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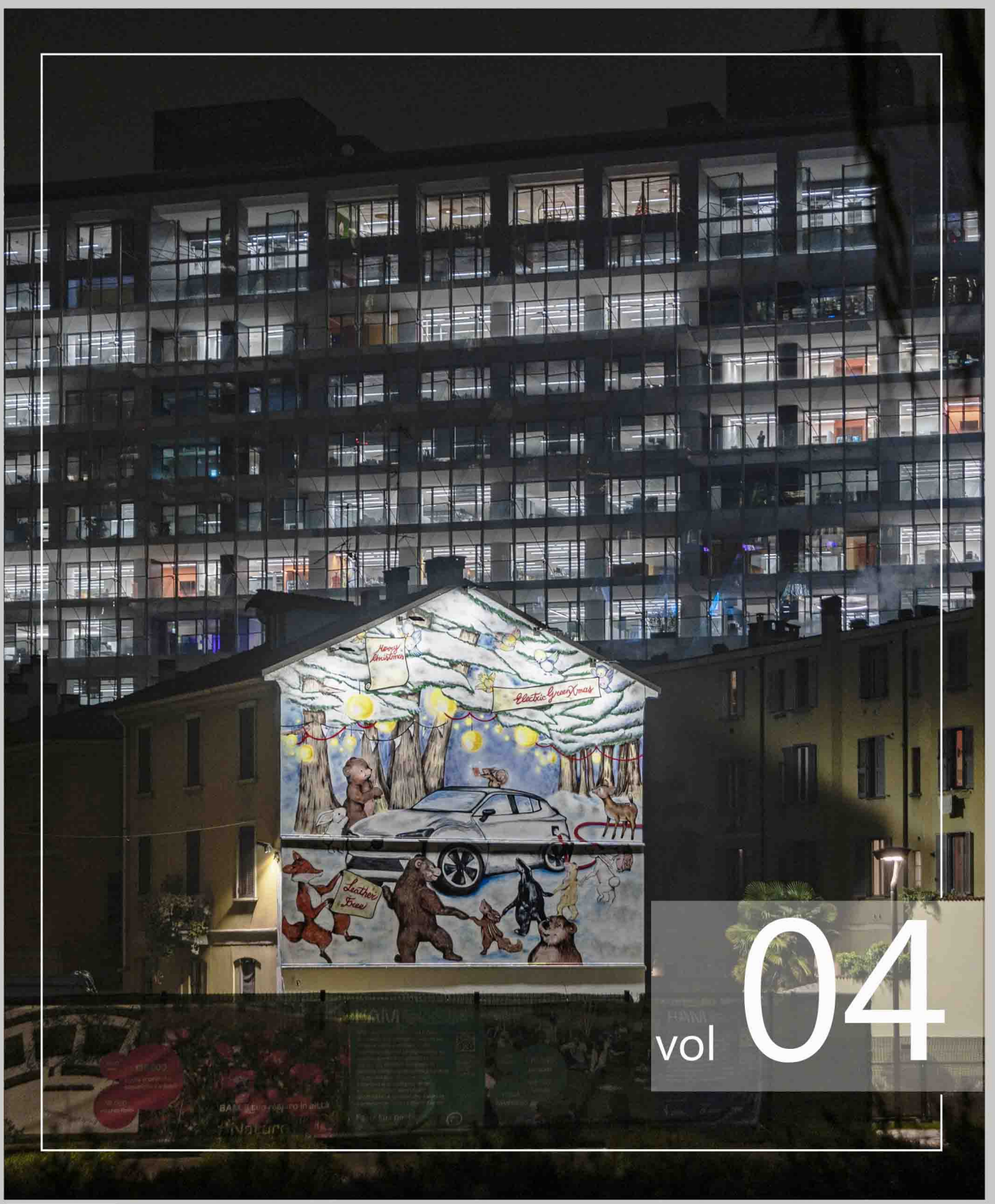

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Editorial

Mehmet Topçu (Editor in-Chief)

We are honored to announce the publication of Volume 4, Issue 3 of the JOURNAL of DESIGN for RESILIENCE in ARCHITECTURE and PLANNING (DRArch) in the final days of the year 2023. As DRARCH welcomes 2024, it is publishing its first-ever review article for the first time.

This first review article is written by Seda Şimşek, İlker Erkan, Fadime Diker and Arzu Şahin. This review article titled as "Evaluation of interior space design criteria on the quality of urban environment: Literature review" focused on the proposition that the effectiveness of the function and quality of the space, spatial requirements have been determined, before and during the design process would increase the quality of the space.

While bidding farewell to 2023, the incredible development of artificial intelligence is of significant interest to the DRARCH team. Midjourney is an AI research lab with its own program and online platform that generates artwork from provided text. By using Midjourney, architectural designs can be turned into artistic works. Experts have found that most spatial designers have yet to try Midjourney and that the program has a significant impact on creative design principles like fluency, flexibility, elaboration, originality and freedom.

The article written by Kübra Müezzinoğlu, Serpil Akan, Halil Yasin Dilek and Yelda Güçlü, titled "An analysis of spatial designs produced through mid-journey in relation to creativity standards" provides the first comments on the subject.

The second research article titled as "Family photos and architectural representation: Using photo collage sketchbook to understand behavior patterns in family apartment buildings" comes from Seda Meral, Berrak Karaca Şalgamcıoğlu and Mehmet Emin Şalgamcıoğlu. This article presents a three-step process of collecting, deconstructing and reconstructing family photos in ethnographic research investigating the sociocultural aspects of behavior patterns in family apartment buildings. To synthesize ethnographic knowledge, research started with obtaining family photos. This photo collage sketchbook has helped us understand various aspects of the family apartment buildings related to architecture and culture. While doing this, the sketchbook prepared with visual contents combined with short notes represents the data collecting and organizing stages and analyzing, interpretation, knowledge-making, and presentation stages.

Another interesting paper deals with use of stone in architecture. Serkan Yaşar Erdinç focused on the key features of stone. The paper titled as "A Timeless Journey of Strength and Beauty: The Potentials of the Use of Stone in Architecture" argues that stone's timeless qualities, durability and versatility make it an ideal material for contemporary architecture, particularly in achieving sustainability and aesthetic appeal.

The fascinating piece of work comes from Alaa Ababneh who is currently a Researcher at the Faculty of Archaeology UAB, Spain. The article titled "A Smart Urban Green spaces and Sustainable Cities: Smart urban management" aims to explore the concept and applications of smart urban green spaces within the context of sustainable cities. The paper delves into integrating advanced technologies, including the Internet of Things (IoT), sensor networks, and data analytics, to create smart urban green spaces that optimize resource efficiency and enhance maintenance and operations.

Mark Alegbe is a registered Architectural Technologist with the Nigerian Institute of Architects NIA, currently serving as a Principal Technologist at Auchi Polytechnic, Edo State, Nigeria. Gwaza Mtaver is an independent researcher with 14 years of industry experience in urban planning and development, environmental sustainability, and architectural design innovations. He holds an HND in Architectural Technology from Federal Polytechnic, Birnin Kebbi. Mark Alegbe and Gwaza Mtaver contributed to DRArch with the article "Climate resilience and energy performance of future buildings in Nigeria based on RCP 4.5 and 8.5 scenarios". This study

DRArch journal has been indexed; DOAJ (Directory of Open Access Journals), TRDizin - TR Index (Tubitak, Ulakbim Türkiye), EBSCO, ICONDA®Bibliographic – The International CONstruction Database, EAAE (Architectural periodicals database), BASE (Bielefield academic search engine), Dimensions (A comprehensive database), Google Scholar (Academic search engine), IdealOnline (Academic search engine), ERIHPlus, Open Archives (OAI-PMH registered data providers), Scilit ("scientific" and "literature" academic search engine), Worldcat-OCLC (The world's largest library catalog), ICI (Index Copernicus master journal list), OpenAIRE, Core - Collection of open (access research papers), Sherpa Romeo (Presents journal open-access policies), Norwegian Register (The Register for Scientific Journals, Series, and Publisher), EZB: Electronic Journals Library, URLICHSWEB(Global serials directory), Internet Archive Scholar, KOAR: Korea Open Access platform for Researchers.

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is about the impact of temperature change across the 36 state capitals in Nigeria, and the Federal Capital Territory, FCT, based on Representative Concentration Pathways, RCPs 4.5 for 2020 and 8.5 for 2090. A simple studio apartment with optimized alternatives for retrofits and new builds was simulated using EnergyPlus for both climate scenarios to determine the strategies for improving the energy performance of future buildings.

Özge Özkuvancı and Alessandro Camiz made research about "The Rebasification of the Roman Theatre in Mediaeval Zaragoza". Within the scope of the study, the typological plan of the city was prepared using the building surveys taken in 1911, and the plan was interpreted as a historical organism.

The article titled as "Observing Patterns for the Urban Fabric as a Place-Shaping Continuum on the Waterfront of the Haliç Area, Istanbul" written by Mehmet Aytekin Saygılı and Elmira Ayşe Gür. The research focuses on the examination of the placemaking activities in a situation where there is no urban fabric, by referring to the help of control variables together with semi-structured interviews with academic members of Istanbul Technical University and investigates the existence of the urban fabric as a place shaping continuum in the Halic area.

The last research is prepared by Emrah Şıkoğlu. The title of the article is "Fractal and geography: Fractal scanning in three different urban areas of Elazığ". The most basic method used in the study is the Fractal Analysis method. In order to make a relevant evaluation, Fractalyse 3.0 program was used. Two bases were created for the urban spots to be used in the program. While one of these bases is the parcels of Elazığ city center, the other one is buildings. In order to measure the parts of the whole mentioned as one of the aims of the study, three different regions of the city were identified and fractal analyzes were carried out separately for those regions.

