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Research Article

INFLUENCE OF DESIGN ON THE ADAPTABILITY OF BUILDINGS: A CASE OF THE CITY OF NAIROBI, KENYA

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ABSTRACT

This study investigated the design and adaptability of civic buildings considering the challenge of static architecture and resultant building obsolescence occasioned by human and environmentally induced change. Static architecture escalates the life-cycle environmental impacts resulting from increased resource consumption, building material production, and demolition wastes. Contemporary sustainability standards emphasize energy-efficient structures and updating existing building stocks. The study explored the concepts of building adaptation, layers that conceptualize the building and link time and material form, adaptability for sustainability, design for disassembly, and obsolescence. Examined here too were the strategies on spatial organization, structural configuration, redundancy, upgradability of building services, and adjustability of the building envelope, that optimize building adaptability. Case studies were probed using environmental behavior research methods of observation and tracing effects of after-use with pre-coded checklists to determine how the original design had affected the adaptability of the buildings over time. Other buildings were reviewed through library research and analysis of archival information. Respondent opinions on fundamental aspects of building design, building use adaptability, and its relationship to design were obtained using structured interview guides. This research demonstrated that design choices on spatial organization (loose fit spaces or multifunctional spaces, structural configuration, building services, and envelope) influenced adaptability of buildings.

Keywords: Adaptability, Redundancy, Upgradability, Adjustability, Obsolescence.

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INTRODUCTION

Buildings account for 40–50% of global energy consumption, primarily allocated to heating, cooling, lighting, and powering appliances during their life cycle (Hui and Cheng, 2008; Gan *et.al*., 2017, 2019; Tobias and Vavaroutsos, 2009, Yudelson, 2010; Cheng *et al*., 2021). As a result, there is an increasing emphasis on creating energy-efficient structures and updating existing building stocks to meet contemporary standards of sustainability (Ching, 2014, 2021; Ching and Adams, 2021; UNEP, 2007; World Economic Forum, 2024). However, approximately 10–20% of energy usage pertains to embodied energy from mining, manufacturing, transportation, and construction, a percentage that escalates when the building's lifespan is short (Hui and Cheng, 2008; Gan *et.al*., 2017, 2019; Cheng *et.al*., 2021; Takva *et al*., 2023).

In the United States, it has been reported that for every four commercial buildings erected, one is demolished prematurely, and for every six houses constructed, one is demolished. This demolition process incurs significant costs and environmental implications, with higher energy impacts compared to adaptive building reuse. Yudelson (2010) suggests that by 2040, 75% of the buildings in operation will either be existing structures or adaptively reused/renovated. Consequently, upgrading current buildings to achieve substantial reductions in greenhouse gas emissions is viewed as a more immediate and environmentally friendly strategy compared to constructing new energy-efficient buildings (Tobias and Vavaroutsos, 2009; TEC, 2008). Considering embodied energy, Jacobs (1993) argues that the most environmentally friendly buildings are the ones already in existence.

Africa has not been left behind when it comes to adaptive reuse of buildings. Showcasing the continent's commitment to preserving cultural heritage and promoting sustainable development are adaptive reuse projects for example in Egypt, with the transformation of the 12th century Al-Darb al-Ahmar district in Cairo into a cultural and artistic hub (Gillian *et al*., 2023). There is also the conversion of the Grain Silo Complex in Cape Town, South Africa, into the Zeitz Museum of Contemporary Art Africa. Locally, through the years there has been an increasing trend of demolishing aged structures in Nairobi to make way for modern edifices which threaten the city's cultural and historical richness (Mohammad *et al*., 2023). One such example is Nairobi House, the city's first three-story building situated at the intersection of Moi and Kenyatta Avenue in the Central Business District (CBD). Regrettably, this historically significant structure was lost due to demolition, unable to adapt to the evolving needs brought about by human and environmental changes. This pattern extends beyond Nairobi's CBD, as numerous art deco houses in such areas such as Parklands, Biashara Street, and Ngara have also met a similar fate, being demolished to make room for skyscrapers.

There are, however, a few success cases where some structures have stood the test of time. A case in point is Kipande House, a 1913 structure used then for issuing identity cards -IDs (Vipande with Kipande as the singular term for an ID) that was renovated to a banking hall for the Kenya Commercial Bank. Opposite this stands the old Provincial Commissioner's office that was transformed into a Nairobi Gallery. A third example is the Kenya National Archives building which used to be a banking hall. Finally, there is the Westminster House a former colonial lodge that was converted to a banking hall and then into a restaurant space. Such buildings underscore the potential of adaptive reuse in preserving heritage and enhancing sustainability (Fava, 2024; Gillian *et al*., 2023; Aytac *et al*., 2016; Fournier and Zimnicki, 2004).

Problem statement

Re-purposing existing structures to revitalize outdated buildings without unwarranted early demolition is a widely acknowledged approach known as adaptive re-use (World Economic Forum 2024; Takva *et al*., 2023; Conejos *et al*., 2011; Conejos *et al*., 2013). It is universally recognized as a practice of sustainable development.

Although a substantial body of knowledge exists on this subject there is scanty information regarding suitable design criteria for maximizing the potential for future adaptive re-use in new construction works. Simply put, adaptive reuse is confronted with the prospect of "*designing for a future we don't know yet, needs we don't have now, and technical possibilities that we are yet to discover*." (ibid).

This study aims to address the challenge of static/rigid architecture that has resulted in building obsolescence when faced with human and environmentally induced change. This obsoleteness is clearly evident through suboptimal performance and premature demolitions of structures. What results is an increase in the life-cycle environmental impacts on resource consumption, building material production, and demolition wastes. It explores ways to increase the adaptability of buildings to keep buildings and building materials in productive use longer. It pursues integration of emerging technologies while absorbing design advancements as they emerge. This thereby reduces the life-cycle environmental impacts of buildings (Mohammad *et al*., 2023; Gillian *et al*., 2023; Rand *et al*., 2021; Gorse and Highfield, 2009; Aytac *et al*., 2016; Blakstad, 2001; Boyd and Jankovic, 1992). The research specifically addresses civic buildings In Kenya. Lessons from this research can be applied to other contexts due to the overarching theme dealt with here. This is the sensitive alteration of built structures to conform to an evolving environment and also to our changing needs.

The research is significant locally because old buildings in Nairobi that are not adaptable are increasingly being demolished to pave way for gleaming new structures. This will eventually result to the city losing its richness in esthetics and heritage. Further, it experiences a drastic surge in the life-cycle environmental impacts intimated above (Mohammad *et al*., 2023; Gillian *et al*., 2023).

Study objectives

In the context of a heightened emphasis on sustainability and mitigation of climate change, the imperative for stakeholders in the built environment to make well-informed, clear decisions concerning future development is emphasized (Langston, 2013; Langston *et al*., 2013; Langston and Smith, 2010; Langston *et al*., 2008, Langston and Shen, 2007; Manewa *et al*., 2013; Lehmann, 2012). The importance of this research lies in enabling building designers to make pivotal design choices that facilitate the resolution of practical challenges. Such challenges concern sustainability and resilience. They also include concerns for evolving spatial requirements, efficient resource utilization, and economic feasibility. Anchoring all these is an ongoing adaptation to the changing technological, social, and cultural aspects of a society (Tobolczyk, 2021; Blakstad, 2001; Gillian *et al*., 2023; Watts, 2005). The research is also timely as it comes in on the backdrop of various demolitions within Nairobi, Kenya where there has been an increasing trend of demolishing aged structures that are erroneously perceived not to be adaptable to make way for modern structures. This trend threatens the city's cultural and historical richness while promoting a rise in the life-cycle environmental impacts on resource consumption, building material production, and demolition wastes (World Economic Forum, 2024; Gillian *et al*., 2023).

