorly ventilated interiors contribute to a sense of isolation and discomfort.

Additionally, the pandemic has prompted a re-evaluation of public health considerations in residential design. The World Health Organization emphasizes that homes should support physical health through adequate ventilation, indoor air quality, and access to outdoor spaces (World Health Organization, 2020). Yet, existing low-rise apartment designs in Lahore often overlook these critical factors, underscoring the pressing need for innovative architectural solutions prioritizing resident health and comfort.

In conclusion, the architectural shortcomings of low-rise apartment buildings in Lahore present a significant problem requiring urgent attention. By failing to accommodate the contemporary demands for adaptability and wellness, these structures hinder the quality of life for residents and pose challenges to urban resilience in future crises. This research investigates these issues in depth, exploring applicable design approaches that can transform low-rise residential architecture into adaptable, healthy living environments suited for the post-pandemic era.

The primary focus of this study is to identify and evaluate design strategies that promote flexibility and adaptability in low-rise apartment buildings. Additionally, the research aims to assess and analyze the following research questions:

1. What are the key challenges concerning adaptability in the current design of low-rise apartment buildings in Lahore?
2. How can international architectural theories and practices related to flexibility be adapted to the local context of Lahore?
3. What are the residents' perspectives on the need for adaptable spaces in their living environments?

2. RESEARCH METHODS

This research adopts a qualitative methodology to explore adaptability and flexibility in low-rise apartment buildings in Lahore, Pakistan. The study focuses on understanding the design principles that can be implemented to enhance the adaptability of these buildings, ensuring they meet the evolving needs of residents over time. The research is grounded in a detailed analysis of architectural theories, fieldwork, and direct engagement with residents.

- **Data Collection through Literature Review:** The study commenced with an extensive literature review of existing architectural theories and design principles, along with academic sources and theses. Notable works by architects were also analyzed to understand their approaches to flexibility and adaptability in architecture. These theories were then critically evaluated for their applicability in the context of low-rise apartment buildings in Lahore.
- **Precedent Analysis:** Fieldwork was conducted across various low-rise apartment buildings in Lahore to observe and document their current design and adaptability. The buildings were analyzed based on their spatial organization, construction techniques, and the ability to accommodate changes in use over time. This

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hands-on approach provided a practical understanding of the challenges and opportunities in implementing adaptable designs in the local context.

- **Data Analysis:** The data collected from the literature review and precedent analysis were analyzed to identify recurring themes and patterns. The analysis focused on understanding how the principles of flexibility and adaptability can be integrated into the design of low-rise apartment buildings, considering the unique socio-cultural and environmental context of Lahore.

The findings were then synthesized to propose a set of design guidelines aimed at enhancing the adaptability of low-rise apartment buildings in Lahore, ensuring they remain functional and relevant in the long term.

3. BACKGROUND RESEARCH

The accelerated adoption of digital technologies in 2020 triggered profound societal shifts, fundamentally reshaping human interactions with the built environment. A pivotal catalyst for this transformation was the COVID-19 pandemic, which magnified the demand for remote work and virtual learning, prompting a reevaluation of residential architecture (De', Pandey, & Pal, 2020). In Pakistan, this shift coincides with an acute housing deficit, with an estimated backlog of 9 million housing units (World Bank, 2016; Mustafa, 2019). Lahore, as a rapidly expanding metropolis, exemplifies these challenges, facing urban land shortages that drive the rise of low-rise vertical residential settlements.

However, the pandemic exposed significant inadequacies in these vertical settlements. Outdated and poorly designed living environments compromise residents' physical and mental well-being, with deficiencies exacerbated under prolonged home confinement (Liu et al., 2023). The pivot to home-based activities such as remote work and online education underscores the critical need for adaptable, flexible, and health-conscious residential designs (Peters & Halleran, 2020). Yet, low-rise residential buildings in Lahore fail to incorporate principles of adaptability, flexibility, or integration with nature, all essential for resilient and sustainable living environments (Askar et al., 2021). Moreover, these structures lack the infrastructure to retrofit or repurpose spaces for evolving needs, such as home offices, fitness zones, and delivery storage facilities (Stoyanov, 2023).

The pandemic also highlighted the rising reliance on remote work and e-commerce, further emphasizing the inadequacies of existing low-rise apartments in Lahore. Constrained by poorly designed and inflexible interiors, residents faced challenges in maintaining productivity, health, and quality of life (Gür, 2021). Municipal lockdowns further underscored these issues, making architectural innovation a pressing necessity for fostering well-being and functionality in residential spaces (Kaya, 2021). Pakistan's growing adoption of remote working, mirroring global trends, calls for a paradigm shift in residential architectural practices.