We believe in the strong relationship between the concept of resilience, characterized by the swift recovery from challenges through adaptive capacities, is at the heart of our exploration. DRArch goes beyond the traditional boundaries of resilience design, delving into the uncharted territories of future design in our ever-evolving world. DRArch stands at the forefront of innovation and foresight in the realm of design. As we navigate the complexities of the modern world, our commitment to anticipating the future, embracing sustainability, and integrating technological advancements with inspiration and aesthetics remains unwavering. DRArch serves as a catalyst for collaboration, providing a dynamic forum that bridges existing design knowledge with a futuristic approach. In essence, DRArch is not just a journal; it is a testament to our collective vision for a resilient, sustainable, and inspiring future. Join us on this transformative journey as we continue to shape the narrative of design for resilience, pushing boundaries and fostering a community o building a brighter tomorrow. I would like to extend my deepest gratitude to all participants and all our readers for the support they provide to the Journal. And I would like to a special thanks to the referees. We look forward to your comments, contributions, suggestions, and criticisms.

Best regards...

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Following names that provided valuable contribution as referees of articles in this issue are:

Muzaffer Ali Arat, (Dr.), Konya Technical University
Serhat Cengiz, (Assoc. Prof. Dr.), İnönü University
Nevset Gul Canakcioglu, (Assoc. Prof. Dr.), Özyeğin University
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DRArch's objectives are:

- to question how future building technologies are revolutionizing architectural design, city planning, urban design, landscape design, industrial design, interior design and education,

- to catalyze the processes that lean on interdisciplinary and collaborative design thinking, creating a resilient thinking culture,

- to improve the quality of built environment through encouraging greater sharing of academicians, analysts and specialists to share their experience and answer for issues in various areas, which distributes top-level work,

- to discover role of the designers and design disciplines -architecture, city planning, urban design, landscape design, industrial design, interior design, education and art in creating building and urban resilience,

- to retrofit the existing urban fabric to produce resilience appears and to support making and using technology within the building arts,

- to discuss academic issue about the digital life and its built-up environments, internet of space, digital in architecture, digital data in design, digital fabrication, software development in architecture, photogrammetry software, information technology in architecture, Archi-Walks, virtual design, cyber space, experiences through simulations, 3D technology in design, robotic construction, digital fabrication, parametric design and architecture, Building Information Management (BIM), extraterrestrial architecture, , artificial intelligence (AI) systems, Energy efficiency in buildings, digitization of human, the digitization of the construction, manufacturing, collaborative design, design integration, the accessibility of mobile devices and sensors, augmented reality apps, and GPS, emerging materials, new constructions techniques,

-to express new technology in architecture and planning for parametric urban design, real estate development and design, parametric smart planning (PSP), more human-centered products, sustainable development, sustainable cities, smart cities, vertical cities, urban morphology, urban aesthetics and townscape, urban structure and form, urban transformation, local and regional identity, design control and guidance, property development, practice and implementation.

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Editorial Team

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Review Article
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Evolution of interior space design criteria on the quality of urban environment: Literature review

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Abstract

Efforts to increase the quality of this environment have been going on since the beginning of the concern for shelter in the history of humanity. The main targets of the user, designers, practitioners, and decision-makers are to carry the quality of life, health, safety, and welfare of individuals and other living things to the next level. Problems have been identified to increase the function and quality of the space, spatial requirements have been determined, and researched, and some design factors have been determined to reach the most appropriate solution. The researchers focused on the proposition that the effectiveness of these factors before and during the design process would increase the quality of the space. However, since research generally focuses on indoor quality, the outdoor quality factors that are part of urban design are not clear. This work, was designed to evaluate the usability of these factors, which were determined and measured especially to deal with the interior, in designs at larger scales (street, neighborhood, city…) and to improve the existing. In designs outside the spatial scale, where almost all factors can be controlled by the relevant stakeholders of the process, the subject is approached through changeable and unchangeable parameters and their balancing. Studies on the factors determined during the process were compiled and their effects on different scales were evaluated as a result of these compilations. As a result of the evaluation, some suggestions were given. In the process of redesigning the space, selecting feasible suggestions, and incorporating them into the creation of the future physical space, using the suggestions as urban rehabilitation tools, and considering these interventions to be flexible and suitable for various factors are of great importance for the psychology of the users.

Keywords: interior design criteria, urban environment, rehabilitation, improvement suggestions

1. Introduction

The concept of architectural design points to very different scales in physical environment design. This concept is associated with many components such as furniture, interior, architectural element, building, roads, streets, landscape.

There is an important relationship between design principles and space quality in space design. Design principles are guidelines that determine the basic features of a space such as aesthetics, order, balance, comfort, and function. Therefore, design principles determine how space is created and organized. Space quality determines the qualities of the space, such as comfort, experience,

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and functionality, that the spaces designed with these design principles provide to the users. Some key points in the relationship between design principles and space quality are shown in Table 1.

Table 1 The relationship between design principles and space quality

Design Principles	Space Quality
It includes elements that shape the aesthetic and visual design of the space, such as color, material, balance, and proportion.	It aims to increase the aesthetic structure and visual appeal of the space.
It ensures that the space is arranged in line with its functional needs and thus usable spaces are designed.	It aims to improve the functionality and usability of a space to provide users with effective and comfortable use.
It determines how to ensure order and balance in the space.	Order and balance achieved through design principles improve the quality of space and emphasize how it relates to the functionality and aesthetics of the space.
With human-oriented design, it ensures that the space is designed in accordance with the needs and comfort level of the users.	It aims to make people feel comfortable and relaxed in the space.
It increases the long-term use and effectiveness of the space by providing flexibility and adaptation.	It aims to enable the space to adapt to changing needs over time.

This relationship between space quality and design principles in space design is in constant interaction from the early design stage of a space to its use. The correct use of design principles meets the needs of users by combining “aesthetics, functionality, usability and comfort”, which increases the quality of the space.

The quality of space environment, which is very important for human health and well-being, depends on factors such as suitable ventilation, fresh air, adequate lighting, and appropriate temperature. People spend most of their time indoors, so the quality of indoor spaces has a direct impact on human health. In addition, spatial conditions are effective on human behavior (Iwashita & Akasaka, 1997; Kasof, 2002; Andersen et al., 2009; Keyvanfar et al., 2014; Deng et al., 2021).

Although physical environmental parameters such as “air temperature, relative humidity, acoustics, air quality, lighting, ventilation and air distribution” are all interrelated, traditional studies on the indoor environment deal with each one separately (Wong et al., 2008). It is necessary to study the combined effects of environmental factors to understand the interactions that cannot be obtained by studies investigating the individual effects of each factor or by studying specific factors alone (Nagano & Horikoshi, 2005). According to various studies on indoor quality, the main factors affecting the quality and comfort of the space are shown in Figure 1.

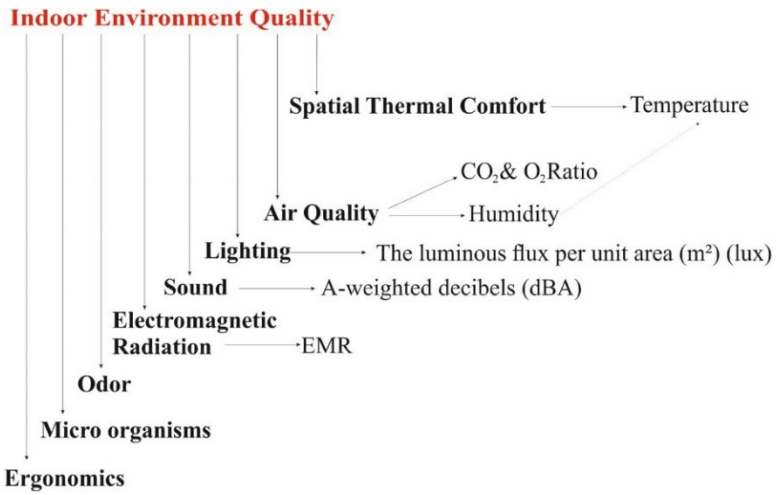


Figure 1 Basic factors affecting the indoor quality (Erkan, 2021)

1.1. Spatial thermal comfort

Energy and thermal comfort are affected by architectural and technical solutions. Therefore, thermal conditions have important effects on design decisions (Attia et al., 2013). Architectural building design parameters (ABPs) determined by designers include features such as indoor air quality, ventilation rate, material properties, building shapes, and building orientation (Rafiq et al., 2003).

Since the perception of comfort is "a psycho-physiological response throughout the cognitive process through thermo-sensitive neurons", thermal temperature, which is one of the physical environmental factors, has a direct effect on people (Erkan, 2020). Thermal conditions in a designated space can reduce "basic aspects of individual human productivity, such as reading, thinking, and doing arithmetic," by 5-15% (Wyon, 1996). It has been observed that when individual employees in Dutch office buildings can control their own thermal environment, their total sick leave due to Sick Building Syndrome (SBS) is 34% lower (Preller et al., 1990). An experimental study conducted in Canadian offices found that workers reporting symptoms of SBS worked 7.2% slower on the Continuous Performance Task ($P<0.001$), a vigilance task in which they had to watch a series of images appearing on a computer screen and respond to someone designated as a target, and made 30% more errors on the Symbol-digit Substitution Task ($P<0.07$), a complex coding task (Nunes et al., 1993).

A passive study of 2150 office workers in Finland found a link between dryness and SBS (Jaakkola et al., 1989). It was determined that dryness and SBS symptoms increased significantly in the air temperature in the range of 20-24 C, and according to the reports of 100 people working in a computerized office at various temperatures applied in this range, thermal conditions had a very significant effect on SBS (Krogstad et al., 1991). Within the scope of the study, each thermal condition was maintained for one week. In the study, when the temperature was at a minimum of 20-21 °C, almost all SBS symptoms increased with temperature, and its effect was observed to be widespread, not limited to only a few sensitive individuals. As a result of the study, the rate of reporting headache and fatigue increased from 10% at 20-21°C to over 60% at 24.5°C, and other SBS symptoms including skin problems showed similar effects.