While previous research has touched upon aspects of design and adaptability, there remains a notable gap in the literature concerning a cohesive and systematic examination of the intricate ways in which design principles influence the adaptability of spaces. This inquiry aims to bridge this gap by providing a nuanced exploration that goes beyond superficial considerations, delving into the theoretical underpinnings of this relationship (Estaji, 2017; Geraedts *et al*., 2014, Geraedts, 2008; Gosling *et al*., 2008; Jones, 2008). The inquiry intends to contribute significantly to research methodology by advocating for a multi-dimensional approach. By employing qualitative methods, including case studies, user surveys, and architectural analyses, the study aims to generate a rich dataset. This diverse methodological approach will enable a holistic understanding of the multifaceted dynamics of design and adaptability, providing a more comprehensive foundation for theory-building (Gillian *et al*., 2023; Aytac *et al*., 2016; Conejos *et al*., 2013; Conejos *et al*., 2011). As an outcome of this inquiry, the theoretical framework that is developed has the capacity to support generalization. The identification of overarching principles governing the impact of design on adaptability could contribute to the creation of universally applicable guidelines. Such guidelines could be valuable not only for architects and designers but also for policymakers, urban planners, and other stakeholders involved in shaping the built environment (Douglas, 2006; Friedman, 2002; Friedman, 2002; Gardner, 1993).

The main aim of this research is to improve environmental sustainability in building design by developing design instruments that would guide deliberate choices during the initial design phase of buildings in a way that would enable future adaptive reuse of buildings. Such instruments would therefore essentially incorporate re-usability of buildings as a fundamental design principle (Mohammad *et al*., 2023; Gillian *et al*., 2023; Rand *et al*., 2021; Aytac *et al*., 2016; Blakstad, 2001).

Specific objectives

1. To delineate the fundamental aspects of building design
2. To identify the forms of adaptability in the use of buildings
3. To determine the relationship of design to adaptability of buildings.

Primary research questions on design

1. What are the basic spatial, structural, services, materials, fenestrations, façade, and form elements of building design?
2. What are the available approaches to building design?
3. How is the process of building design sequenced?

Primary research questions on adaptability

1. What are the various aspects and elements of adaptability of buildings?

Theoretical framework

Explored here is design and adaptability, delving into how buildings are designed and how they accommodate change it explores ways to enhance adaptability by examining various parameters (Fava, 2024; Gillian *et al*., 2023; Mohammad *et al*., 2023; Aytac *et al*., 2016; Schmidt *et al*., 2011). While adaptability is defined in diverse ways, a common theme is the building's capacity to respond to and accommodate change, whether focused on user needs or broader criteria like market conditions.

To infuse adaptability into building design, the general approach involves over-specifying mechanical and electrical plant sizing, floor area provision, and structural elements (Nageim *et al*., 2010; Finch, 2009; Ellison and Sayce, 2007; Millais, 1997). This is coupled with the identification of physical aspects such as material durability, span depth, and floor-to-floor height) and specific technical solutions such as moveable partitions, drop ceilings, raised floors) (Schmidt *et al*., 2011; Fuster *et al*., 2009; Karlen, 2009; Kincaid, 2002). In addition, understanding the building's configuration and the interactions between its components sheds light on how it will endure change (Mohammad *et al*., 2023; Schmidt *et al*., 2011). The concept of layers is introduced as a way to conceptualize the building, linking time and material form, with components viewed as different "layers" of longevity (Duffy, 1990). Brand (2022) further expands this concept, categorizing the total building into different layers of lifespan (Blackwell, 2024) Table 1.

Schmidt *et al*. (2011) elaborate on the layers concept by associating them with six distinct strategies or categories of changes for considering adaptability Table 2. This offers a more holistic understanding of how buildings transform over time, without attempting to forecast specific outcomes for buildings. Instead, it establishes connections between different types of changes and the frequency and areas in which they are likely to occur.

From the literature review, it is clearly evident that the approach to adaptability should move beyond a uniform solution and be tailored to its inherent complexity (Fava, 2024; Gillian *et al*., 2023; Aytac *et al*., 2016; Aytac *et al*., 2024). Valuable lessons can and should be gleaned from the entire building stock, contributing to continual refinement in the design of adaptable buildings in the future. The limited number of concepts addressed by the majority of sources underscores the absence of a comprehensive framework or synthesized approach for implementing adaptability. With only a few exceptions, the literature generally does not explicitly establish a holistic framework for adaptability. This observation reflects an identified gap prevalent throughout the literature.

METHODS

Research design

The environmental behavior research methodology that utilized observation of behavior research methods and observation of physical traces techniques through pre-coded checklists, photographs, and sketches were applied to well-selected case studies. These were brought to bear here was to explore insights regarding the influence of design on the adaptability of buildings, in a comprehensive exploration of complex, context-specific factors that may otherwise not be easily quantifiable.

Target population

The target population here comprised of key informants in the specific complement of professionals that oversight design, delivery and use of buildings complemented by the particular cluster or type of buildings selected for study here (Burns and Grove, 1997). The value of their selection is explained here below in brief.

Civic buildings

Buildings of public use and significance within the city of Nairobi. These may cover the range of public functions that embrace administration, education, and even recreation.

Building managers

Building managers are charged with the responsibility to ensure that the needs of tenants are met. They are therefore well-equipped to understand the potential obstacles in fulfilling these requirements. They fit in well in the target population. The selected property managers to act as respondents were those responsible for the surveyed buildings.

Building users

The term building users here refers to the individuals residing in or using the adaptively reused structures in any other formal regular manner. They are a critical component of the target group as they have practical experiential insights on the performance of the buildings. They served as well as an essential cluster of respondents.

Architects

Architects play a pivotal role in the design of buildings. Their perspectives on the adaptability of conventional designs were crucial in evaluating how well structures met the past needs and how they could meet the present and future requirements of the occupants. They are a crucial set of respondents for this study.

The Board of Registration of Architects and Quantity Surveyors mandates that all architectural and quantity-surveying firms seeking practice be registered not only with the Registrar of Companies but also with the Board. Consequently, the Board could competently supply an exhaustive list of consulting firms in the country, making it easy to reach them. As of November 2023, the board had 207 registered architectural firms.

Sample frame

The sampling frame for this study was adaptively reused buildings within Nairobi because this provided more meaningful insights into the relationship between design and adaptability.

Sample size and sample technique

Buildings known for their adaptability were selected as case studies for in-depth study, as they contained good, detailed information that was most relevant to the study research questions.

Data collection techniques and tools

For this study, data collection techniques included individual and focused interviews, observation, and building performance assessments.

Data collection tools that supported observation

Photographs

Photographs were used to record the physical environment and other features that were left out during observation. Photographs are very accurate, and their use avoided going back to the site of the case study by picking out things and areas of interest for the study.

Drawings and sketches

These were used where taking of photographs was prohibited, for instance, due to security concerns.

Observation checklist

This involved checking off and filling a prepared list of features documented and important to the study. This was used for the comparative analysis.

Data collection tools that guided interviews

Questionnaires/structured interview schedules – tools

The questionnaires were primarily self-administered and only complemented with guided interviews where this failed. They targeted the following groups of respondents:

a. Building users
b. Property managers/building owners
c. Architects

Questionnaire/structured interview schedule format

The questionnaires included both open-ended and closed-ended questions. Closed-ended or structured questions were used for common aspects, allowing respondents to tick relevant options. This approach facilitated ease of response and a more user-friendly experience. Open-ended questions aimed to gather unique data specific to each case under study, ensuring respondents were not limited in their perspectives and enriching the collected data.

Questionnaire/structured interview schedule administration

Both self-administered and researcher-administered questionnaires were used. While respondents filled and returned self-administered questionnaires, this method faced challenges in busy establishments. Consequently, researcher-administered questionnaires were employed to boost the response rate in such cases. These data collection instruments (techniques and tools) were used in complementarity to gather data in the several ways that are illustrated here below.

Flexibility of use

This refers to the ability of a building to be repurposed or reconfigured for different uses over time without substantial structural modifications. Individual and focused group interviews were carried out guided by structured interview schedules that were administered on building users and stakeholders to understand their perspectives on the ease of adapting the building for different purposes. These same data collection techniques and tools were also used to assess the various building layouts and designs to determine if they allowed for easy reconfiguration without extensive modifications.

Pertinent research questions that were probed here included:

a. Where could expansion or modifications be made?
b. Could the current layout allow for the integration of new components or the removal of existing ones without major disruptions to the functionality of the buildings?