Literature review table

Title	Key Findings and Contributions
Post-pandemic lifestyle changes and their interaction with resident behavior in housing and neighborhoods: Bursa, Turkey	Highlights behavioral shifts in housing use, emphasizing flexible designs to adapt to evolving needs during and after the pandemic.
Assessment of the Change in Design Strategy of Apartment Buildings in the Post-COVID-19 Pandemic Era	Explores adjustments in design strategy for apartment buildings, advocating for multifunctional spaces, increased natural ventilation, and adaptable layouts.
Health and Housing: Lessons from the Pandemic	Emphasizes the need for better ventilation, natural lighting, and community spaces to address psychological stress and health concerns post-pandemic.
Architecture for a	Proposes urban designs that integrate green spaces, improve

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Post-COVID World	ventilation, and support social distancing without sacrificing community interaction.
Human-Centered Residential Architecture in the Post-COVID Era	Investigates how the pandemic has shaped design strategies, emphasizing adaptability, well-being, inclusivity, sustainability, and resilience in residential architecture.
Post Pandemic Architecture	Analyzes and explores what post-pandemic architectural housing will look like, considering the impact of the pandemic on design strategies.
A Proposed Sport Center with Focus on Pandemic Architecture in Lapta-Girne, Northern Cyprus	Explores designing pandemic-resilient spaces like sport centers, focusing on enhanced ventilation and social distancing measures.
A Post-Pandemic Reassessment of the New Urbanism Principles	Discusses the compatibility of New Urbanism principles with post-pandemic design, emphasizing resilience and adaptability in urban planning.
The Contemporary Project	Investigates urban architectural adaptations post-pandemic, with a focus on sustainability and community-centered design.
Post Pandemic Apartments in Palestine	Proposes post-pandemic apartment designs incorporating "transformable living walls" and quarantine-friendly features like negative pressure rooms.

4. RESIDENTIAL BUILDINGS IN LAHORE'S URBAN CONTEXT

Lahore, the capital of Punjab province and Pakistan's second-largest city, serves as a key industrial and economic hub. Renowned for its progressive and cosmopolitan outlook, Lahore has historically been the cultural and administrative heart of the Punjab region. Over the past two decades, the city has experienced significant urban growth, driven by rural-to-urban migration in pursuit of better healthcare, education, and employment opportunities (Javed & Riaz, 2020).

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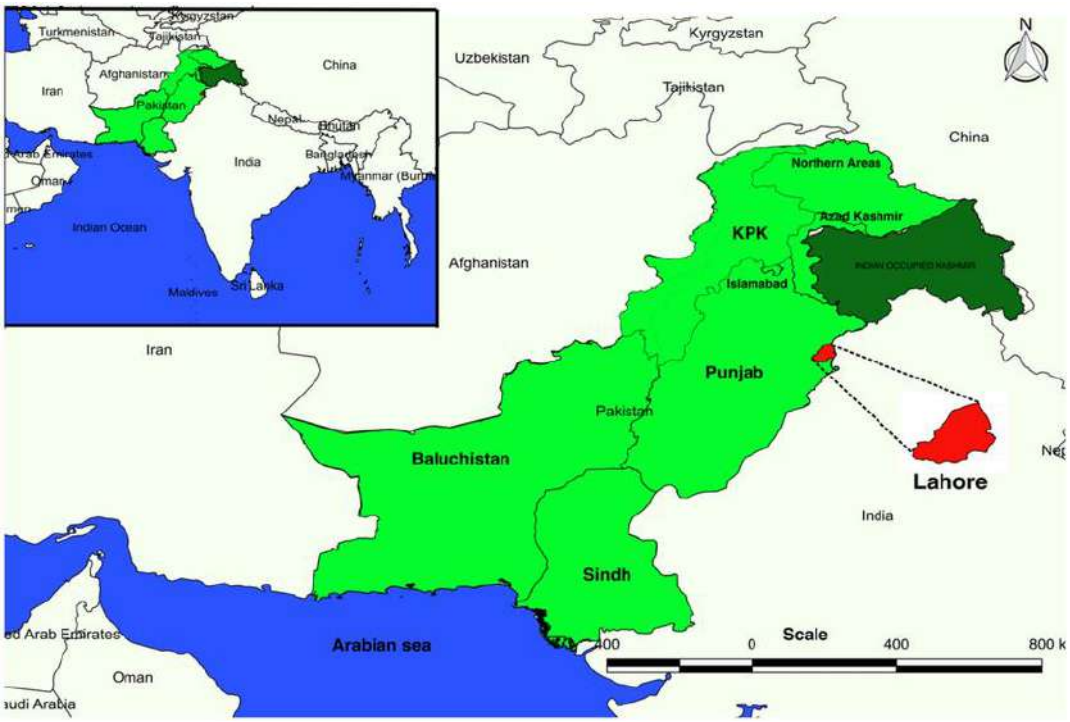

Figure 1 Map of Pakistan (Khan et al., 2021)

Once a small walled settlement, Lahore has transformed into a sprawling metropolis.
Unlike planned cities, Lahore evolved organically, extending beyond its historic walled boundaries in an unregulated manner.

Figure 2 Map of The Walled City Lahore (Walled City of Lahore Authority, n.d.)

While its walled city retains a vibrant heritage of monuments, havelis, bazaars, and cultural customs, modern urban planning struggles to keep pace with the demands of a growing population. The lack of cohesive planning exacerbates housing challenges, particularly in vertical residential settlements, where designs fail to address contemporary needs.

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4.1 Observation of Planning Practices in Lahore

It is evident that the current design of vertical settlements in Lahore is not suitable for the current situation. The COVID-19 pandemic intensified awareness of these architectural deficiencies. Residents in low-rise apartment buildings face numerous challenges, including limited natural light, inadequate ventilation, and insufficient space for outdoor or communal activities. Addressing these shortcomings requires a holistic approach that emphasizes functionality, sustainability, and user well-being.

The figure below shows the city's growth in detail.