The findings obtained as a result of the literature review can be listed as follows:

- ✓ Thermal conditions that provide optimum comfort may not provide maximum efficiency. In an experiment that performed mental work at different temperatures (Pepler & Warner 1968), American subjects were most thermally comfortable at 27°C, where they did the least effort and did the least work. Subjects performed most work at 20°C, but most felt uncomfortably cold at that temperature.
- ✓ The effects of heat stress on human efficiency are not always linear. In an experiment (Pepler & Warner 1968) performing mental work at different temperatures, it was concluded that the work rate was minimal at 27°C. However, it will naturally decline below this value in extreme cold or heat. Heat acclimated factory workers residing in South Africa have been shown to perform industrial tasks significantly better at 32°C than at 26°C or 38°C during 8 hours of exposure in normal work clothes (Wyon et al., 1982; Kök et al., 1983). It has also been shown that muscle strength is maximized at moderate cold stress before declining to more extreme levels (Clarke et al., 1958). These nonlinear effects are in marked contrast to the steady decline of comfort above and below the maximum at some neutral temperatures.
- ✓ The critical temperature for performance in temperate regions is about 30°C for normal humidity levels (Pepler, 1964).
- ✓ Accident rates in temperate regions are lowest at 20°C and increase by over 30% below 12°C and above 24°C (Vernon 1936). In addition, it is assumed that accidents increase due to the decrease in human efficiency in adverse working conditions.

Since people spend most of their time indoors, providing the necessary thermal comfort can increase productivity and improve the overall quality of life. Thermal comfort outdoors depends on "sunlight, wind, and the overall design of open spaces," and therefore "trees, shade, and regular use of open spaces" can increase outdoor comfort in hot weather conditions. Urban design elements such as "arrangement between buildings, street widths and building heights" affect the microclimate in the city and determine thermal comfort (Chatzidimitriou & Yannas, 2016; Zheng et al., 2023). Spatial thermal comfort should be considered in overall urban planning as well as in indoor and outdoor design to improve users' quality of life, save energy and generally create a more sustainable and comfortable living space.

1.2. Air quality

By incorporating strategies such as proper ventilation, air filtration, material selection and data analytics, architects and construction professionals can create healthier and more sustainable environments for occupants and the environment.

Outdoor air quality is effective in natural events such as dust storms as well as factors such as vehicle emissions, industrial pollution, forest fires. Outdoor air pollution is an important environmental health problem. Outdoor air pollution causes an estimated 200,000 premature deaths in the United States every year, while worldwide it causes an estimated 4.2 million premature deaths (Environmental Protection Agency, 2022).

Indoor air quality (IAQ) has a significant impact on human health and productivity and plays an important role in maintaining a healthy environment. Indoor air pollution causes an estimated 50,000 premature deaths each year in the United States. Similarly, poor indoor air quality causes various health problems and we can list some of them as follows (Environmental Protection Agency, 2022):

- May trigger asthma symptoms.
- May cause eye, nose, and throat irritation.
- It can lead to more serious health problems such as lung cancer and heart disease.

Indoor air quality is responsible for up to 30% of sick building syndrome (SBS) cases, which include symptoms such as headaches, fatigue, and respiratory problems (Roffael et al., 2019). Exposure to indoor pollutants such as volatile organic compounds (VOCs) can cause respiratory and neurological symptoms as well as cognitive performance (Nazaroff & Weschler, 2019).

One of the most important factors in maintaining indoor air quality is ventilation. Increased ventilation rates can reduce indoor carbon dioxide (CO_2) concentrations and improve cognitive function in office workers (Chen et al., 2017). Similarly, increased ventilation rates provide a 14% improvement in the academic performance of students in the classrooms (Langer et al., 2015). An important factor in ventilation is the air exchange rate (AER), which is the amount of air exchanged between indoor and outdoor environments during a given period. The recommended AER for office buildings is 8-10 liters per person per second (Seppänen et al., 2006).

Another important factor in ventilation is the use of air filters. Installing high efficiency air filters in a building can reduce fine particulate matter (PM2.5) concentrations by up to 40% (Allen et al., 2016). Using portable air cleaners with high efficiency particulate air (HEPA) filters can reduce indoor PM2.5 concentration by up to 60% (Fisk et al., 2019). The use of electrostatic air filters can reduce indoor PM2.5 concentrations up to 80% (Zhang et al., 2018).

In addition to ventilation and air filters, the use of low-emission building materials can also improve indoor air quality. The use of low-emission materials such as paint and carpet can significantly reduce VOC concentrations in buildings (Hodgson et al., 2002).

Measuring indoor air quality can provide important information about indoor air quality and can be used to improve the health and well-being of building occupants. Appropriate measurement

methods should be used to evaluate indoor air quality in buildings. Sensors and air quality indices (AQIs) that provide a numerical score representing the overall air quality in a particular location are commonly used to measure indoor air quality. Wireless sensor network is used to measure various indoor environmental factors such as temperature, humidity, and carbon dioxide levels (Kim et al., 2017). Other methods used to measure indoor air quality include air sampling and personal exposure monitoring. For example, an AQI was used to assess indoor air quality in different building types in China (Wang et al., 2019), while air sampling was used to measure the concentrations of various pollutants, including volatile organic compounds (VOCs) and formaldehyde, in different building types (Kim et al., 2018). Also, the IAQ varies significantly between buildings, and it was concluded that some building materials and ventilation systems have a significant impact on the IAQ (Kim et al., 2018).

In terms of measurement methods, air quality can be monitored using both passive sampling methods such as diffusion samplers and adsorption tubes, and active sampling methods such as personal air samplers and continuous monitoring systems. Passive sampling methods collect contaminants over a period of time, while active sampling methods collect real-time data on pollutant concentrations.

Chen et al. (2018), used a real-time IAQ monitoring and control system with sensors for temperature, relative humidity, carbon dioxide, and total volatile organic compounds (TVOCs) in a commercial building in California to investigate the relationship between IAQ and energy use. Optimizing the ventilation rates of the building according to IAQ conditions can provide an annual average of 15% energy savings and a 26% reduction in peak demand and, in addition, providing real-time IAQ feedback to building users can encourage them to engage in behaviors that can further improve IAQ, such as opening windows or adjusting the thermostat (Chen et al., 2018).

As a result of the study which measuring particulate matter (PM10 and PM2.5), sulfur dioxide (SO_2), nitrogen dioxide (NO_2) and ozone (O_3) concentrations in indoor and outdoor environments of 15 residential buildings in Patna, India, they found a strong correlation between indoor and outdoor concentrations of PM10, PM2.5 and SO_2, while a weak correlation between NO_2 and O_3 (Yadav et al., 2018). It was also concluded that outdoor air quality has a significant impact on indoor air quality in urban areas, especially for PM and SO2 (Yadav et al., 2018). Similarly, data on indoor and outdoor PM2.5 concentrations, temperature and humidity were collected over a two-month period to investigate the effect of building features on outdoor and indoor air quality at a university in Guangzhou, China (Zheng et al., 2018). Within the scope of the study, it was concluded that the dynamic filter effect was positively correlated with the number of floors and negatively correlated with the distance to the nearest road, and the dynamic filter effect was higher during the daytime than at night (Zheng et al., 2018).

Air pollution can cause various health problems indoors and outdoors, have negative effects on the ecosystem, and reduce general social well-being by limiting people's time in open spaces. In urban design, policies such as "transportation planning, placement of green areas and industrial areas" have significant effects on local air pollution levels (Larkin et al., 2016). Improving air quality is important for environmental sustainability as well as improving overall health and quality of life. For these reasons, in urban planning, transportation strategies and environmental policies need to be considered together to protect or improve air quality.

1.3. Lighting

Visual conditions depend on parameters such as “brightness distribution, illumination and homogeneity, glare, color of light, color rendering, flicker rate and amount of daylight” (EN 12464-1, 2002). Daylight, which is a source of illumination, is very important on people's health (Edwards & Torcellini, 2002; Hansen, 2006; Košir et al., 2011; Mirrahimi et al., 2013; Acosta & Figueiro, 2015), sustainability of living resources (Dobrin, 1998; Kim & Kim, 2010; Konis, 2013; Korsavi et al., 2016; Al Zaabi et al., 2017), energy saving (Li & Lam, 2001; Bodart & De Herde, 2002; Galasiu & Veitch, 2006; da Fonseca et al., 2013), productivity and success of people (Leather et al., 1998; Fontoynont,

2002; Park & Athienitis, 2003; Ruck, 2006; Manav, 2007; Krüger & Dorigo, 2008; Winterbottom & Wilkins, 2009; Erlalelitepe et al., 2011; Samani, 2012; Şansal, 2013; Ahadi et al., 2016; Shishegar & Boubekri, 2016). Therefore, daylight is a necessary and useful strategy for providing visual comfort (Fakhari et al., 2021). However, adequate integration of natural and artificial light sources is required to support visual and non-visual requirements in indoor environments (Krüger et al., 2018). Lighting conditions affect human performance with vision, circadian rhythm, and perceptual system (Boyce et al., 2003).

Lighting preference can be affected by individual characteristics such as gender (Chellappa et al., 2017; Huang et al., 2020), age (Boyce, 1973; Knez & Kers, 2000; Park & Farr, 2007; Zhong et al., 2017) and personality (Despenic et al., 2017).

Various studies are carried out to investigate the effect of light on space design. The classification of studies investigating the effect of light on space design and some studies are shown in Table 2.