Scalability and modularity

The interest here was to assess whether the buildings could easily accommodate expansion or be scaled up or down as needed, without significant disruptions or changes to the core structure. Structured interview schedules administered to individual respondents, pre-coded checklists, annotated sketches, photographs, and drawings were used here to review the building's design plans and construction materials to assess the potential for expansion or adaptation. These served well to evaluate the modularity of building components and analyze how they could be modified or replaced to accommodate changes.

Interrogated here were the following research questions:
a. What were the areas where expansion or downsizing could occur?
b. How could the building envelope be modified or adapted to accommodate changes in scale?
c. What were the constraints of the local building codes, regulations, and zoning requirements regarding expansions or downsizing?

Structural resilience

Of interest here was the evaluation of how well the buildings could withstand changes in environmental conditions or external forces, such as natural disasters or technological advancements, without compromising their overall integrity. Interviews guided by structured interview schedules with individual consulting structural engineers were carried out to evaluate the resilience of buildings to various environmental factors and stressors. This assisted in assessing the durability of the materials used in the construction and understanding how they contributed to the overall resilience of buildings.

Research questions that were pursued here included:
a. Could the foundation and footprint of the buildings support additional loads?
b. Could the foundations be extended or incorporate new structural supports to accommodate expansion without compromising the stability or structural integrity of the buildings?
c. Was the load-bearing capacity of the foundation, walls, and roof, as well as the overall stability of the structure sufficient?
d. Were the materials used for construction of sufficient performance in strength and durability?

Technological integration

The interest here was to examine the capacity of buildings to integrate new technologies and systems seamlessly, enabling them to adapt to emerging trends and advancements. Drawings and designs as well as observations on the actual buildings were used to review the technology and infrastructure of buildings while also assessing their compatibility with emerging technologies. Furthermore, evaluated was the adaptability of the building systems to integrate new technological advancements without significant structural changes.

The following secondary research questions were looked into here:
a. What were the current technology systems implemented within the buildings, including communication networks, security systems, and automation features?
b. Were these technologies installed efficiently?
c. Could the existing technology infrastructure be scaled up or upgraded to accommodate the integration of new technologies without the need for substantial structural modifications?

Accessibility and universal design

Ventured here was the assessment of whether the buildings were designed to be accessible to individuals with diverse needs, ensuring that they could adapt to the requirements of different users, including those with disabilities. Accessibility audits to evaluate the building's compliance with accessibility standards were conducted here through critical observation-led reviews of the actual buildings and their design drawings. Assessed here were the layout features, and amenities to determine their usability for individuals with diverse needs.

Table 1: Building layers and time

Layer	Description	Timescale
Site	Geographic setting of building	Eternal
Structure	The load-bearing elements including foundations	30–300 years
Skin	The exterior surfaces provide a weather-protecting layer	20 years
Services	The working guts of a building – HVAC, electrical, plumbing, sprinklers, etc.	7–15 years
Space Plan	The internal layout – internal partitions, doors, etc.	3–30 years
Stuff	Furniture, equipment, personal positions of occupants	Daily

Source: Njuguna, 2024, adapted from Brand , 2022.

Table 2: Adaptable strategies and layers (adapted from Schmidt *et al.* 2011)

Strategy	Type of change	Building layer (s)	Frequency of change
Adjustable	Change of task	Stuff	High
Versatile	Change of space	Stuff, Space	High
Refitable	Change of performance	Space, Services, Skin	Moderate
Convertible	Change of function	Space, Services, Skin	Moderate
Scalable	Change of size	Space, Services, Skin, Structure	Moderate/low

Source: Njuguna, 2024, adapted from Schmidt *et al*., 2011

The following secondary research questions were examined here:
a. Were the building's layouts, volumes, services, utilities, lighting, acoustics, signage, wayfinding, and circulation well adapted to emerging user accessibility needs?

RESULTS AND DISCUSSION

The survey of Architects revealed that a majority of them (68.8%) felt that design was a central aspect of adaptability (Fig. 1). The findings here further revealed critical insights into the relationship between design choices and the ability of buildings to adapt to changing needs over time.

By examining various design elements, spatial configurations, and technological integration, the study highlighted the value of foresight in design for creating flexible and resilient structures. The adaptability of buildings emerged as a multifaceted concept, encompassing not only physical flexibility but also the incorporation of sustainable materials, smart technologies, and user-centric design principles.

It is clearly evident that certain adjustments to the building designs (spatial configuration, structural systems, services, and envelope) greatly affected how adaptable a building was (Tables 3-6).

About two-thirds (62.5%) of the Architects surveyed in the city of Nairobi confirmed their preference for the Plug and play elements of design as effective influences for the adaptability of buildings (Fig. 3). This inclination of the architects should ably then address the prevailing status of buildings in the city. At present, there were few buildings that were intentionally designed for adaptability and proven to withstand the test of time. Traditionally, designers and owners had operated under the assumption that their buildings would not undergo significant changes.

Even when the inevitability of change was recognized, there was little market incentive for developers and owners to invest in long-

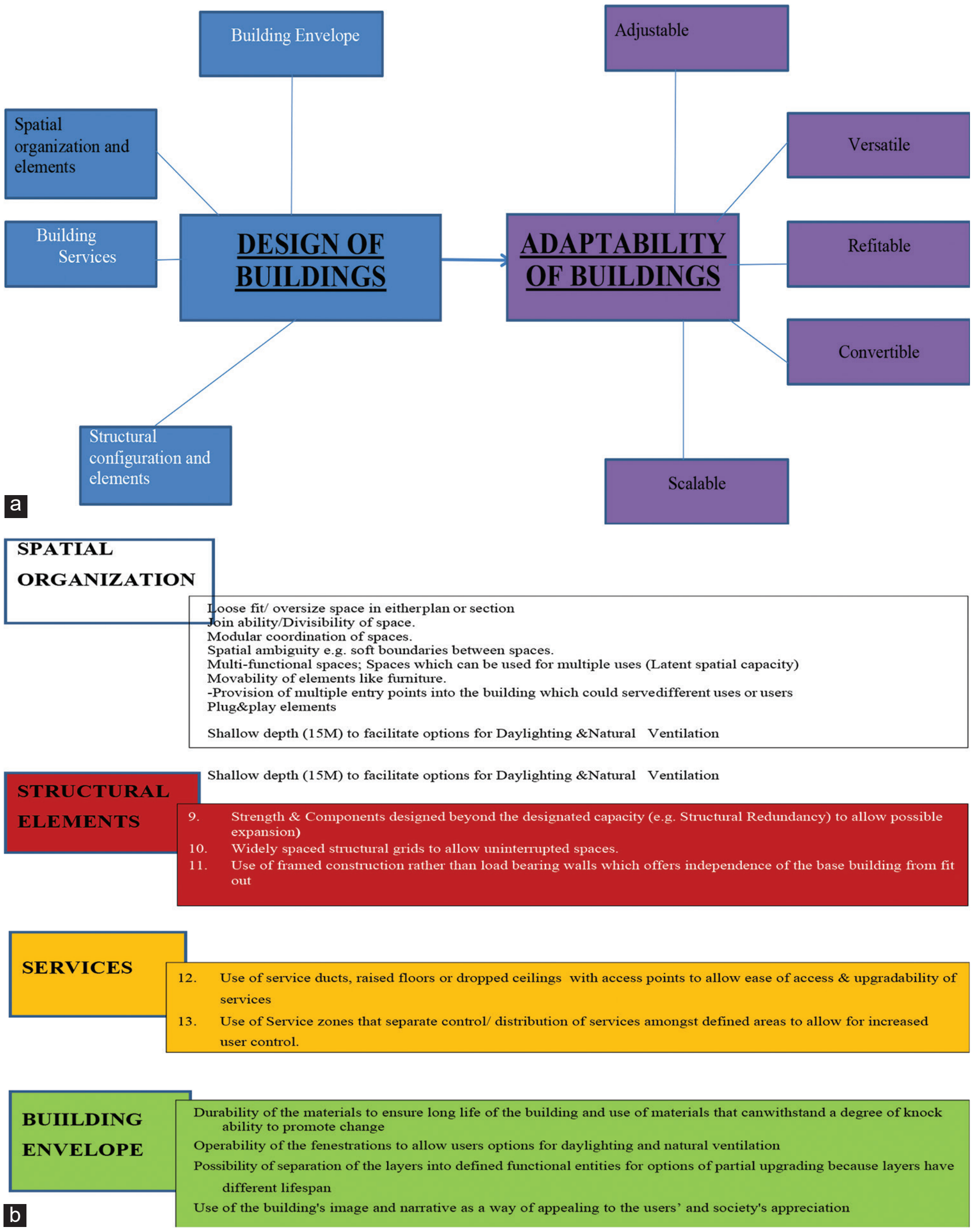

Fig. 1: (a) Conceptual framework, (b) Attributes of building design elements. Source: Njuguna, 2024