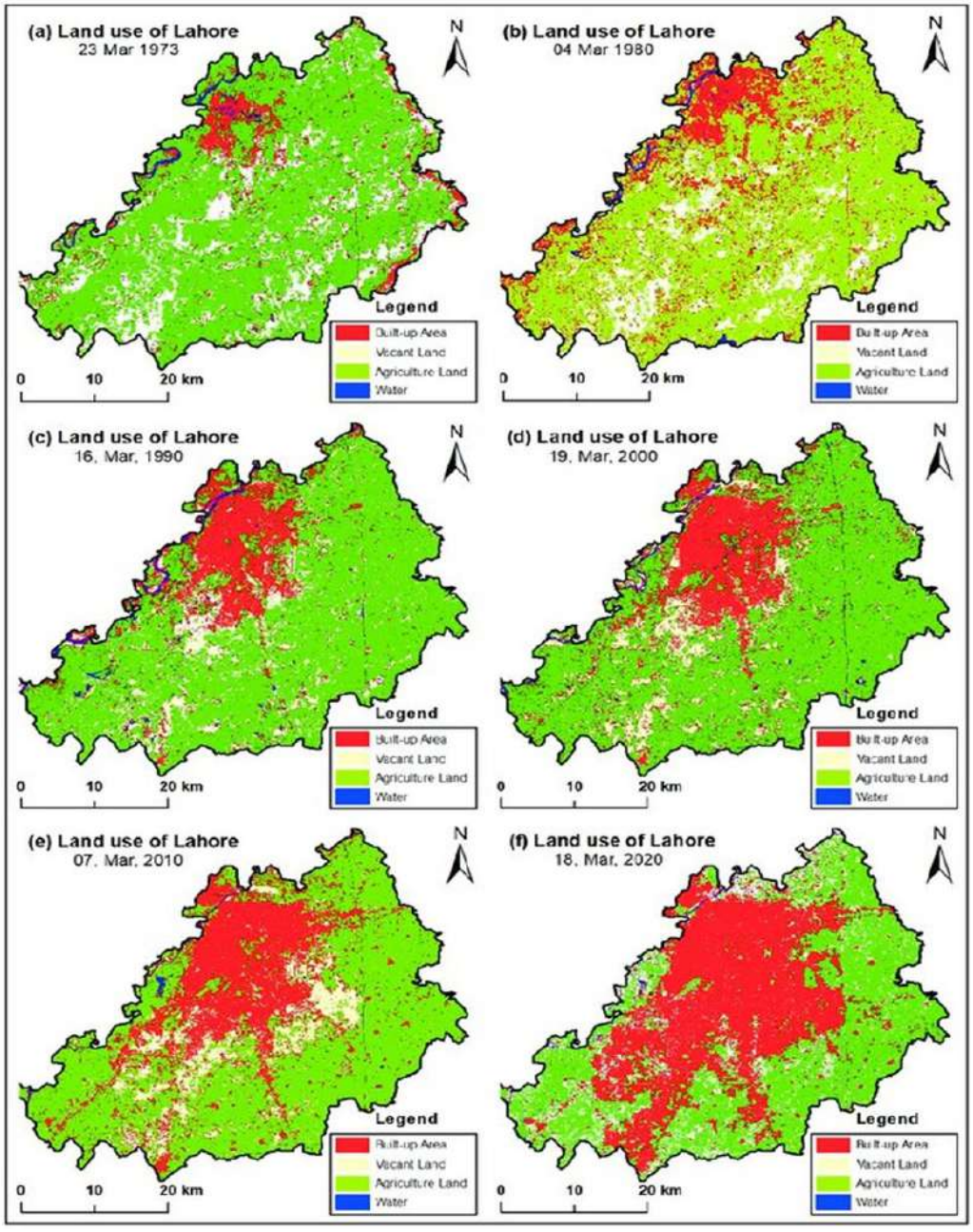

Figure 3 Land use map of Lahore from 1973 to 2020 (Nasar-u-Minallah, Zia, Atta-Ur Rahman, & Riaz, 2021)

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4.2 Current Architectural Practices in Lahore

- ***Impractical Window Size:***

Low-rise apartment buildings in Lahore often feature windows that are smaller in size compared to modern design standards. These small windows limit the entry of natural light and fresh air into the living spaces, resulting in dim and poorly ventilated interiors and the elimination of interior and exterior connectivity. Or in most recent design practices where there are larger windows or semi-open spaces to make the design approach a bit more modernized, the windows occupy the entire wall spaces and hence become inoperable which causes extreme heat accumulation and hinders cross ventilation in the 9-month long summer.

Figure 4 Recent low rise apartment building construction in Lahore

- ***Limited Natural Light:***

In addition to the small window size, the orientation of low-rise apartment buildings in Lahore may further limit the amount of natural light that enters the living spaces. Along with poor orientation, in most cases there is a lack of natural lighting due to the density of the surrounding structures that blocks the light from entering into the major parts of the residential spaces. The city planning of Lahore needs a serious reevaluation on the dense neighborhoods scattered around the city. Poor natural light exposure can have adverse effects on residents' mood, productivity, and overall health.