Table 2 The effect of light on space design

The effect of light on space design	Explanation	Researchers
Investigation of the effect of light on color temperature	It examines how lights of different color temperatures change the atmosphere of the space and how people respond to these changes.	Sinoo et al., 2011; Lan et al., 2021; Li et al., 2021; Jiang et al., 2022; Zeng et al., 2022
Comparison of natural and artificial light	Examines the differences and similarities between natural light sources and artificial light.	Mavromatidis et al., 2014; Al-Ashwal and Hassan, 2018; Chen et al., 2023
The effect of light on the perception of space	It examines the effect of different light levels and qualities on the perception of space. These studies investigate how people perceive spaces, how light affects the appearance of shapes, volumes and textures, and the importance of visual comfort.	Ozorhon and Uraz, 2014; Stokkermans et al., 2018; Hvass et al., 2021
Light management	It explores how light management systems in buildings should be designed. These studies include the placement of light sources, the lighting of indoor and outdoor areas, the design of automatic light sensors and other systems.	Li et al., 2010; Hu, 2017; Dupláková and Flimel, 2017; Edytia et al., 2021
Using Natural Light	Investigates the importance of using natural light in space design. These studies examine how sunlight changes the atmosphere of the space, the effect of natural light on the perception of space, and how natural light helps to save energy.	Baker et al., 2013; Yoon et al., 2016; Wong, 2017; Iommi, 2019; Lee et al., 2022

As a result of the literature review, lighting has various effects on outdoor, indoor, and urban design. Outdoors; It can increase safety and improve visibility, help create an aesthetic atmosphere by highlighting buildings, parks and other areas, and can make a significant contribution to environmental sustainability by saving energy through appropriate lighting design. Indoors; It can improve the comfort of the space and increase the functionality to perform certain tasks, reduce energy costs and reduce environmental impacts, contributing to people improving their mood and increasing work efficiency. In urban design, it can determine the visual hierarchy of buildings, streets, and public spaces, support the night economy, increase the safety of public spaces, and reduce crime rates in areas such as "parks, squares and pedestrian paths".

Considering these various effects of lighting, it is necessary to adopt the right strategies not only in indoor and outdoor design but also in urban design processes.

1.4. Sound

Sound is defined as “a phenomenon that affects our experiences in daily life and helps us define our location and direction” (Aburawis, 2019). Hearing, speaking, and communicating with voice are

among the most distinctive features of human development and culture (Öner, 2021). In addition, hearing is one of the most important ways of survival in living things (especially animals). For example, animal species such as songbirds and frogs use sound and hearing as essential elements of mating rituals or marking areas.

The thermal, lighting, and acoustic design of a space all play an important role on the comfort, performance, and quality of life of the individual (Rozhin, 2022). Influenced by physical, environmental, and social factors, sounds interact and interfere with the connections of listeners and context (Truax, 1996). Sound connects with the quality of life in a place (Bernat, 2016; Bogusz et al., 2011; Hojan et al., 2012). Although sound is an invisible element, it is perceived by the users of the space unconsciously (Nowicka, 2020). Sound in architecture is a feature that affects the space both functionally and aesthetically.

Every sound is unique by nature and emerges once in a vacuum, irreversibly and irreversibly (Öner, 2021). Therefore, each soundscape is region-specific and unique, and it is not possible to capture the exact repetition of the same sound at another time or place. Sound is a form of energy and is created by vibration. The strength of sound is measured in decibels (db).

The term “acoustics”, which deals with the production, control, transmission, reception, and effects of sound, derives from the Greek word “akoustos” and means “heard, heard”. Acoustics, defined as “the science of sound” (Shahryar, 2012), is an environmental variable that significantly affects the human impression of an indoor environment. Acoustic studies have brought the term “acoustic comfort” to the literature. Acoustic comfort can be characterized as (Rasmussen et al., 2010):

- ✓ Absence of unwanted sound
- ✓ Desired sounds with the right level and quality
- ✓ Opportunities for activities without being heard by other people or annoying them.

The acoustic environment is divided into two sub-headings as indoor and outdoor acoustic environments (Brown et al., 2011). Interior spaces have different functional and acoustic properties compared to outdoor spaces (Çakır, 2019). In these interiors, which are surrounded by walls, floors and ceilings, acoustic parameters, especially reverberation time, are considered. Due to the different functions of indoor spaces, the needs and expectations of users differ according to outdoor soundscapes.

Soundscape is an emerging research field first introduced in the 1970s (Schafer, 1970). Soundscape can be summarized as the perception and understanding of an acoustic environment by the individual, group and/or society (Yang & Kang, 2005). This concept is defined as “the field that studies the effects of an auditory scene on the physical responses and behavioral characteristics of its inhabitants” (Truax, 1978).

When sound is taken as the main source for listening and working, it has the feature of making the invisible visible and the intangible accessible. When one hears a place, one hears certain interactions between places, people, and perhaps machines, as well as what they cannot see. Normally the average sound level in the room is used as the indoor sound level or the indoor noise level. Sound can be used as a tool to understand the dynamics, perceptions, and sociopolitical characteristics of the city (Çağlar, 2013). Significant increase in sound level near an open window is a matter of common experience, but even with closed windows sound levels vary considerably within a typical room (Shahryar, 2012).

It has been claimed that the “symbolic sound” (soundmark) for the auditory landscape of the city is the following: the landmark is a derivative of the concept of landmark, which means the sign element associated with the sense of hearing (Öner, 2021). Every building or space has its own sound of intimacy or monumentality, invitation or rejection, hospitality, or hostility (Pallasma, 2007).

The concept of noise is often defined as “unwanted sound”. Many laws and regulations are regulated by noise. There is a very important disconnect between the user’s perception of sound and the planning discipline in the urban space (Öner, 2021). The only approach adopted in many countries is the noise control approach. Required noise reduction (NR) is defined as the difference between the outdoor sound level and the desired indoor sound level (Shahryar, 2012). The main sources of external noise levels are air, road and rail traffic and industrial/commercial activities. The external noise level is the value that can be observed near the outside of the building. There are three types of noise (Schafer, 1977):

1. Unwanted sound
2. Non-musical sound (non-periodic vibration)
3. Any loud noise / disturbance in the signaling system.

Unwanted noise is effective in the emergence of emotional reactions such as anger-irritation in individuals (Schafer, 1969). Noise can also be defined as “as yet unrecognized sound” that has the potential to be redesigned, waiting to be appreciated and evaluated in a new context.

Noise from outside can be reduced in the following ways (Shahryar, 2012):

- ✓ by quietening or removing the source of noise,
- ✓ by attenuating the sound on its path to the receiver,
- ✓ by obstructing the sound path between source and receiver,
- ✓ improving the sound insulation of the building envelope.

Buildings can be evaluated in three aspects, and they are listed as follows (Aburawis, 2019):

- ✓ **Technical performance:** The technical element that can be measured by specific instruments in the building at a particular time.
- ✓ **Behavioral performance:** The behavioral element is related to the occupants’ satisfaction within the sonic environment, which reveals how occupants affected by the context and space design.
- ✓ **Functional performance:** The functional element is concerned with the occupant’s activities in the space, which affect their needs and space design.

To find qualitative feedback of users, positive or negative experiences of sound environment quality are investigated by various objective and subjective data collection methods (Hassanain, 2007). It is thought that the psychological process is understood if a human perception is analyzed in the sound environment (Aburawis, 2019).

Hearing structures the experience and understanding of space (Pallasmaa, 2007). Although sound often provides temporal continuity in which visual impressions are embedded, people are normally unaware of the importance of hearing in spatial experience. For example, when the soundtrack of a movie is removed, the scene loses its plasticity, sense of continuity and liveliness. The most basic auditory experience created by architecture is tranquility. Architecture presents the construction drama muted to matter, space, and light. After all, architecture is the art of petrified silence.

When the place is heard and listened to, it releases its soul, character, and energy to the listener in a holistic sense (Öner, 2021). Each step taken with the act of listening in the space offers the user more data to communicate with the space. Thanks to this three-dimensional sense, it reaches different and many layers in the perception area of the individual and finds its place in different rooms of our memory. Therefore, the layers of sound in the landscape presented to the individual in auditory sense in a particular place can determine that person’s mood and feeling and the soundscape presented in a repeated / similar character and structure in the long run. It also

determines the attitude of the individual towards the place and the quality of the bond she/he establishes with the place.

The effects of the space imposed on the perceived sound in relation to the psychological reflections of the space are referred to as “context effects” (Nilsson & Berglund, 2006). In addition, when people organize sounds in a way that is consistent with the meanings, they attribute to the acoustic signals they hear, it has been observed that the semantic implications of the source are more effective than the physiological characteristics of the sound (Guastavino, 2006). This cognitive process affects the desire, emotional decisions, and spatial orientation of the space user.

Environmental noise outdoors can negatively affect human health and reduce quality of life. In urban design, outdoor noise can be reduced by using solutions such as noise control strategies and green spaces. Sound design in interior spaces significantly affects acoustic comfort. At the same time, keeping noise levels under control can make positive contributions to human health and general productivity. Considering these impacts, sound design should be considered together with various design factors and play an important role in planning processes.

1.5. Electromagnetic Radiation

Electromagnetic fields play "the same or even more important role as the chemical body" (Zang, 2003). Earth's natural electromagnetic fields and all biological systems operate at extremely low frequencies between 1 and 30 Hz. The band up to 300 Hz is designated as extremely low (ELF) and voice frequency (VF) (Mains power in the home is 50 Hz in the UK.) (Saunders, 2003).

The function of the mind and body (endocrine glands and immune system) is controlled by extremely weak electrical brain waves that interact with the electromagnetic environment. For this reason, it is necessary to investigate whether naturally occurring and human-induced electromagnetic fields pose a health hazard. The possible dangerous effects of electromagnetic fields in the home are mentioned more frequently because of exposure to a wide variety of artificially produced electromagnetic radiation caused by systems such as GSM, UMTS, wireless internet via WLAN. Although it is estimated that it may be harmful to health, there is no conclusive evidence.

An overdose of radiation such as solar flares, geopathic stress, or generated electromagnetic fields can produce abnormal biological changes that can disrupt the release of vital endocrine secretions. Exposure to low-frequency electromagnetic fields can reduce melatonin secretions by up to fifty percent (Reiter & Melatonin, 1996).

Each (construction) material has its own electromagnetic properties, such as mechanical and thermal conductivity properties. Electromagnetic properties to consider are permittivity (or dielectric constant), electrical conductivity, and magnetic permeability. These structural features are required to determine reflection and transmission loss from a wall, for example. They are generally frequency dependent. The measurement of these values is usually carried out in anechoic chambers with special measurement setups (Vizi & Vandenbosch, 2016).

It is possible to know the electromagnetic properties of building materials, to dampen from walls and to simulate electromagnetic fields inside all buildings using computer programs.