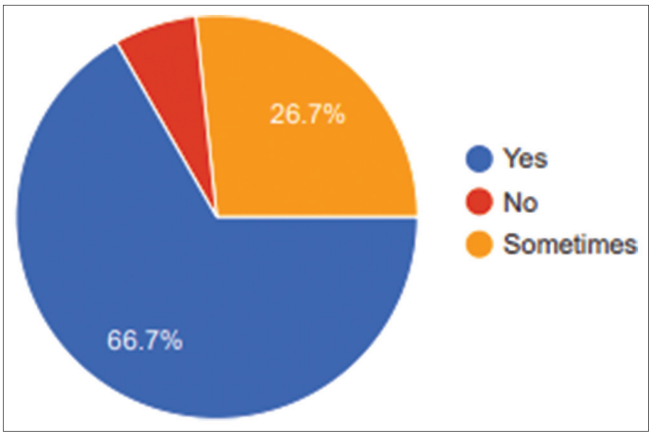

Fig. 2: Expert opinion of architects regarding the influence of design on building adaptability. Source: Njuguna, 2024, field data

term adaptability. Initial investments in more adaptable building structures often did not yield immediate economic benefits, making it uncommon to find older buildings purposefully designed for adaptability. A considerable 87.5% of the architects surveyed in the city favored the user control parameters as useful influences to ensure the adaptability of buildings (Fig. 4). An overwhelming majority (93.75%) of the architects surveyed in the city were satisfied that the non-fixed objects design parameters were effective influences to bring into play to positively influence the adaptability of buildings (Fig. 5).

Detachable connections, operable elements, movable walls

The design parameters of detachable connections were moderately popular instruments with the architects surveyed for inducing adaptability in buildings. They were rated by 87.25% of the architects to be moderate, higher moderate, and high on impact in this regard (Fig. 6). On their part, the operable elements and movable walls as design parameters were considered moderately, higher moderately,

Table 3: Case study observations on aspects of spatial organization in buildings

S. No.	Aspects of spatial organization that influence building adaptability	Character of variable	Local case study observations	
			Westminster house	Kenya national archives
1	Loose fit/oversize space	Spaces that are sized larger than the standard or functional necessity in either plan or section/not designed to a particular typology standard	Because the building was modified from being a dilapidated colonial lodge to bank premises Most of the floor spaces are large and open areas which can be adapted for various purposes over time without major structural changes this has provided the tenants with the freedom to configure their spaces according to their specific requirements, resulting in the spaces with generous floor space fostering tenant adaptability	Considering its initial use was a bank and current use is a national archive a typology that mostly has sizes that are a bit bigger and spaces that are open. There are spaces for example the ground floor display gallery, The library and the multifunctional space which have larger than normal space that makes the spaces easily adaptable
2	Joinability/ Divisibility of space	Space (s) which can be joined together or divided into smaller individual spaces to support multiple spatial configurations including possibility of multiple tenure	The building has spaces that can be easily joined together offering flexibility in function. For example, the areas in the first and second floor hosting the restaurant have a large open space with support spaces on its periphery which can be joined or divided and can be adapted for various purposes, such as collaborative workspaces, events, or different activities and currently allows the tenants to host different events like art festivals and jazz concerts and are adaptable for events of varying sizes. Divisible spaces within the building provide privacy and focus for example for the support spaces like the offices which are smaller units that allow for concentrated work or confidential meetings. Divisible spaces on the ground floor have enabled multi-tenancy with different shopfronts facing Kenyatta Avenue and Standard Street	The spaces on the side of the display gallery can be joined to form one space if need be. The user of the spaces can also interchange offices because there are a variety of same sized rooms.
3	Modular coordination of spaces	Spatial coordination between systems within a building which have physical consequences	Not implemented in the project	Not implemented in the project
4	Spatial ambiguity	Blurring of boundaries between interior/ exterior uses through soft boundaries	The design and configuration of some spaces within the building are intentionally left open-ended or flexible. This design approach allows for multiple interpretations and uses of the space, providing a degree of openness this can be seen in the ground floor units of the building that have adopted glass walls that blurs the boundary between the inside and the outside which also functions as a marketing strategy	Masonry walls separate interior and exterior spaces around the building thus no soft boundaries.
5	Multi-functional spaces	Space that can be used for various functions/uses (latent spatial capacity)	The building has multi-functional spaces that are designed to serve various purposes, allowing for versatile use. For example, the large and open design of the first and second floor that was being used as a banking hall then turned into dining spaces for the current tenant could easily transform into a collaborative workspace, art display or performance space showcasing the flexibility inherent in the design as evidenced by the space being turned to an art show at times and also hosting jazz events within the space by the current tenant	The display space, the library and the multiuse hall are the only spaces that are multi-functional and that allow for diverse uses within the same area.
6	Movable elements	Furniture; equipment, etc., that can be freely moved throughout the space/ building	The space has movable elements, such as partitions and furniture which contribute to adaptability by enabling the easy reconfiguration of spaces, the bar is the only thing that will be dismantled if there needs to be an immediate change in use, the planter boxes can also be move around	Kenya national archives does not have fixed furniture all the furniture and display cases and items are movable which contributes to adaptability by allowing quick reconfiguration of spaces. Facilitating easy adjustments to the layout based on changing requirements. Especially in display areas

(*Contd*...)

Table 3: (*Continued*)

S. No.	Aspects of spatial organization that influence building adaptability	Character of variable	Local case study observations	
			Westminster house	Kenya national archives
7	Multiple access points with option for isolatable spaces	Provision of multiple entry points into the building that gives the option for serving different uses or users; a section of the building which can function in separation from the rest of the building	The Westminster House has two access points one facing the Kenyatta Avenue and the other facing standard street with several access to the ground floor spaces the design of this access points has allowed for example the space hosting the offices and break room can be annexed and sublet the same space can also be merged to one space if need be. The spaces in the first floor seem to be designed to accommodate a wide array of activities It is also notable that the ground floor spaces with several access on both sides facing Kenyatta Avenue and Standard Street have led to having spaces for multitenancy	The building has two access points and can therefore have the ability to create isolatable spaces a feature that enhances its adaptability providing options for controlled access and creating separate zones.
8	Plug-and-play elements	Elements which can be easily added or removed without a marked disruption allow different use of spaces	Not implemented in the project	Not implemented in the project

Source: Njuguna, 2024, from field data

Table 4: Case study observations on aspects of structural configuration

S. No.	Aspects of structural configuration that influence building adaptability	Character of variable	Local case study observations	
			Westminster house	Kenya national archives
1	Over design capacity	Structural Strength and Components designed beyond the designated capacity (e.g. Structural Redundancy) to allow possible expansion	Even though the expansion capabilities of the Westminster House has not been tested, and modifications cannot be done with respect to the building being a conservation structure the buildings structure has withstood varied user occupancy as the building changed use without need for intervention on its structural systems.	Kenya National archives was designed with overdesign capacity that allowed for modifications like IN 1960 Cobb and Archers architects vertically extended the building which was done to accommodate user needs as it changed ownership Bank of India to Kenya commercial bank.
2	Uniform and/or wide structural grid	Space (s) which can be joined together or divided into smaller individual spaces to support multiple spatial configurations including possibility of multiple tenure.	A uniform structural grid in the building's structural layout. This design choice has enhanced adaptability by providing flexibility in interior configurations. Spaces can be easily adapted or subdivided without being constrained by a rigid structural grid.	The building uses a wide structural grid enhancing its adaptability by providing a flexible framework for interior layouts. This design also has allowed for varied spatial configurations over time and modifications without significant structural constraints. The structure has a 4m x4m structural grid in most instances which doesn't limit flexibility much with a few projections in the form that complicate the form
3	Choice of structural system	Use of framed construction rather than load bearing walls which offers independence of the base building from fit out	The Westminster house used a concrete framed construction with columns and beams for bearing all the loads thereby making it easy to bring down any interior walls for modifications	Kenya National Archives building has columns and beams for bearing the loads (Concrete framed)

Source: Njuguna, 2024, field data

and highly effective contributors to the adaptability of buildings by 93.75% of the architects surveyed in the County City of Nairobi, in both instances (Figs. 7 and 8).