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Figure 5 Congested Low rise Apartment buildings in Lahore that does not allow appropriate amount of direct sunlight to enter the buildings. Buildings were constructed in the early late eighties. Reference: Taken by author 2018

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- ***Low Ceiling Height:***

Another characteristic feature of low-rise apartment buildings in Lahore is the relatively low height of ceilings. Low ceilings can make rooms feel cramped and claustrophobic, especially when combined with small windows. Additionally, low ceilings may restrict air circulation and contribute to a sense of stuffiness within the living spaces. Recent research suggests that the way people think, and act is affected by ceiling height. The authors of said research theorized that when reasonably salient, a higher versus a lower ceiling can stimulate the concepts of freedom versus confinement, respectively (Lavrusik, 2007).

- ***Limited Open/Outdoor Space:***

Many low-rise apartment buildings in Lahore lack adequate open space, both within individual units and in communal areas. This limited open space can restrict residents' ability to move freely and engage in outdoor activities, diminishing their overall quality of life.

Figure 6 Recently built low-rise apartment building in Lahore. The balconies do not allow free moving space for the resident to leisurely sit and have family time as a source of outdoor activity, such a balcony barely even serves as an outdoor space. Taken by Author 2023

- ***Inadequate Cross-Ventilation:***

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Due to the compact layout of low-rise apartment buildings and the small size of windows, achieving effective cross-ventilation can be challenging. This results in poor air circulation and ventilation within the units, leading to indoor air quality issues and discomfort for residents. It is observed during the research that there is a lack of technical skills that must be focused on and new ideas and practices should be looked into, to provide residents with the most comfortable living conditions possible.

Figure 7 Low-rise apartment building in "Androon" Lahore, built in the 90's, lacking any elements for ventilation except the windows that cannot be opened during the immense heat wave throughout most of the year. Taken by author, 2018.

- ***Absence of Greenery:***

Low-rise apartment buildings in Lahore often lack greenery and landscaping, both within the building complex and in the surrounding area. The absence of green spaces deprives residents of opportunities for relaxation, recreation, and connection with nature, impacting their mental and emotional well-being.

- ***Inefficient Thermal Insulation:***

Many low-rise apartment buildings in Lahore exhibit poor thermal insulation, leading to excessive heat gain in summer and heat loss in winter. Inefficient insulation contributes to discomfort for residents and increases energy consumption for heating and cooling.

- ***Rigid Layout:***

Low-rise apartment buildings in Lahore often feature rigid and standardized layouts, with little flexibility for customization or adaptation to residents' changing needs. This lack of flexibility can hinder residents' ability to personalize their living spaces and may lead to a sense of monotony and dissatisfaction with the built environment.

- ***Lack of Dedicated Spaces for Remote Working:***

Many low-rise apartment buildings in Lahore lack designated areas for remote work or study. This can lead to challenges in productivity and concentration, as residents struggle to find suitable spaces within their homes to work effectively.

- ***Aesthetics Over Functionality:***

In some cases, low-rise apartment buildings prioritize aesthetics over functionality, adopting architectural styles or design elements that may not be well-suited to the local climate or context. It was observed that the cultural integrity was kept intact. There is always a cultural characteristic either in the construction style or the facade or at some point in the final exterior or interior. This can result in buildings that fail to provide adequate protection against heat, humidity, or inclement weather, compromising residents' comfort and well-being.

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4.3 Potential effect on health and well-being

The built environment profoundly influences residents' physical and mental health. In Lahore, where economic constraints limit access to public spaces, residents spend a substantial portion of their time indoors (Amerio, 2020). This extended indoor time, particularly among those working or studying remotely, has significant health implications (Hyeon-Seung Lee, 2021). Research indicates that urban residents spend approximately 90% of their time indoors, highlighting the critical role of residential environments in overall well-being (Xiao et al., 2022).

Direct Effects include poor indoor air quality, inadequate lighting, and insufficient ventilation, leading to respiratory issues, discomfort, and reduced cognitive function (Amerio, 2020). **Indirect Effects** encompass psychological impacts such as stress, anxiety, and depression stemming from feelings of confinement and monotony (Hyeon-Seung Lee, 2021). The pandemic's impact on daily life underscores the need for architectural practices that address these concerns, promoting health, productivity, and quality of life in residential spaces (Rashed, 2024).

5. THEORIES OF ADAPTABILITY AND FLEXIBILITY IN ARCHITECTURE

In the contemporary era, characterized by the rise of digital lifestyles, remote work, and online education—accelerated by the COVID-19 pandemic—the role of the home has transcended its traditional function as a mere living space. Even as the pandemic subsides, it is evident that the spaces in which we live must undergo significant transformations to foster resilience and adaptability in response to the evolving needs of society. In this context, examining the theories and concepts of flexibility and adaptability, as advanced by renowned architects, is crucial in developing designs that are relevant to the post-pandemic realities of Lahore.

Gerrit Rietveld, a key figure of the De Stijl movement, asserts, "The concept of flexibility creates a building which is not a fixed entity, but a palimpsest on which can be inscribed any lifestyle and any life view" (Rietveld, 1920). This notion underscores the importance of designing spaces that can accommodate diverse user needs and evolve over time. Similarly, the famous quote from Tomasi Di Lampedusa's The Leopard—"For things to remain the same, everything must change"—offers a poignant reminder that cities can only endure if they possess the capacity for change and adaptability. This resilience, particularly in architectural and urban planning, is essential for the survival of urban environments (Lampedusa, 1958).