Providing a healthy indoor environment for building occupants has always been a challenge for designers due to chemical and physical indoor parameters. At present, people's concern is that the body is constantly exposed to radio and television transmitters, mobile base stations, wireless networks, etc. exposure, how radio frequency and microwave radiation affect human health. The radio frequency (RF) spectrum range is from 3 kHz to several hundred GHz. Microwave ranges from 1 GHz to 40 GHz and are used in contemporary point-to-point, wireless and satellite communications. Various studies of non-ionizing radiation such as RFR (Radio Frequency Radiation) levels are being researched all over the world to resolve safe human exposure levels.

Specific guidelines and standards have been issued by the ANSI (American National Standards Institute) /the IEEE (Institute of Electrical and Electronics Engineers), the ICNIRP (International Commission on Non-Ionizing Radiation Protection), the NCRP (National Council on Radiation protection and Measurements) and other organizations. These standards are expressed in power density in mW/cm². For instance, the 1992 ANSI/IEEE exposure standard for the public was set at 1.2 mW/cm² with the antennas operating in the 1800-2000 MHz range (Hakgudener, 2007).

1.6. Odor

Odor in indoor quality can be effective on human behavior. Pleasant odors in the space can significantly improve the mood and performance of the users (Rui et al., 2017). Similarly, outdoor odor quality plays an important role in urban planning and design. For example, creating green spaces provides users with positive emotional experiences (Kim et al., 2016).

Improving indoor air quality has a positive effect on human health, productivity, and comfort. Improving indoor air quality provides a 9-20% increase in cognitive function and a 4-16% increase in productivity (Cheng & Ling, 2019). Improving indoor air quality provides an 8% reduction in sick building syndrome symptoms (Liu & Zhu, 2020). Increasing ventilation rates from 5 L/s per person to 10 L/s per person can reduce the risk of sick building syndrome symptoms and airborne infectious disease by 40-70% (Sundall et al., 2011). "Increasing ventilation rates and reducing concentrations of indoor air pollutants such as PM2.5 and CO_2" results in higher perceived air quality and greater comfort (Jia & Zhai, 2019). Examining the effects on indoor air quality of an office building using the CO_2 level as a representation for indoor air quality, it was concluded that higher CO_2 levels are associated with lower productivity, with a 50% reduction in cognitive scores observed at 1,400 ppm CO_2 levels compared to 550 ppm (Pagilla et al., 2015).

Natural ventilation in spaces can be effective on indoor odor quality. The odor density of the pollutants negatively affects the comfort of the users (Mølhave et al., 1986). Pollutant levels are higher indoors than outdoors, so people who spend most of their time indoors are exposed to more pollutants (Steinemann et al., 2016). In the analysis of odor distribution indoors, it was observed that the levels of pollutants decreased with natural ventilation (Lin & Hwang, 2017). Increasing the air exchange rate from 1.5 to 3 air changes per hour resulted in a 27% reduction in odor complaints (Lee et al., 2019).

Accurate measurement of odor perception is important for sensory evaluations and instrumental analysis, and more objective and sensitive odor quality measurements can be made with the developing technology (Kim et al., 2021). It is used in sensor-based monitoring systems to increase the accuracy and efficiency of odor quality assessments in outdoor environments (Wu et al., 2021). Based on the odor index, an accuracy of up to 95% was obtained with the MLP algorithm in estimating indoor air quality (Chang & Lin, 2020). Also, this method is efficient and cost-effective for monitoring indoor air quality.

1.7. Micro organisms

Indoor environment quality (IEQ) plays an important role, especially for people who spend most of their time indoors. Examining the microorganisms that people interact with indoors and outdoors is very important in terms of the relationship between architecture, biodiversity, and human health (Kembel et al., 2012). Spaces with poor indoor quality can cause many diseases for users (Sadek & Nofal, 2013) and can also affect people's cognitive functions and thus their learning and working performance (Wang et al., 2021). Indoor quality is handled through visual factors other than indoor air quality, thermal environment, lighting, noise, and light (Wang et al., 2021). The presence of microorganisms is generally examined under the heading of indoor air quality.

Humans are exposed to millions of microorganisms every day that can have beneficial or harmful effects (Prussin & Marr, 2015). Microorganisms have a great impact on the comfort level of people in the space. Factors such as "people, pets, plants, sanitary installations, heating, ventilation and air conditioning systems" are seen as sources of microorganisms in the built environment (Prussin

& Marr, 2015). Microorganisms show different effects in different types of spaces and spread depending on different sources. For example, microorganisms that pollute the air with actions such as coughing, talking, laughing, sneezing in hospital buildings (Hiwar et al., 2021) spread due to lack of maintenance such as dusty floors and moldy surfaces in a building such as a school building (Haverinen-Shaughnessy et al., 2015).

While the presence of a small number of microorganisms in the air in the built environment is considered a normal situation, an increase in this amount can become risky (Di Giulio et al., 2010). The increase in the number of microorganisms in indoor spaces is generally associated with temperature, relative humidity, and CO_2 level values (Hiwar et al., 2021). The humidity factor here is considered as one of the most important factors in mold formation (Kubba, 2010). It also has a strong effect on the survival of microorganisms in the air (Hiwar et al., 2021).

Various solution options are available for these factors that adversely affect indoor air quality. The use of plants in hospital interiors improves indoor air quality by reducing the number of microorganisms in the air (Sadek & Nofal, 2013). Similarly, all room areas in the hospital structure should be cleaned regularly (Onmek et al., 2020). The design strategies of space ventilation are of great importance against diseases spread by airborne microorganisms (Kembel et al., 2012).

Microorganisms have decisive effects on health, environmental quality, and overall quality of life in outdoor, indoor, and urban design. The role of urban design on microorganism impact can determine how urban planning contributes to environmental sustainability and public health goals. Therefore, the effect of microorganisms should be taken into consideration in the urban design process.

1.8. Ergonomics

Ergonomics, which is the process of harmonizing the physical environment with humans, is of great importance in architectural design. The important aspects of ergonomics in architectural design are user comfort, safety, accessibility, functionality, sustainability, efficiency, and satisfaction. Therefore, ergonomics ensures that architectural design is user-oriented and allows people to use spaces more efficiently and comfortably.

Since its existence, human beings have needed to consciously and purposefully change and/or rearrange their environment according to their own characteristics. The concept of ergonomics, which is derived from the Greek words “ergos (work)” and “nomos (law)” (Dul & Weerdmeester 2007), is the whole of arrangements and practices made to optimize design, working, and living conditions according to human characteristics (Karwowski, 2000; Güler, 2001). Ergonomics deals with human anatomical features, anthropometric measurements, physiological capacities, and tolerances and examines the basic theories of human-machine-environment compatibility, organic and psychological reactions caused by workplace location and environmental variables (Sabancı, 1989).

Arrangements in the understanding of " suitability for human beings " on the tools and architecture that people will use to facilitate human life form the basis of ergonomics (Duyar, 1995; Dereli et al., 2006). Since the focus is on people, ergonomics considers the physical and psychological abilities and limitations of people. Therefore, factors such as body posture and movements of people, environmental factors, sensory information, and work organization play an important role in ergonomics. These factors have a great impact on the safety, health, comfort, and productivity performances of people in their daily lives (Çobanlar & Koyuncu, 2022). Therefore, we can list the main purpose of ergonomics as follows:

- ✓ To facilitate human life,
- ✓ To provide comfort, health, and safety conditions,
- ✓ Increasing productivity and quality of life.

Ergonomics basically interacts directly with disciplines such as anatomy, physiology, psychology, neurology, engineering, design, behavioral sciences, and management sciences. Designs for human use are expected to meet ergonomic criteria such as functionality, anthropometrics, aesthetics, economy, originality, and compatibility with the physiological and cognitive capacities of users (Akın, 2013). To create a comfortable and safe space, it is necessary to provide the necessary ergonomic standards (Soldatenko et al., 2021). This situation emphasizes the importance of the ergonomics factor in the design of indoor and outdoor spaces.

People spend most of their time indoors and therefore ergonomic control of indoor spaces has a great impact on people's comfort, health, and productivity (Erozan et al., 2023). Although there are similarities in terms of ergonomic control in large, closed areas (such as factories) and small closed areas (such as offices and classrooms), there are also important differences (Erozan et al., 2023). For example, while factors such as noise level, vibration level and dust/smoke level are in the foreground in the indoor environment of the factory building, factors such as temperature and humidity that affect the indoor air quality are in the foreground in the classroom and office environment.

As a result of the literature review, it is seen that the concepts of interior design and ergonomics are mostly discussed together with the factors affecting the quality of the indoor environment at the point of improvement of living spaces and working spaces.

Acoustic environment, ventilation and air-conditioning, thermal environment, visual environment (such as nature scenery), ergonomic conditions and furniture designed spaces have beneficial effects on people (Salonen et al., 2013). For example, the factors that affect the quality of the indoor environment of the library in educational buildings have important effects on the performance of the educational institution and the health and well-being of the users (Lee, 2014). Factors such as lighting, ventilation, thermal level, acoustics, chair and desk ergonomics, room size have effects on learning spaces (López-Chao et al., 2019). An ergonomic indicator for student well-being in educational buildings should be included in sustainability assessment tools (Saraiva et al., 2019). The role of ergonomics in improving the quality of the sustainable built environment (Hedge et al., 2010; Halid et al., 2019) and ergonomic design problems (Hedge & Dorsey, 2013) were investigated. (Hedge, 2013).

There is a consistent correlation between employee productivity and indoor air quality, temperature control, privacy and interaction, and ergonomics (Saraiva et al., 2019). However, while thermal comfort and ergonomic furniture criteria are more important for certain groups, aesthetic and privacy criteria seem to be the least important among some groups (Saraiva et al., 2019).

To improve working environments in terms of ergonomics, it focuses on the control of physical environment parameters (Subramanya, 2022). For example, it should be optimized into the ergonomic design process by understanding the impact of window design on indoor comfort and human behavior (Fusaro & Kang, 2021).