They registered a mode observation of higher moderate for operable elements with a 37.5% frequency of occurrence and a mode observation of the moderate, higher moderate, and high levels of impact on building

Table 5: Case study observations of aspects of building services in buildings

S. No.	Aspects of building services that influence building adaptability	Character of variable	Local case study observations	
			Westminster house	Kenya national archives
1	Service ducts/raised floors/dropped ceilings space	Use of service ducts, raised floors or dropped ceilings with access points to allow ease of access and upgradability of services	The building has used Service ducts and raised floors to provide organized pathways for building utilities. These features have enhanced adaptability by allowing easy access to and modification of essential systems such as electrical, plumbing, and HVAC without the need for major structural interventions	Kenya National archives has Service ducts for HVAC Systems and fire risers it also utilizes dropped ceilings to provide organized pathways for utilities. These features enhance adaptability by allowing easy access to these services
2	Service zones	Use of Service zones that separate control/distribution of services amongst defined areas to allow for increased user control	Service zones with control by different tenants have been incorporated and this has enhanced its adaptability by providing a clear framework for the installation, maintenance, and modification of utility systems. This has also ensured that changes in technology or usage are efficiently accommodated without disrupting the entire building.	The building has grouped wet areas with water supply on the rooftop and services like the stairs and lift are within one region. Electrical services are concealed above the ceiling

Source: Njuguna, 2024, field dat

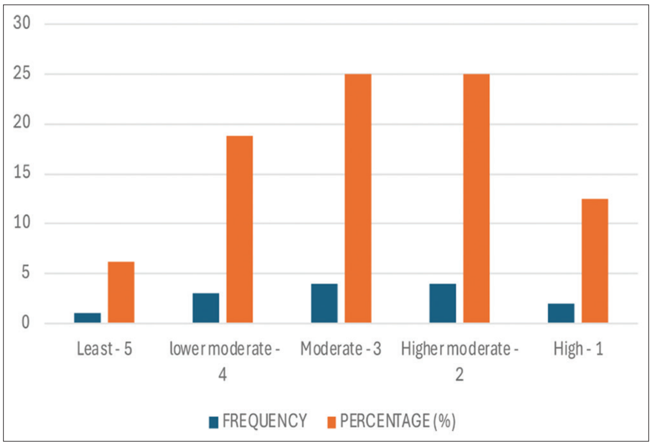

Fig. 3: Rating of the influence of the plug-and-play design parameters on the adaptability of buildings. Source: Njuguna, 2024, field data

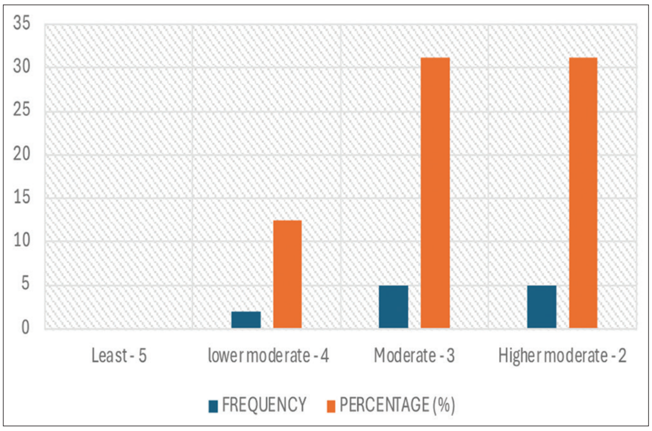

Fig. 4: Rating of the influence of the user control design parameters on the adaptability of buildings. Source: Njuguna, 2024, field data

adaptability with a 31.25% frequency of occurrence for all three levels of impact (Fig. 7).

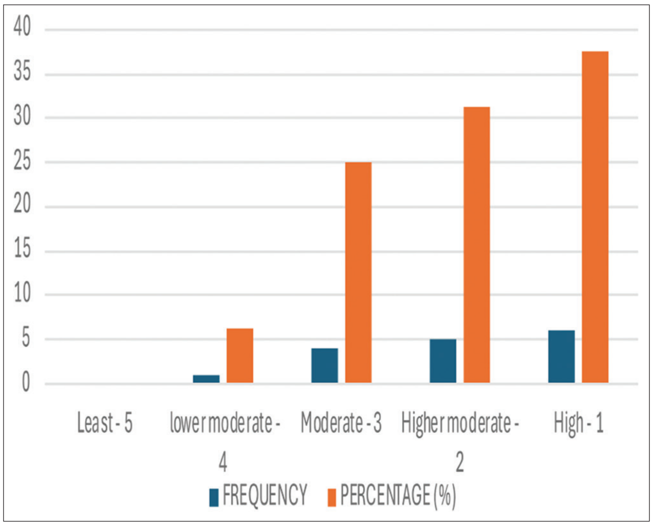

Fig. 5: Rating of the influence of non-fixed objects design parameters on the adaptability of buildings. Source: Njuguna, 2024, field data

Variety of room sizes, corridor widths, frame construction

Designing spaces with a variety of room sizes and use of frame construction were both very popular strategies with architects registering a considerably favorable rating of 93.75% for the moderate, higher moderate, and high levels of impact on the adaptability of buildings (Figs. 9 and 11).

Provision of wide corridors was thought to be an effective design instrument for imbuing adaptability in buildings by a slightly lower proportion (87.5%) of the architects surveyed (Fig. 10).

Flexible ducts, storage spaces, structural redundancy

Architects registered a notable preference for the use of flexible ducts to attain adaptability in buildings. To this extent, 93.75% (50% moderate and 43.75% high levels of impact) of entered a verdict in favor of flexible ducts as design parameters of value (Fig. 12). Interestingly though the mode occurrence was set at moderate impact (at a 50% frequency) with higher moderate a close second (at a 43.75% frequency) in a situation where non-architects rated

Table 6: Case study observations of aspects of the building envelope

S. No.	Aspects of the building envelope that influence building adaptability	Character of variable	Local case study observations	
			Westminster house	Kenya national archives
1	Materials durability and knockability	Durability of the materials to ensure long life of the building and use of materials that can withstand a degree of knock ability to promote change	Durable materials, capable of withstanding wear and tear over time, were used contributing to the longevity of the building. (Stone, Concrete, and Steel) However, adaptability also requires the ease of modification. Materials that are "knock able," meaning they can be easily altered or replaced without excessive effort or cost, enhance adaptability. This combination has allowed for structural resilience while accommodating changes as needed. The building nearing 100 years with the only changes that have been done being roof, flooring and services is testament of its durability.	The building used Durable materials like stone and Concrete which have enhanced its longevity and reduced the need for frequent repairs or replacements. Some of the materials like flooring which has mainly been tiles are easy to repair/replace allowing for easier alterations and renovations.
2	Buildings as layers	Possibility of separation of the layers into defined functional entities for options of partial upgrading because layers have different lifespan	With regards to building layers the several layers of the building have different lifespan and can be refitted as evidenced by changed roofing when the building was first restored in 1992 and then the flooring with the subsequent adaptive reuse.	Kenya national archives used the Layered building design approach an approach that provided flexibility by allowing modifications to specific layers like the roof without affecting the entire structure or the changes in layers like flooring and changes in the partitions as the archives adapted the building to suit its functions.
3	Operability of fenestrations	Operability of the fenestrations to allow users options for daylighting and natural ventilation	The building has provisions for both mechanical and natural ventilation, operable windows on the side facing Kenyatta Avenue and Standard Street the roofing system has manually controlled sun-cut-out louvres that functions for ventilation and daylighting. These fenestrations provide additional options for "servicing" the building	The building has operable fenestrations (windows and doors) that includes double hung windows and casement windows on the facades and skylight windows on the uppermost floor that impact its adaptability by offering users the option for natural light, ventilation, and spatial configuration.
4	Esthetics	Use of the building's image and narrative as a way of appealing to the users' and society's appreciation	The Westminster house is one of the few remaining historic buildings within the city with a stone-clad exterior, uniquely wooden paneled interior, and a listed front façade the building still retains most of the original features that increases its esthetic appeal	Apart from the exterior façade that has been retained there are small details within the building that have been preserved like the columns and the interior coffered ceiling. The Kenya national archives has a unique esthetic creating a certain image and value that is unique and has value to many Kenyans that is why it is a conservation building.