Following the devastation of World War II in 1945, the necessity for post-war reconstruction catalyzed the development of adaptable residential architecture. These early models focused on enhancing user well-being and safety, emphasizing comfort, health, security, and quality of the indoor environment. More importantly, they addressed the need for spaces that could evolve over time to meet the diverse, dynamic needs of individuals, enabling personal self-expression within a framework that could adapt without disrupting the fabric of the surrounding neighborhood (Kooi, 2022). Architects and theorists have long recognized the critical importance of designing spaces that can accommodate a range of functions, user preferences, and future modifications. The challenge in a "liquid society" (Bordoni, 2016)—one marked by constant societal changes—is to meet the growing demand for housing while ensuring that such designs remain socially and environmentally sustainable. Social housing must be sufficiently flexible to accommodate the evolving needs of its residents if it is to endure and continue to serve its purpose.

This flexibility introduces the notion of temporality in architecture, suggesting that impermanence should not be seen as a limitation but as an opportunity to design housing that can accommodate changing needs. In this sense, residential design should be capable of adapting to the evolving requirements of households. This adaptability is not only a response to societal changes but also an essential feature of sustainable residential design, allowing for the broadest range of potential occupants. A novel design strategy aimed at achieving this flexibility involves utilizing architectural modules that maximize available space, reduce the number of private areas, and incorporate shared amenities. Furthermore, adopting low-tech and low-impact construction methods is vital to achieve both environmental sustainability and adaptability (S3DA Design, 2021).

Vernacular architecture has long demonstrated a capacity for flexibility, responding to social and economic changes, as well as external pressures such as natural disasters, wars, disease outbreaks, and pandemics. These events often lead to sudden demographic shifts, altered economic conditions, and changing lifestyles, necessitating adaptable housing solutions.

As discussed, the concept of flexible architecture is not a recent development but is deeply rooted in modernism, particularly as applied to the housing crises following the First and Second World Wars. Modernist architects, seeking functional design solutions, gravitated toward industrial methodologies and modular

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systems, enabling mass production at scale.
This approach facilitated the creation of buildings with versatile layouts, independent of the construction systems employed. A notable example is Le Corbusier's Domino system (Le Corbusier, 1923), a two-story unit consisting of concrete slabs supported by columns, with an open staircase. The structural modules—pre-fabricated frames—could be rapidly assembled, with only the addition of walls and windows required. This framework granted architects the freedom to shape both the building's façade and interior, regardless of the construction system used. Le Corbusier referred to this as plan libre, a concept that allowed for spatial flexibility by decoupling the structural elements from the interior and exterior design. The Domino system thus laid the foundation for subsequent architectural innovations, such as the layering method and the open-plan layout, both of which promote adaptability in design. Building upon these principles, contemporary practices can explore new avenues for achieving architectural flexibility and adaptability in response to modern housing challenges.

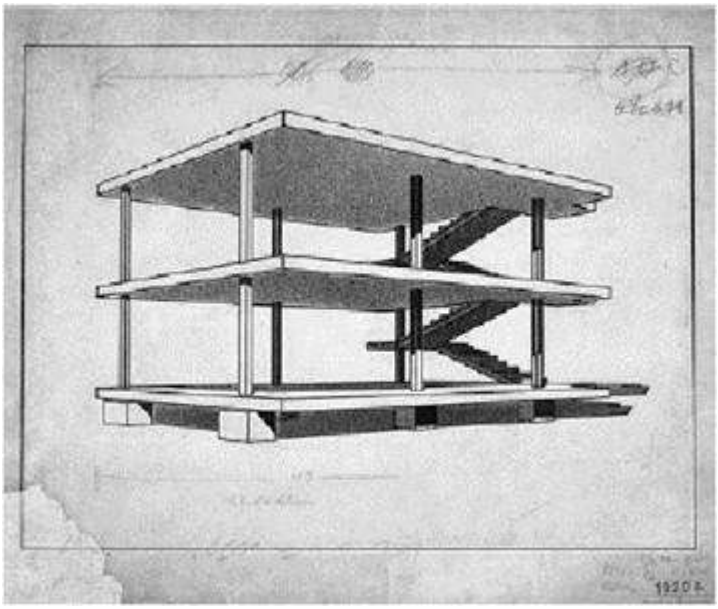

Figure 8 Le Corbusier's Domino House 1914. (Kooi, 2022)

5.1 Habraken's theory

Habraken's theory of "supports" (Habraken, 1972) introduced a framework for Dutch housing that emphasized user participation, a core principle facilitating adaptability. This approach distinguished between the permanent structural elements of a building, termed 'supports,' and the customizable living spaces, known as 'infill' (Habraken, 1972). By allowing residents to modify their living spaces, this model promoted a sense of ownership and adaptability within the built environment.
To enable designs that facilitate easy assembly and disassembly, the "open building movement" (Habraken, 1998) prioritized modern construction techniques and the use of prefabricated elements, including structural components, infills, and subsystems. This methodology aimed to create flexible and adaptable housing solutions that could evolve with changing user needs (Habraken, 1998).
Furthermore, Habraken and Walter Segal viewed the use of flexible systems as a means to create a "flexible" social space, emphasizing user participation and self-building elements and components. This perspective contrasts with the open building system, which often employs highly technical building methods (Segal & Habraken, 1985).
By the 20th century, flexibility had become a concept requiring careful thought and consideration in architectural design, applied to numerous projects. The relationship between order and flexibility is crucial; while Habraken's ideas focus on creating adaptable structures, balancing order—providing stability and organization—and flexibility—allowing dynamic changes—ensures that architectural spaces remain relevant and functional over time. This interplay of order and flexibility is not merely a technical consideration but a

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philosophical one, embodying the duality required for architecture to both endure and evolve in response to societal shifts.