It is of great importance to keep the ambient conditions within optimum limits for people who stay indoors for a long time during the day (Erozan et al., 2023). In addition, fuzzy logic method, which is a thinking and decision-making mechanism that enables making the right decision by digitizing information (Diker & Erkan, 2022a) is used for indoor ergonomic control (Erozan et al., 2023) and to guide indoor scene synthesis (Fu et al., 2020). In addition, fuzzy logic can solve complex problems much faster because it is like human thought and can work with verbal variables (Diker & Erkan, 2022b).

People may have to do some of their work outdoors. In particular, weather and climatic conditions affect people differently. Ergonomics is of great importance in reducing health risks arising from adverse weather and climatic conditions (Soldatenko et al., 2021).

In the pioneering studies discussed, it is seen that public recreation and service areas are frequently examined. Gülgün and Altuğ (2006) discussed the ground texture of the region and the

ergonomic standards of the roof, environment, and furniture elements in the study in which İzmir Promenade was chosen as the application area. In a similar study, Yörük et al. (2006) handled design elements such as stairs, ramps, roads, pavements, flooring, roof elements, lighting elements, dustbins, signboards, and seating elements in landscape designs from an ergonomic point of view. In the study, which deals with the "green ergonomics" approach in public recreation areas, suggestions for various design needs have been created along with ergonomic requirements that will create a pro-nature emphasis (Pavlíková, 2020).

2. Factors increasing the quality of life in urban environment

Cities are complex spaces where people live, work, and interact, and the way these areas are organized holds great importance in terms of sustainability, quality of life, and their impact on people's daily lives (Carmona, 2010). Urban design is a critical discipline that encompasses the planning, development, and improvement of the physical and functional structure of cities. This discipline involves a variety of factors, including street layout, building placement, green spaces, transportation systems, and public areas (Gehl, 2013). Urban design contributes to the creation of livable and attractive cities by ensuring that cities are both aesthetically pleasing and functional (Carr, 1992).

One of the primary goals of urban design is to ensure that cities are designed to the highest standards in terms of sustainability, accessibility, safety, and aesthetics. Sustainability encompasses reducing environmental impacts, enhancing energy efficiency, and preserving green spaces. Accessibility aims to make cities accessible and usable for everyone (Calthorpe, 1993). Safety focuses on making public spaces and streets secure and reducing the risk of crime (Newman, 1973). Aesthetics shape the appearance and identity of cities, contributing to the preservation of cultural and historical values.

The importance of urban design is increasing with each passing day, as cities attract a significant portion of the world's population. Cities are centers that shape people's lifestyles, cultural interactions, and economic opportunities. Therefore, the effective implementation of urban design will contribute to future cities being livable, sustainable, and inclusive.

Urban design directly affects the quality of human life. Lynch (1960) examined how cities are perceived and how people navigate through them. Green spaces, public transportation systems, walkways, and public areas in a city are of critical importance for people to move around comfortably, socialize, and relax, ultimately influencing their quality of life. Cities are complex spaces where people live, work, and interact, and the organization of these areas, their sustainability, and their impact on people's quality of life are of great significance (Jacobs, 1961).

Quality of life is defined as “individuals' perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns” (Whoqol Group, 1995).

“Health, participation, in/dependence, communication, personal factors, and environmental factors” affect people's quality of life (Hilari et al., 2015). WHOQOL (World Health Organization Quality of Life) examines the quality of life in 6 areas: "physical domain, psychological domain, level of independence, social relationships, environment, and spirituality/religion/personal beliefs" (Whoqol Group, 1995).

Environmental quality, which is a sub-branch of quality of life, covers objectives such as protecting natural resources, reducing environmental pollution, and preventing harmful effects on human health. Space design has many factors that affect environmental quality. The environmental quality of a place depends on many factors such as air, water, noise, heat, lighting, and green spaces. Ensuring environmental quality is important for a sustainable environment. A sustainable space design can minimize energy consumption without harming the environment by promoting the efficient use of natural resources. Thus, this helps to protect natural resources and contributes to the creation of a more sustainable future, considering the needs of future generations.

Indoor and outdoor are quite different from each other in terms of architecture and design. Indoors are enclosed spaces in buildings or structures and are usually spaces people use to work, live, or rest. For example, indoor areas in buildings such as houses, offices, hotels, hospitals, shopping malls are considered indoor. These spaces are usually closed, limited, and controlled.

On the other hand, outdoor is the name given to open spaces outside buildings and can take place in any environment that can be natural or artificial. These venues can include many different places such as parks, gardens, streets, beaches, alleys, and outdoor activities. Outdoors is open, large, and free and less controlled. In terms of architecture and design, interior design includes various factors such as furnishings, lighting, colors, and materials, while outdoor design includes factors such as landscaping, lighting, outdoor furniture, and structural features.

Interior quality has a significant impact on quality of life and overall well-being. This quality results from the combination of various factors and encompasses several elements of interior design, including lighting, air quality, sound insulation, ergonomics, color selection, material usage, and furniture arrangement, among others. How these factors are achieved at the urban scale forms an integral part of urban design. Urban planning and design processes involve decisions such as building placement, integration of green spaces, design of public spaces, and traffic regulations. For example, in high-density urban areas, building placement and heights can enhance natural light reaching interior spaces. Additionally, reducing traffic noise and increasing green spaces can improve indoor air quality (Jacobs, 1961; Gehl, 2013).

The impact of urban design on interior quality encompasses not only the interiors of buildings but also numerous factors that affect the quality of life for city residents. Therefore, urban design should incorporate numerous positive practices and strategies to enhance interior quality. The effects of urban design on interior quality are an important subject that requires further examination and research, and there is a need for more studies in this area (Lynch, 1960; Carmona, 2010; Gehl, 2013; Lynch, 1981).

It is important to increase environmental quality, as people have needs such as quality air and lighting during the time they spend in places. Indoor air quality can be improved by encouraging the use of natural light, ventilation, and green spaces in a space design process. Both interior design and exterior design are the processes of designing spaces in an aesthetic, functional and useful way. Therefore, a good space design creates an environment in which the users can live comfortably through the correct planning and design of the interior and exterior spaces.

Both interior design, exterior design, and urban design have significant impacts on human health and well-being. For instance, natural elements are effective in reducing the stress levels of those working in interior design (Kaplan, 1993). Nature views are influential in the healing process of patients (Ulrich, 1984), and the natural environment is effective in reducing mental fatigue among individuals. Urban green spaces have positive effects on people's mood and well-being (Dallimer et al., 2011).

Interior design, exterior design, and urban design exhibit significant interaction. These three design disciplines complement each other and work together to enhance the impact and functionality of a city or buildings on the quality of life for their users.

Alexander (1977) argues that interior design, exterior design, and urban design can complement each other and emphasizes the need to consider indoor and outdoor spaces together using patterns. Lynch (1964) examined how cities are perceived and understood by people. Gehl (2013) advocates for a human-centric approach in urban design. He also discusses how urban design impacts economic development and asserts that the creative class is sensitive to the quality of both indoor and outdoor spaces in cities (Florida, 2002).

Interior design, exterior design, and urban design interact with each other and collaborate to enhance the functionality, aesthetics, and quality of life of a city or a structure. The interaction

between these design disciplines can help people better understand their living environment and make design decisions with more informed insights.

To establish interaction between the city and the people, it is necessary to ensure that the environmental conditions in which people live are appropriate, and all factors affecting human health and well-being, including social, political, and environmental health, should be considered (Pacione, 2003). The urban environment is characterized by a high density of built (man-made) elements and infrastructures, high population density, soil and air pollution, noise, low biodiversity and scarcity of natural ecosystems (Olszewska-Guizzo et al., 2021b). These factors constitute the sum of environmental exposures harmful to human well-being and mental health (Tost et al., 2015).

Urban environmental quality is one of the main topics of environmental psychology. Because the quality of settlements is essential for human life. “Noise pollution, environmental pollution, air pollution, crowded and uncomfortable environments, lack of urban infrastructure etc. These conditions” negatively affect the quality of the urban environment and cause “many physical and psychological problems, including health problems, distress, negative thoughts, decreased cognitive function and prosocial behavior”, but “green spaces, forests, education and health areas, appropriate transportation and infrastructure”. opportunities” affect the quality of the urban environment positively (Vural, 2020; Erkan, 2023). Therefore, urban environmental quality is a multidimensional concept that has both positive and negative effects on human well-being and health (Bonnes et al., 2018). Eco-environment quality is the result of many factors such as economy, pollution, climate, and disasters (Talebmorad et al., 2021).

In urban planning, the main purpose is to meet human needs and requirements. Therefore, design quality has some effects on people's desire to use the space (Mohamed & Othman, 2012). Therefore, architects, landscape architects and urban designers design people oriented as spaces have a direct relationship with users, and therefore their designs should prioritize people's health and well-being (Marans, 2012; Shamsuddin et al., 2012; Olszewska et al., 2014; Banaei et al., 2017).

Outdoor design in urban design has many factors that shape the physical environment of a city or residential area and affect users' experiences in open air spaces. In addition to increasing the visual appeal of a residential area, outdoor design can also increase social interaction in the area. It can also help protect environmental factors such as sustainable use of natural resources, protection of green areas, consideration of environmental factors. Outdoor design also considers factors such as physical security and lighting to make outdoor spaces feel more comfortable and secure for users. This can help people use the outdoors more often and thus lead a healthier lifestyle.

To address deficiencies in urban design and outdoor space design, it is necessary to emphasize multiple stakeholder collaboration, increase green spaces, and focus on sustainability and environmentally friendly design in urban planning and outdoor space design.

In urban design, collaborative efforts among various stakeholders are crucial to ensure there are no shortcomings in urban design projects and that they are successful. In this context, there should be more effective communication and collaboration between city residents, municipalities, designers, and local authorities. Azadi (2011) draws a parallel between the definition of collaboration, whether formal or informal, mentioned by Smith (2009), and Hemmati's (2002) concept of a 'multi-stakeholder process.' According to Hemmati (2002):

- ✓ All significant stakeholders should come together for communication and decision-making on a specific issue.
- ✓ Communication among stakeholders should ensure equality and accountability.
- ✓ Three or more stakeholder groups and their opinions should be equally represented.
- ✓ Adherence to democratic transparency and participation principles is essential.
- ✓ The formation of partnerships and strengthened networks among two or more stakeholders is necessary.