Source: Njuguna, 2024, field data

the instrument of high-level impact. The storage spaces design instrument was rated equally favourably also recording 93.75% preference. However, with equal showing for the moderate, higher moderate, and higher levels of perceived impact on the adaptability of buildings with equal mode frequency values of 31.25% for all three (Fig. 13).

The same high rating of 93.75% was seen in the popular choice by architects of the structural redundancy strategy for fostering adaptability of buildings. Similar mode features (31.25% frequency occurrence in each of the moderate, higher moderate, and high levels of perceived positive impact) occurred here too, and with no architect considering this design parametric of extremely low value (Fig. 14).

Loose fit, raised floors, simplicity and legibility

A modest 56.25% of the architects surveyed viewed the loose fit design parameter as a potent tool for creating adaptability in buildings (Fig. 15). A not much lesser proportion of 43.75% see it as being not a very useful design parameter with which to introduce adaptability in buildings. The mode value in these responses occurs at the lower

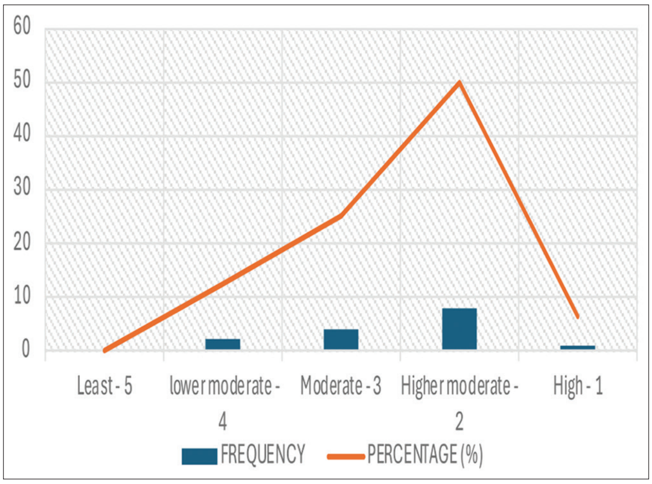

Fig. 6: Rating of the influence of the detachable design parameters on the adaptability of buildings. Source: Njuguna, 2024, field data.

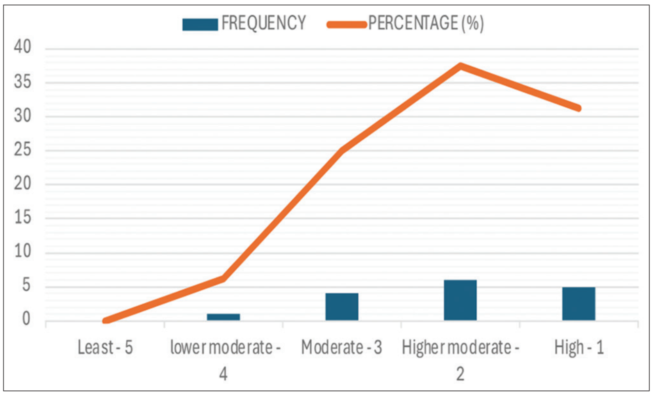

Fig. 7: Rating of the influence of the operable elements design parameters on the adaptability of buildings. Source: Njuguna, 2024, field data

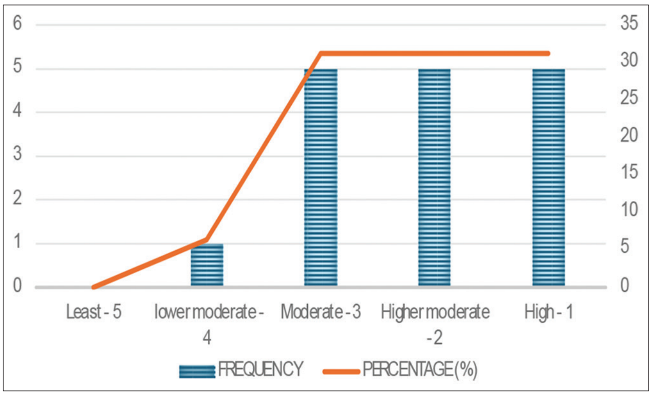

Fig. 8: Rating of the influence of the movable walls design parameters on the adaptability of buildings. Source: Njuguna, 2024, field data

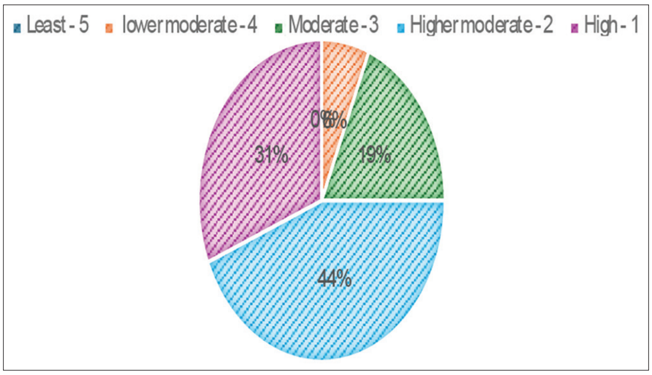

Fig. 9: Rating of the influence of the variety of room sizes design parameters on the adaptability of buildings. Source: Njuguna, 2024, field data

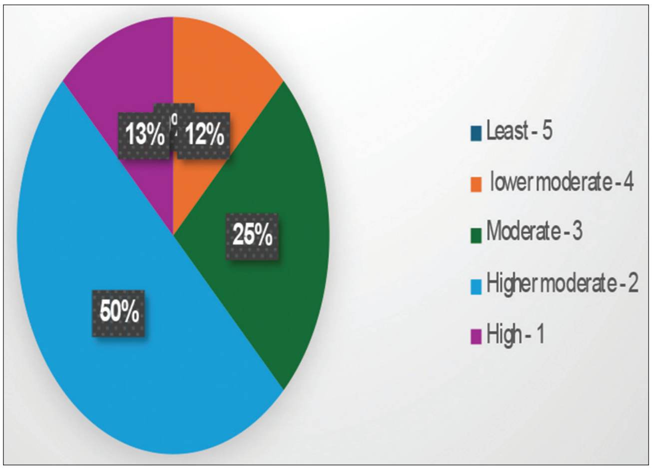

Fig. 10: Rating of the influence of the wide corridors design parameters on the adaptability of buildings. Source: Njuguna, 2024, field data

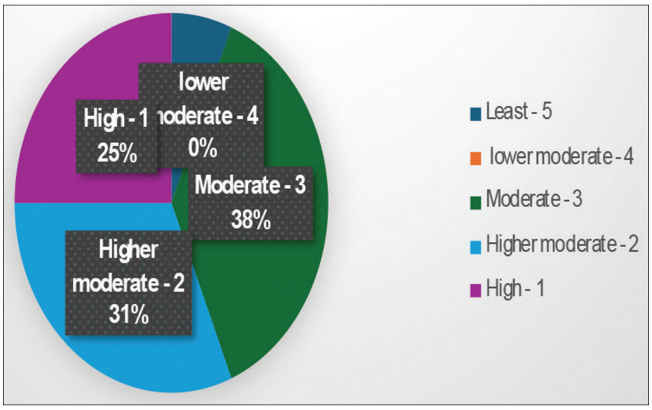

Fig. 11: Rating of the influence of the frame construction design parameters on the adaptability of buildings. Source: Njuguna, 2024, field data

moderate level of impact with a frequency occurrence of 31.25%. This is reinforced by the next closest value to the mode of that settles at both the moderate and the higher moderate levels of impact. These two show a frequency occurrence of 25%.