5.2 Order and Flexibility

The dual principles of order and flexibility are fundamental to the sustainability of architectural design (Habraken, 2003). While order provides the structural framework that ensures organization, it also facilitates the connection between individual components and the overall system. This system of order delineates the boundaries of possibility, thereby maintaining clarity and coherence within the architectural composition. In contrast, flexibility introduces a dynamic dimension, empowering users to modify or adapt the environment according to their evolving needs. This interaction between the static and dynamic is not merely a functional relationship, but a fundamental aspect of architectural adaptability, which allows the built environment to resonate with its inhabitants over time.

Renowned architect Frank Gehry underscores the significance of architectural adaptability, asserting, "Architecture should speak of its time and place, but yearn for timelessness" (Gehry, 2009). Gehry's designs exemplify this idea, frequently utilizing modular components and flexible spaces to accommodate changing functions without losing their intrinsic sense of place or permanence. His approach aligns with the necessity for architecture to remain relevant as it interacts with the ever-evolving needs of society, while maintaining its timeless quality.

In this context, a housing complex designed for university students serves as an illustrative example of this balance between order and flexibility (Malofiy, 1998). As students typically reside in these spaces for relatively short periods, ranging from one to three years, the design must accommodate their transient needs. To achieve this, it is imperative that the dwelling units allow for easy and rapid adaptation to changing spatial requirements. Movable interior partitions serve as a critical element in this flexibility, enabling the spatial configuration of each unit to be adjusted based on the number of occupants, time of day, or seasonal usage. The structural framework, however, remains consistent and fixed, providing the necessary order that supports the adaptability of the interior spaces. This interplay between a static structural system and dynamic interior elements exemplifies the concept of flexible architecture, where organization and adaptability coexist to meet both functional and social demands.

Christopher Alexander, in his seminal work *A Pattern Language*, emphasizes the importance of designing flexible environments that promote community and human well-being. He advocates for ageless design principles rooted in human behavior and interaction patterns, encouraging architectural approaches that evolve over time to meet the needs of its users (Ishikawa, Silverstein, & Alexander, 1977). These principles resonate deeply in the context of flexible residential designs, where adaptability is key to creating environments that can evolve alongside their inhabitants' changing circumstances.

However, it is crucial to recognize that the tension between order and flexibility is not merely technical but philosophical. In their isolated states, both flexibility and order can lead to undesirable outcomes. A system that is purely flexible risks devolving into chaos, while a system that is excessively ordered can become sterile and devoid of vitality. The synergy between these two forces is, therefore, indispensable for the development of resilient and adaptable architectural systems. This interdependence underscores the notion that architecture thrives when it can adapt to the changing conditions of both society and the individual (Malofiy, 1998).

Architect Rem Koolhaas further extends the idea of flexibility with his concept of "deliberate ambiguity," which champions the notion that architecture should remain open to interpretation and adaptable to diverse uses and meanings. Koolhaas's innovative design of the Seattle Central Library is a prime example, challenging conventional notions of library spaces by integrating technology, public engagement, and adaptable spaces that can be easily reconfigured for various functions. His approach aligns with the idea that architectural spaces must be responsive to the evolving demands of society, reflecting its dynamic nature.

Similarly, in the context of low-rise buildings, flexibility and adaptability are especially crucial due to their intimate scale and the diverse occupancy patterns they may support. Architect Elizabeth Plater-Zyberk, co-founder of the Congress for the New Urbanism, champions mixed-use development and compact, walkable neighborhoods as essential strategies to promote adaptability and resilience within urban environments. By integrating residential, commercial, and communal functions into a single framework, low-rise buildings can better serve the needs of their inhabitants while fostering vibrant, sustainable communities. This approach is exemplified in projects such as Seaside, Florida, where a blend of traditional neighborhood design and modern sustainability principles creates an environment that accommodates diverse lifestyles and promotes long-term

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community resilience.

Thus, the balance between order and flexibility, combined with the insights of architects like Gehry, Alexander, Koolhaas, and Plater-Zyberk, emphasizes the importance of adaptable designs that can respond to the changing needs of society while fostering a sense of permanence and identity. These principles not only influence the way spaces are designed but also shape the way communities interact with and inhabit them, ensuring their relevance and sustainability in the face of societal and environmental shifts.

5.3 Adaptable design elements

It is evident from the extensive body of work referenced above that both architects and theorists emphasize the critical role of flexibility and adaptability in architecture, particularly in the context of low-rise buildings. By embracing these principles, designers can create environments that are not only responsive to evolving needs but also adaptable to a diverse range of functions, ensuring their relevance and longevity over time. As the built environment continues to transform in response to demographic shifts, technological advancements, and environmental challenges, the ability to design flexible, adaptable spaces will remain paramount in shaping a resilient and inclusive urban landscape.