It is evident that prioritizing multi-stakeholder collaboration is essential for addressing deficiencies in urban design.

Increasing green spaces in outdoor design can provide more opportunities for outdoor activities and improve environmental quality. Gianfredi et al. (2021) conducted research on the relationship between urban green spaces and health indicators, analyzing the connection between exposure to public urban green spaces and physical activity and mental health outcomes. They have demonstrated the potentially beneficial effects of exposure to public urban green spaces. In this context, there should be a greater focus on how parks, gardens, and green spaces can be designed and sustainably maintained.

Sustainability and Environmentally Friendly Design: Cities are responsible for a significant portion of global CO_2 emissions, and they are particularly at risk due to rapid urbanization and the effects of climate change, leading to the depletion of natural resources and agricultural lands (Ameen et al., 2015). Therefore, it is of paramount importance for urban design to be environmentally friendly and sustainable to conserve natural resources and reduce energy consumption. Sustainable design principles and practices should be increasingly emphasized and prioritized in the field of urban design.

3. Conclusion

As a part of architectural design and urban design, which is one of its biggest components, outdoor design is important for increasing the livability and quality of a residential area. However, outdoor environmental quality factors have not been fully clarified since the researches focus on indoor quality. The main reason for this uncertainty is that different uncontrollable factors affect the design in different geographies during the outdoor design process (Table 3). These factors are political decisions, natural disasters that require urgent structuring, economic conditions, management changes, wars, climatic factors (climate change process) and migrations. Therefore, during the interior design process, it is much less likely to use some of the elements considered before and during the design process, and the like, outdoors. It is possible that some of these factors, which cannot be applied in the design process of the exterior, but are known to increase the quality, can be used to improve the current situation. The quality of outdoor spaces, which develop without intervention, can be improved to a certain extent with interventions at various scales, without waiting for them to complete the structural front. In the areas where improvement will be made, first the problem should be identified, then the relevant intervention should be selected and implemented.

In this context, in residential areas; Increasing and creating green areas (increasing humidity, increasing visual comfort, improving air quality, balancing radiation, etc.), for the same reasons, using more trees on streets, roads and streets in the urban landscape and thus increasing the ecological contribution in the urban area, laws and regulations preparation of regulations, urban furniture, bus stops, ramps, stairs, designing lighting elements in accordance with anthropometric dimensions, increasing sensory surfaces and improving floor coverings, increasing visual comfort, designing / creating semi-open spaces, developing designs that will provide air circulation, mass placement, density Short and long-term improvement interventions can be implemented such as designing the bridge, gauges and their relations, taking into account the prevailing wind direction and sun effect, and directing natural light and radiation in this way, re-handling the traffic, and making vegetative noise curtains (Table 3).

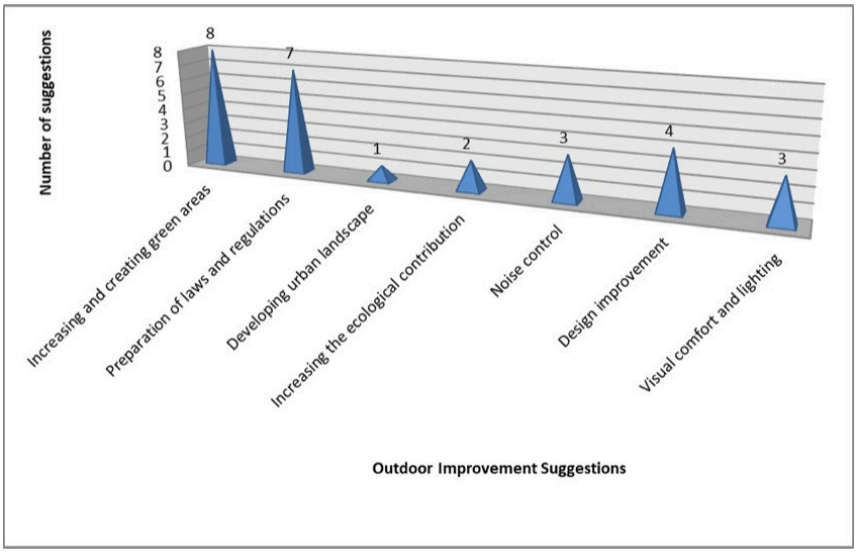
Table 3 Indoor and outdoor improvement suggestion

Design Criteria	Indoor	Outdoor	Outdoor Improvement Suggestions
Air quality	✓	✓	▪ Increasing and creating green areas ▪ Preparation of laws and regulations
Temperature	✓	✓	▪ Increasing and creating green areas ▪ Preparation of laws and regulations
CO2 & O2 ratio	✓	✓	▪ Increasing and creating green spaces ▪ Preparation of laws and regulations ▪ The use of more trees on streets, roads, and streets in the urban landscape ▪ Increasing the ecological contribution in the urban area
Humidity	✓	✓	▪ Increasing and creating green areas ▪ Using more trees on streets, roads, and streets in the urban landscape ▪ Increasing the ecological contribution in the urban area
Lighting	✓	✓	▪ Orientation of natural light and radiation by designing mass placement, density, gauges, and relations by considering the prevailing wind direction and sun effect.
Sound	✓	✓	▪ Traffic restructuring ▪ Making vegetative noise curtains ▪ Construction of noise barriers
Odor	✓	✓	▪ Increasing and creating green spaces ▪ Preparation of laws and regulations. ▪ Following the local government through the establishment of relevant units
Electromagnetic Radiation	✓	✓	▪ Placing and shielding radiation sources as far away from settlement as possible ▪ Laws and regulations, checking with measurements
Micro Organisms	✓	✓	▪ Increasing and creating green areas to increase humidity ▪ Designing by considering the dominant wind direction and sun effect of mass placement, density, gauges, and relations
Ergonomics	✓	✓	▪ Designing bus stops, ramps, stairs, lighting elements in accordance with anthropometric dimensions in urban furniture ▪ Increasing sensory surfaces and improving floor coverings ▪ Increasing and creating green areas ▪ Increasing visual comfort ▪ Design/creation of semi-open spaces ▪ Development of designs that will provide air circulation

To compare the ratios of the factors to be used in improvement, suggestions regarding each other were collected in 7 main groups. They are 'increasing and creating green areas', 'preparation of laws and regulations', 'developing urban landscape', 'increasing the ecological contribution', 'noise control', 'design improvement' and 'visual comfort and lighting'. As seen in Table 4; the rate of 'creation and increase of green areas' shows that this proposal is the most important and effective of the table. Another important group of recommendations is the 'preparation of laws and

regulations'. Since these two proposals affect many factors, their widespread impact in the urban area will also be great. This sequence was continued by 'design improvement' and 'visual comfort and lighting' (Table 4).

Table 4 Suggestion groups



It can be said that the suggestions created in the Table 3-4 can be used in the formation of urban space in two different ways. First, In the process of re-designing the urban space, it is necessary to select the applicable ones among the proposals in question and to consider them in the formation of the physical space of the future. The other is the intervention to be made by seeing these suggestions as a kind of urban rehabilitation tool. This type of intervention can be implemented at different scales and in a way that provides opportunities in different settlements. Therefore, they should be considered as flexible interventions, not rigid and limited. Topographic and geographical features of the area where the rehabilitation will be applied, climatic conditions, economic conditions of the relevant administration and socio-cultural structure of the user should be taken into consideration. Multi-faceted research to be carried out will provide a better result, and because of the improvement of the physical environment of the user, improvements will be seen in their social environment and therefore in their psychology. Because there is an interaction between physical environment conditions and psychology that supports each other.

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Resume

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An analysis of spatial designs produced through mid-journey in relation to creativity standards

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Abstract

The purpose of this study is to comprehend how the artistic spaces developed by designer Hassan Ragab using Midjourney, one of the artificial intelligence technologies whose significance is growing every day, fit into the intersection of architecture and art. Using the random sampling method, six space modellings with three distinct forms and functions were selected for the study from the artistic spaces made by Hassan Ragab via Midjourney. People who have received or are undergoing design training were surveyed to analyze their perception of creative design principles in selected works. A total of 200 participants from two distinct design sub-professional groups were subjected to the research. According to the study, artificial intelligence offers a way for people without artistic ability to access art. Midjourney is an AI research lab with its own program and online platform that generates artwork from provided text. By using Midjourney, architectural designs can be turned into artistic works. Experts have found that most spatial designers have yet to try Midjourney and that the program has a significant impact on creative design principles like fluency, flexibility, elaboration, originality and freedom.

Keywords: artificial intelligence, art, architecture, midjourney, Hassan Ragab

1. Introduction

Thanks to modern technological advancements and mechanization, the world is now globalizing in a more comfortable and, at least partially, more automated direction. The cognitive and mental abilities of people are transferred to machines during this process, which leads to an increase in the amount of responsibility placed on machines (Yakar, 2020; Poole, MackWorth, Goebel & Randy, 2020). The most effective and notable technological advancement in the world today is artificial intelligence, whose significance is growing by the day. The use of artificial intelligence technology appears in various disciplines and all areas of life, such as economy, automobile, health, tourism, education, literature, agriculture, military, energy mining and engineering (Bayrak, 2022). The use of artificial intelligence has, indeed, become an influential force in the fields of art and architecture, taking on a prominent role in a new era (Çelenk & Kurak Açıcı, 2022). This era was brought about through a lengthy process that incorporated both hardware and software systems. The development of AI in architecture is categorized into four main areas: modularity, computational design, parametric design, and artificial intelligence. As per Chaillou, the use of AI in architecture is a natural progression and accumulation of prior concepts using relevant technologies (Hegazy & Saleh, 2023). The use of space as a form of art is increasing in contemporary works of art with the use of artificial intelligence, which also increases the interaction between art and architecture

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(Çelenk & Kurak Açıcı, 2022). A frequently occurring intersection has started to emerge where art and space interact. The similarities between architecture and art have grown in this context, and as a result of these processes, architecture has acquired new values through digitalization and artificial intelligence (Bayrak, 2022; Selçuk, 2022).