The raised floors design parameter reflects more or less the same profile where 43.75% of the architects considered it a useful instrument to inbuilt adaptability in buildings (Fig. 16). The contrary view had an even stronger showing at 56.25%, tilting the balance marginally against the use of this design element to promote adaptability in buildings. The mode value here as may be expected inclined toward the less favor, settling at the low moderate with a frequency occurrence of 37.50%. The perception that this design parameter was of the least value registered conspicuous 18.75% not encountered with any other design element so far. The simplicity and legibility design parameter showed improved favor with the architects as having a positive impact on the

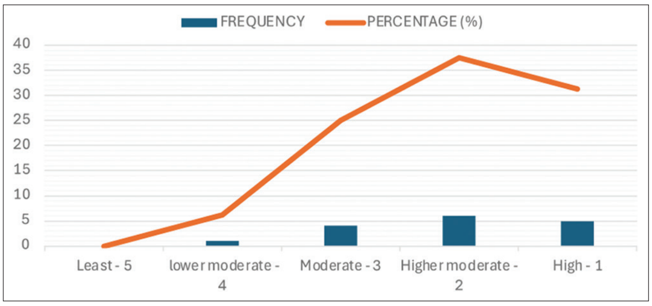

Fig. 12: Rating of the influence of the flexible ducts design parameters on the adaptability of buildings. Source: Njuguna, 2024, field data

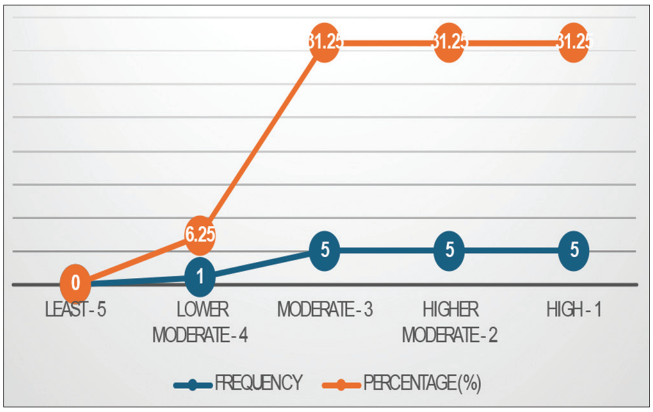

Fig. 13: Rating of the influence of the storage spaces design parameters on the adaptability of buildings. Source: Njuguna

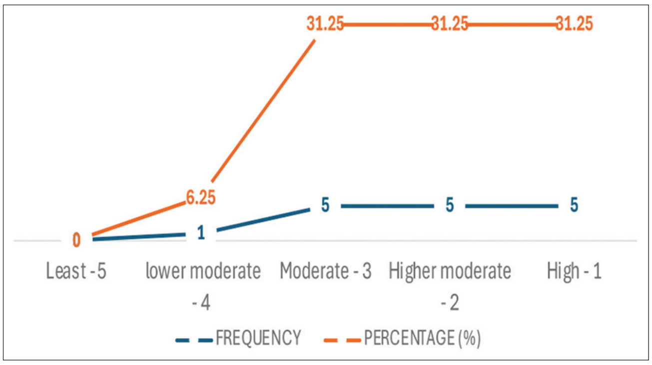

Fig. 14: Rating of the influence of the structural redundancy design parameters on the adaptability of buildings. Source: Njuguna, 2024, field data

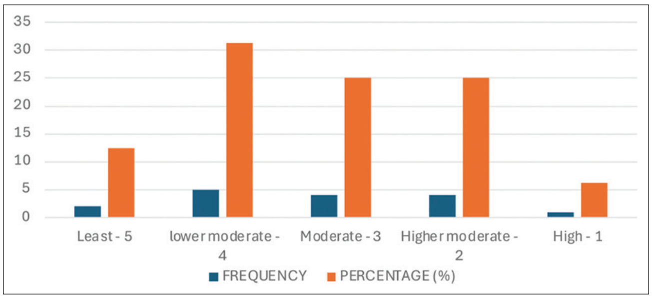

Fig. 15: Rating of the influence of the loose fit design parameters on the adaptability of buildings. Source: Njuguna, 2024, field data

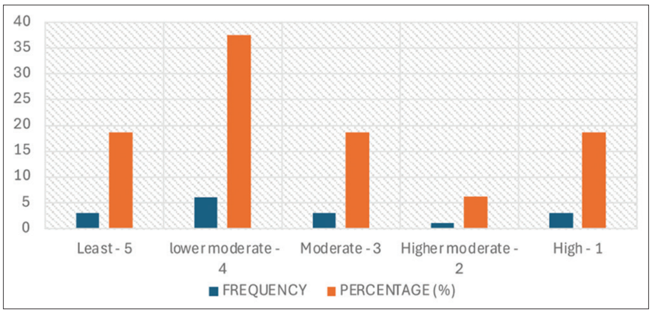

Fig. 16: Rating of the influence of the raised floors design parameters on the adaptability of buildings. Source: Njuguna

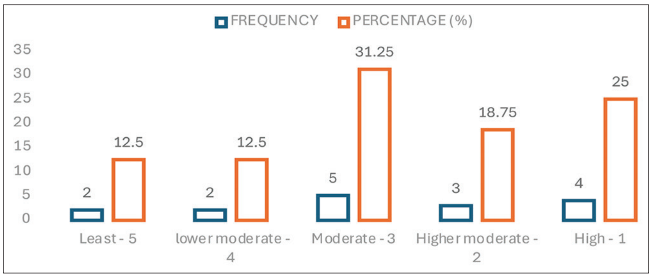

Fig. 17: Rating of the influence of the simplicity & legibility design parameters on the adaptability of buildings. Source: Njuguna, 2024, field data

adaptability of buildings for of those surveyed who returned 75% at moderate, higher moderate, and high impact levels (Fig. 17). Here the mode value lay at the moderate with a 31.75% frequency occurrence.

Dropped ceilings, multi-functional spaces, additional service capacity

Dropped ceilings do not fare well in their inclination as design parameters that promote adaptability in buildings with only 50% of the architects surveyed favoring them in this role with the moderate, higher moderate, and high impact level verdict (Fig. 18). It is important that the mode representing the most commonly occurring response is located at the lower moderate level of influence with a 37.5% frequency of occurrence.

Multifunctional spaces on the other hand are highly favored by all 100% of the architects ranking it at having moderate, higher moderate, and high levels of influence on the adaptability of buildings (Fig. 19). That latter two categories command a visible 75% positive recommendation for use in ensuring adaptability in buildings is achieved through design. As would be expected, the mode here occurs at the higher moderate level with a 50% frequency of occurrence.

The additional service capacity parameter of design has value with the architects for the purpose of designing buildings that are adaptable (Fig. 20). It is endorsed with moderate, higher moderate, and high levels of impact that total to an 81.25% rating by architects. The mode value leans clearly toward the higher levels of impact thing at the higher moderate and higher levels with a 31.25% frequency of occurrence. There is no ambiguity here of its perceived ability to drive design toward adaptable buildings (Table 5).

Most architects (68.8%) viewed buildings as a series of layers and therefore as being easily adaptable (Fig. 21). In contrast, the majority of old buildings had rigid designs that discouraged adaptation. Their spatial deployment and service systems lacked flexibility, making it difficult to meet the evolving needs of users (Table 6).