Moreover, scholars differentiate adaptability into two distinct dimensions: flexibility in architectural design, social function, and user needs, alongside flexibility in structural systems, technological components, and construction methods. This distinction is pivotal, as it allows architects to consider adaptability not solely from an aesthetic or functional perspective but also from technical and economic viewpoints, thereby ensuring that buildings can evolve in response to future demands without necessitating substantial additional resources. This multi-faceted approach to adaptability fosters more sustainable architectural solutions that can withstand the test of time.

The literature consistently supports the concept of adaptability facilitated by spatial overcapacity. As noted by Vandamme and Rinke (2023), the "loose fit" model promotes a larger floor area, with open-plan spaces free from permanent fixtures that allow for ease of conversion. By minimizing load-bearing walls and maximizing ceiling height, architects can create environments that offer abundant daylight and accommodate diverse uses, including the addition of intermediate floors. Structural typologies, such as short or wide spans and skeletal or massive structures, remain enduringly viable as they form the backbone of resilient buildings that can adapt to future needs.

By integrating these design principles, aligned with the foundational theories of adaptability and flexibility, low-rise apartment buildings in Lahore can better address the needs of their residents while enhancing overall quality of life. Various construction methods that allow for incremental changes through simple design alterations or renovations could facilitate additional interventions in a building as its users' needs evolve:

1. **Modular Expansion**: Rem Koolhaas' work, particularly his ideas on open-ended architecture and adaptability, exemplified in projects like the Seattle Central Library, provides a useful framework for modular expansion in low-rise buildings. In the context of Lahore, apartment buildings can be designed with the flexibility to incorporate additional floors or extensions as urban populations grow. Koolhaas' concept of adaptability could be implemented in Lahore's rapidly urbanizing areas, allowing buildings to expand both vertically and horizontally, thereby accommodating the increasing density without necessitating major structural overhauls.
2. **Merge & Divide**: Drawing from the work of Elizabeth Plater-Zyberk, particularly her advocacy for mixed-use development that promotes community engagement, the "Merge & Divide" concept could be effectively integrated into Lahore's low-rise apartments. In a culture where extended families are common, apartments could be designed with the flexibility to merge or divide spaces depending on family size and function. The compact, walkable neighborhoods championed by Plater-Zyberk would encourage the creation of shared spaces that evolve according to residents' needs, fostering a sense of community and resilience.
3. **Flexible Commons**: Christopher Alexander's "A Pattern Language" introduces the idea of designing environments that foster human interaction and well-being. This concept can be applied to Lahore's low-rise apartments through the integration of flexible, undefined communal spaces that could serve as social gathering points, play areas, or temporary workspaces. In Lahore's culturally rich context, where community bonds are strong, these spaces could be adapted to various social functions, echoing Alexander's emphasis on designing patterns that align with human behavior and social needs.
4. **Adjustable Partitions**: The concept of "Plan Libre," championed by Le Corbusier, where structural elements are decoupled from the interior design, can be adapted for Lahore's low-rise apartment buildings. Adjustable partitions would offer the flexibility to reconfigure spaces based on changing family needs, such as converting a

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living room into a guest area during extended family visits. This is particularly pertinent in Lahore, where extended family visits are frequent, and the need for space optimization is crucial.

5. **Retractable Elements**: Gerrit Rietveld's approach to flexible design, as demonstrated in the Rietveld Schröder House, provides valuable insight into the use of retractable elements. Low-rise apartments in Lahore could incorporate movable walls, foldable balconies, and retractable awnings, all of which would allow for versatile living environments that cater to the diverse needs of Pakistani families. This flexibility would enable residents to adapt their homes based on seasonal needs, occupancy levels, and lifestyle changes.
6. **Adaptable Space**: Inspired by Rem Koolhaas' concept of "deliberate ambiguity," which encourages flexible use of spaces, low-rise buildings in Lahore could incorporate adaptable rooms that serve multiple functions. A single room could serve as a living area, a study, or a bedroom, depending on the needs of the occupants. This design approach is especially relevant in Lahore's evolving urban lifestyle, where spaces must be multi-functional to accommodate changing living arrangements, work-from-home scenarios, and visiting guests.

By incorporating these adaptable design elements into low-rise apartment buildings in Lahore, architects can create environments that not only respond to the current needs of residents but also offer the flexibility to evolve as those needs change over time. Such design approaches are instrumental in enhancing the long-term resilience, functionality, and sustainability of urban housing.

6. FINDINGS, DISCUSSION AND CONCLUSION

The study highlights the critical importance of flexibility and adaptability in architectural design, particularly for low-rise apartment buildings. These principles are essential for addressing the evolving needs of urban populations and ensuring that spaces remain functional, inclusive, and relevant over time. Architects and theorists, such as Frank Gehry, Christopher Alexander, Rem Koolhaas, and Elizabeth Plater-Zyberk, emphasize the necessity of creating adaptable environments that reflect their time and place while maintaining a sense of timelessness. Flexibility in architecture allows for spaces that are responsive to changing societal needs and diverse occupancy patterns, ensuring resilience in the face of urbanization and shifting family dynamics.

An essential theme emerging from the findings is the interplay between order and flexibility. Structural order provides a stable framework that supports adaptability, enabling dynamic changes in function, use, and spatial configurations. The duality of these elements ensures that architecture remains both coherent and responsive. A solely ordered system risks sterility, while an entirely flexible one may devolve into chaos. Together, they create a harmonious balance that fosters growth and evolution. Examples such as Le Corbusier's "Plan Libre," which separates structural elements from interior spaces, highlight how this balance can be achieved.

Adaptability manifests on multiple scales, from macro-level concepts like modular expansion to micro-level interventions such as adjustable partitions and retractable elements. For instance, modular expansion, inspired by Koolhaas's work, allows low-rise buildings to accommodate vertical or horizontal growth, addressing the challenges of increasing urban density in cities like Lahore. On a smaller scale, flexible interior solutions such as movable walls or adaptable spaces enable user-driven modifications, providing immediate functionality to meet changing needs.

Cultural and contextual considerations are crucial in shaping adaptable designs. In Lahore, strong family bonds, community ties, and extended family living patterns necessitate culturally sensitive solutions. Concepts like "Merge & Divide" allow apartments to be combined for large families or divided as family sizes change. Similarly, "Flexible Commons," influenced by Alexander's ideas, can create shared spaces that foster social interaction and community engagement, resonating with Lahore's cultural emphasis on hospitality and interconnected living. By integrating these culturally relevant solutions, low-rise apartments can enhance social cohesion while meeting the demands of modern urban lifestyles.

Economic and sustainable benefits further underscore the value of adaptable design principles. Techniques such as "loose fit" designs, which provide spatial overcapacity and minimize permanent structures, reduce the need for extensive renovations, optimize material usage, and extend the lifecycle of buildings. Modular and flexible designs, with features like retractable elements and adjustable spaces, offer cost-effective solutions that allow buildings to evolve incrementally. This is particularly significant in Lahore, where affordability is a critical factor in housing development.

Adaptable and flexible designs also contribute to sustainable urban development by creating future-proof buildings. These designs align with global efforts to promote environmentally responsible architecture, as they accommodate multiple uses and future changes with minimal resource input. For example, open floor plans, high ceilings, and load-bearing structural systems allow for easy conversion and efficient reuse, ensuring long-

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term sustainability.
Despite the clear advantages, implementing adaptable design in Lahore faces challenges such as financial constraints, regulatory barriers, and resistance from developers. Addressing these obstacles will require policy support, community engagement, and greater awareness of the long-term benefits of adaptable architecture. By synthesizing cultural, economic, and architectural insights, adaptable design principles offer a pathway to creating resilient, inclusive, and sustainable housing solutions that can transform low-rise apartment living in Lahore and beyond.

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8. CONCLUSION

The COVID-19 pandemic has profoundly illuminated the challenges and opportunities within urban residential architecture, particularly in the context of low-rise apartment buildings in Lahore, Pakistan. This research explores the critical need for adaptability and quality of life in these structures, emphasizing the imperative for architectural practices to evolve to meet the demands of a post-pandemic world.
Traditional architectural principles, while foundational, have proven inadequate in addressing the dynamic requirements of contemporary urban living. The shift towards remote work and digital lifestyles necessitates a transformative approach to residential design, ensuring living spaces are flexible, adaptable, and conducive to both physical and mental well-being. This study identifies significant shortcomings in current low-rise apartment buildings in Lahore, including poor ventilation, insufficient natural light, low ceiling heights, and a lack of green spaces. These deficiencies have been exacerbated by the pandemic, with extended periods of home confinement revealing the adverse effects on residents' health and well-being.
An analysis of Lahore's existing low-rise apartment conditions underscores the urgent need for design innovation. Many of these buildings lack the elements necessary to support adaptability and connectivity with nature, creating environments ill-suited to the evolving needs of their inhabitants. The absence of flexibility in spatial design and insufficient integration of natural elements highlight a critical gap in current architectural practices, adversely affecting residents' physical, mental, and emotional health.
Drawing on architectural theories and practices, this research advocates for the incorporation of adaptable and flexible design principles in residential architecture. Concepts such as Habraken's 'Supports' and Le Corbusier's 'Domino House' offer valuable frameworks for creating residential spaces that accommodate diverse functions and future modifications. These principles emphasize open floor plans, higher ceilings, and modular systems that allow easy reconfiguration and personalization. Such strategies are essential for transforming static living spaces into dynamic environments that cater to the changing needs of their occupants.
The integration of green spaces and natural elements emerges as a critical factor in enhancing residents' quality of life. The absence of greenery in many of Lahore's low-rise apartment buildings deprives residents of essential opportunities for relaxation, recreation, and connection with nature—elements that are indispensable for mental and emotional well-being. Innovative design strategies that prioritize sustainability, cultural inclusion, and functionality can address these shortcomings, creating healthier, more vibrant living environments.
The findings of this research call for a paradigm shift in the architectural approach to low-rise apartment buildings in Lahore. A holistic perspective is needed—one that considers the socio-economic and cultural contexts of residents while addressing the environmental and psychological impacts of the built environment. By prioritizing adaptable design principles, architects and urban planners can craft residential spaces that respond to the immediate demands of the post-pandemic era and promote long-term resilience and well-being.
In conclusion, the future of urban living in Lahore depends on embracing adaptability and flexibility in architectural design. The lessons from the pandemic must inform the creation of residential buildings that support diverse lifestyles and foster holistic health. This research lays a foundation for reimagining urban

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living, offering a blueprint for designing low-rise apartment buildings that are sustainable, functional, and attuned to the evolving needs of their inhabitants. By adopting these principles, we can pave the way for a more resilient, vibrant, and inclusive urban future in Lahore and beyond.

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