These buildings struggled to accommodate changes in business nature, such as expansion or contraction, or shifts in operational modes driven by new technologies that aimed at enhancing productivity. Inflexible

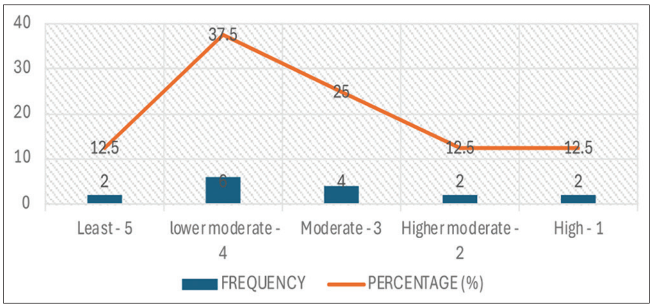

Fig. 18: Rating of the influence of the dropped ceilings design parameters on the adaptability of buildings. Source: Njuguna

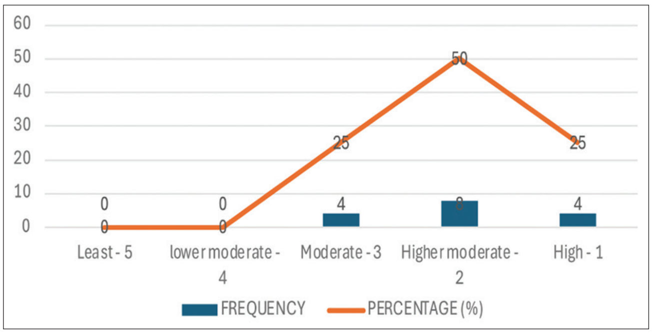

Fig. 19: Rating of the influence of the multifunctional spaces design parameters on the adaptability of buildings. Source: Njuguna

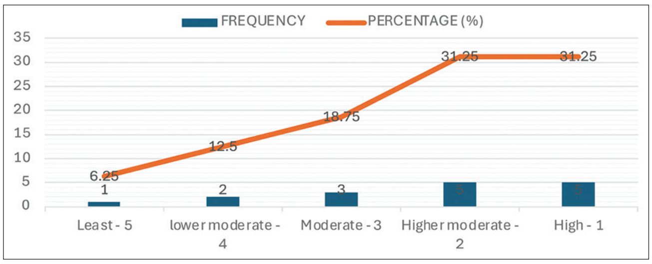

Fig. 20: Rating of the influence of the additional service capacity design parameters on the adaptability of buildings. Source: Njuguna, 2024, field data

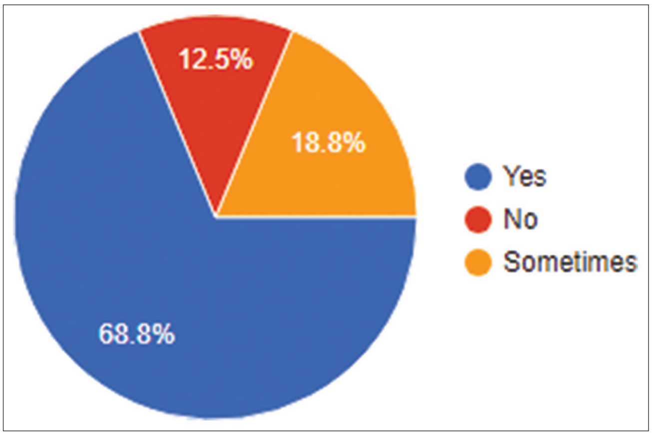

Fig. 21: Architect's expert view of buildings as a series of layers and therefore as being easily adaptable. Source: Njuguna, 2024, field data

workspaces hindered user productivity, as they could not easily support necessary changes.

CONCLUSION

Most people did not consider the building as layers with different life spans, and this led to extensive demolitions when refurbishing spaces for adaptive reuse. It suggested that detachable connections be made and a way to clearly access the different layers and adjust or adapt this also be aided by the ability of the materials to withstand a certain degree of knock-ability and for the structural strength to accommodate changes.

Of the adaptable buildings analyzed which are The Kenya National Archives and the Westminster House in Nairobi it is noticeable that the aspects that made the building adaptable were not a result of a conscious choice to make adaptable spaces. Instead, the buildings were designed to house specific functions and users. It was only coincidence these typologies tended to use loose-fit spaces and have a certain exterior look. This suggested that adaptability could be done in categories where certain typologies were adaptable to certain typologies and functions.

For buildings to be adaptable the developers have to accept an increase in the initial construction costs. The cost implications come as a result of issues like increased ceiling height, increased structural redundancy, and use of more durable materials. Cultural limitations will need to be addressed suitably as most adaptable spaces have adopted openness despite there being cultures that embrace more private spaces.

The findings underscored the importance of a holistic approach to building design that considered long-term flexibility and adaptability. Architects, urban planners, and stakeholders involved in construction must recognize the dynamic nature of societal, technological, and environmental changes. Integrating adaptable design features from the outset not only future-proofs buildings but also enhances their overall functionality, sustainability, and user satisfaction.

Recommendations

The preceding discussions on findings and conclusions lead to the following recommendations:

1. For future building developments, careful consideration should be given to the flexibility of space deployment, and service upgradability. These considerations ought to be integrated during the design stages to prevent subsequent modifications that could result in high costs and inconveniences. To achieve this adaptability, the following measures should be incorporated into the design:
   a. Implementation of open floor plans with light and demountable partitions
   b. Integration of multifunctional spaces
   c. Incorporation of partition-able spaces
   d. Placement of services in accessible areas, avoiding hidden locations within the structure
   e. Ensuring adequate storey heights to accommodate service ceilings.
2. To promote the principles of adaptability during the design phase, the costs associated with incorporating these principles should be significantly lower than those costs that are linked to traditional alterations in less adaptable buildings. These cost savings can be weighed against the uncertainty of when and what alterations will be necessary. One approach to realizing this is to include incentives in public policies aimed at sustainable development.
3. Regarding existing old buildings, alterations and improvements will be necessary to meet changing occupant needs. However, these modifications come at a cost due to the inherent inflexibility of buildings. Several rehabilitation strategies can be considered:
   a. For space deployment: Retention of the entire existing external envelope, including the roof, with minor internal structural alterations, or major internal structural alterations involving extensive demolition of interior structural walls to create an open floor.
   b. For adequate cable management: Implementation of a raised floor system, service ceilings, or trunking.
4. On sustainability, the following initiatives are advised:

a. Increase awareness among planners, developers, and estate managers regarding practical measures to incorporate sustainability into developments.
b. Establish a framework for assessing sustainability issues related to buildings and infrastructure.
c. Provide developers with a method to systematically address sustainability in their proposals, facilitating demonstration of value and approaches to planning authorities.
d. Assist planners in specifying sustainability in supplementary planning guidance/development codes.
e. Foster ongoing research in the field of adaptable building design to stay abreast of technological advancements, changing environmental considerations, and evolving user expectations. In addition, incorporate these findings into educational curricula for future architects and designers.

Areas of further studies

1. Expand the scope of the study to include residential buildings, assessing their adaptability to changing occupant needs, especially as people's requirements evolve over time
2. Explore further studies on how public policies directed at urban development in Kenya can be leveraged to promote the concept of adaptability.

ETHICAL COMMITTEE CONSIDERATION STATEMENT

The study adhered to fundamental ethical principles concerning participant rights. It thus incorporated the following five key principles of informed consent, voluntary participation, confidentiality and anonymity, transparency, and accountability.

a. Informed Consent: All participants were initially engaged to ensure they comprehended and were comfortable with the objectives and procedures used in the interviews and observations involving them. It was clearly communicated that the research was self-funded and academic in nature, providing no additional benefit to the researcher beyond scholarly contributions.
b. Voluntary Participation: Participants were granted the freedom to choose whether to take part in the study and could exit the process discreetly at any time they wished, thereby preserving their dignity and avoiding any stigma.
c. Confidentiality and Anonymity: The research avoided collecting personally identifiable information by anonymizing participant identities through coding instead of recording respondents' names. A deliberate data management strategy was implemented to ensure all data was stored securely, with access restricted solely to the researcher, supervisors, and other authorized personnel.
d. Transparency: The findings, outcomes, and implications of the study were shared with respondents in an accessible and transparent manner, utilizing their internal community management structures. Similar information was also disseminated to relevant institutions from which key informants were sourced.
e. Accountability and power Imbalances: The study employed neutral, non-coercive language while honoring the autonomy of all participants. This approach fostered equality between the researcher and respondents, thereby minimizing bias or prejudice during the observation or interview processes.

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AUTHORS' CONTRIBUTIONS

Michael Macharia Njuguna conceived the study, collected data, analyzed the data, and wrote the research report under the supervision of Mwangi Maringa. Mwangi abstracted the paper from the research report, with Macharia providing strategic inputs on research methods and the illustrations for survey results. Maringa also carried out the editorial work on the paper. All authors read and approved the final draft of the paper.

CONFLICTS OF INTEREST

The study took care to detect and mitigate or manage any conflicts of interest that became apparent during the research to maintain the authenticity of the study. In the eventuality, no conflicts of interest came up.

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