2. What is "Artificial Intelligence", the New Perception of Reality?

Because of the industrial revolution that occurred in Europe, the way that things are produced has changed, and the production of machines-which will have an impact on people for centuries-has taken center stage; so much so that mechanization is an area that is still increasing in importance today (Bayrak, 2022). Ardatürk (2022) characterizes the relationship between people and production change as a process of "machines accompanying people, people accompanying machines, software accompanying machines." This procedure changed into another model by the 20th century's end. It can be said that this new model, which we particularly encounter in the twenty-first century, has altered the industry's overall digitalization balance using a technique distinct from all earlier ones (Ardatürk, 2022). Artificial intelligence is the key component of this production innovation. Yang (2020) asserts that the ability of artificial intelligence to mimic human mental abilities in intricate operations across a range of applications makes it a revolutionary innovation (Bayrak, 2022).

Artificial intelligence is the simulation of human intelligence in machines or systems, as defined by Coşkun and Yetkin in 2002. These machines are capable of carrying out tasks and operations defined in their programming and can develop their abilities through the data they collect. Nils J. Nilsson, a prominent figure in the field, defines artificial intelligence as the incorporation of intelligence into machines (Nilsson, 2019). The development of artificial intelligence is expected to continue at a rapid pace and eventually surpass the limits of human intelligence. The defeat of Go Champion Lee Sedol by Google Deepmind's AlphaGo in 2016, four times in a row, and the defeat of World Chess Champion Garry Kasparov by IBM's Deep Blue artificial intelligence computer in 2015, were significant advancements in the field of artificial intelligence. These noteworthy developments have changed people's perceptions about AI (Kantürk, 2022; Bayrak, 2022; Ardatürk, 2022).

2.1. Relation of Space, Art and Artificial Intelligence

Numerous studies have examined the connection between space and art, and these two ideas have been characterized as universal and subsets of one another (Özsavaş Uluçay, 2017). Although both art and space are tools for communication and expression, their origins in distinct fields have kept them apart (Morkoç, 2013). Before modern art, artistic thought made use of the fictitious space; in contrast, in contemporary art, the art object transcends its boundaries and integrates with the space by making use of the space it is in (Arnold, 2010; Güler, 2014). Therefore, the understanding of contemporary art emphasizes the design process.

The art world has seen a major shift in recent years as digital production has become the primary means of creating contemporary art, rather than just a supplementary tool (Yüksel, 2014; Selçuk, 2022). Thanks to the abundance of software and applications available, many 21st-century artists are now incorporating artificial intelligence algorithms into their work. The rapid progress of computer technology has opened up new creative possibilities, allowing artists to explore new dimensions in their work with the help of artificial intelligence (Selçuk, 2022).

By utilizing sub-branches of artificial intelligence, such as machine learning and computational creativity, we can enhance our ability to identify and assess visual data and create new images by synthesizing. These applications can be used to categorize artists and their works based on their level of creativity, conduct aesthetic analysis, and evaluate artistic styles (Yakar, 2020).

Artificial intelligence technology is incredibly versatile in creating creative and artistic works. With deep learning, it can switch between various styles, comprehend facial expressions and body language, and even create images from text. It can add perspective and unique textures to line drawings, resulting in photorealistic outcomes. AI algorithms are constantly evolving and learning,

generating new versions and collecting data from online databases to enhance targeted works (Yakar, 2020).

Over the course of 30 years, an artificial intelligence by the name of AARON was directed by instructions modeled after those of a painter, and some of the paintings this program created were displayed in renowned museums around the globe. The ability of AARON to continuously learn and grow while painting is crucial in this regard (Bayrak 2022; Kantürk 2022). Deniz Yılmaz, an artificial intelligence created by Turkish designer and artist Bager Akbay, can also compose poetry (Cem, 2020; Bayrak 2022; Kantürk 2022).

The use of artificial intelligence in art has become increasingly important, providing artists with a way to create new works and broaden their experiences beyond their local surroundings. This integration of technology into art not only offers a modern interpretation of the art form but also acts as a helpful assistant to artists, as noted by Yakar (2020). Furthermore, Kayıhan (2021) highlighted the rise of digital art production, where algorithms are replacing the traditional role of the artist due to the effects of digitization.

2.2. Artificial Intelligence Effect in Architectural Space Setting

Architecture in the 21st century has intensified its focus on imaginative explorations of space, pushing design applications beyond human imagination (Çelenk & Kurak Açıcı, 2022). Space has become not only a material for designers but also a multidisciplinary workspace for discovering the invisible imaginary dimensions of space by designers, philosophers, and artists from various disciplines. Artificial intelligence is becoming more important in this context as it enables experiential applications. The unexplored possibilities and insurmountable boundaries in architecture have led to the emergence of different expression techniques and a new aesthetic understanding (Çelik, 2023). The partnership between designers and machines has enhanced the virtual reality space by broadening its horizons, as noted by Anadol (2020) and Çelenk and Açıcı (2022). This collaboration has impacted the relationship between buildings and individuals, and digitalization in architecture has transformed the limits and potential of space, facade, and materials (Anadol, 2020; Çelenk & Açıcı, 2022).

Midjourney is an exceptional example of how artificial intelligence can be utilized to enhance design practices in today's world. This intelligent technology can convert written texts into visual models with skilled artistic worth, and it is highly beneficial for design-oriented fields, particularly art and architecture (Domestika Blog, 2019). In 2022, a San Francisco company launched Midjourney as an extension of the chat server "Discord" (Salkowitz, 2022 cited in Radhakrishnan, 2023). Midjourney soon broadened its scope to include architecture, sculpture, art, and graphics. This artificial intelligence utilizes the "Prompt" text-to-illustration system. The "demand" letter, which includes a specific order and system to carry out this operation, is recognized by artificial intelligence (Panicker, 2022, cited in Radhakrishnan, 2023). This client-based AI art tool has generated a lot of debate, particularly in relation to architectural images (Radhakrishnan, 2023).

Midjourney is known for its extensive and varied capabilities. Firstly, it produces high-quality images that precisely depict the entered text. Secondly, it offers customization options that enable users to specify details to include or exclude from the images and adjust properties like color, style, and texture. Thirdly, the program is both speedy and scalable, delivering prompt results to input queries and featuring a straightforward interface with clear instructions. The Midjourney platform has the capacity to generate outputs. Unsupervised learning is the method used to train Midjourney, which enables machines to recognize patterns without human intervention. So, it can be said that Midjourney is a useful tool for tasks like testing design alternatives, visualizing design concepts, and creating research aids in the fields of architecture, design, and communication sciences (Turgay, et al., 2023).

Egyptian architect Hassan Ragab is a well-known artist and one of Midjourney's influential users and practitioners. He is regarded as a leading figure in computational architecture, a well-known

multidisciplinary designer, and a conceptual artist (Domestika Blog, 2019). In this area, Ragab has established a space at the intersection of art and architecture and creates works that address the region's future in architecture. The projects carried out using artificial intelligence can be viewed as an illustration of how architecture has changed in terms of aesthetics. The work related to Midjourney is more intense in the current time frame among the areas in which Ragab operates (Hsnrgb, 2019). Ragab displays architectural works in a digital environment using Midjourney, reflecting a fresh perspective on the future and reality free from material constraints. With his works handled with surreal and abstract concepts, he seeks to broaden his understanding of architecture in both real and virtual environments (Gazete, 2019).

Ragab examines iconic designs of extraordinary interiors in addition to his studies of conventional architecture and Islamic forms. While it frequently uses warm colors and shaded palettes in architectural and urban scale projects to reflect nature, it stands out with unusual materials, flowing textures, and vibrant color schemes in interior designs. The work of Ragab includes references to other architectural styles, well-known artists, architects, and works in addition to these key components. In his writings, he arranges these references. Ragab's artificial intelligence art combines representative Art Nouveau designs with deconstructive transitions of Zaha Hadid and fluid volumes of Spanish architect Antonio Gaudi to produce an original design approach (STIRworld, 2019).

Ragab emphasizes that the scope of Midjourney will go far beyond merely converting words into images; rather, it will develop over time to produce works that have practical applications. Ragab makes the following future prediction in this regard: "Robots will reference housing functions and connect with these visual forms through machine learning. Who knows? Perhaps models will be created on-demand, materials will be delivered by drones, and permissions will be managed by AI systems. We can't predict the future with certainty, but it will undoubtedly be interesting," hinted at potential outcomes (SceneNow, 2019).

Space is the start and the end of architecture, as is clear from the literature cited above. In this context, there are more similarities between architecture and art, and digitalization has given architecture new values. The purpose of this study is to comprehend the place of artistic spaces made with the Midjourney program, one of the increasingly significant artificial intelligence technologies, at the intersection of architecture and art. The works produced by internationally renowned designer Hassan Ragab using the Midjourney program will be examined for this purpose in terms of the geometric forms chosen within the parameters of the research. The study examines six different works in total that were created using three different geometrical forms-triangular, circular, and rectangular-as well as two different functions-facade and interior.

Studies on various creativity measurement tests have been carried out from the 1960s to the present. The creativity test created by E. Paul Torrance in 1966 stands out as the one that has been used the most in the literature in this situation. The ability to directly measure creativity makes this test particularly significant. According to Torrance, creativity is made up of four key components: fluency (the ability to generate a variety of ideas), flexibility, originality, and elaboration (Aslan, 2001). Torrance's Creative Thinking Test was used in this study because it has a broad scientific research foundation and is appropriate for the study's topic. Hassan Ragab's creative Midjourney outputs are evaluated using Torrance's parameters. The element of freedom is also considered in the evaluation along with these parameters. Below are the research hypotheses that were developed in this direction in accordance with the research's purpose and chosen research methodology.

H1: In the context of the principle of fluency, one of the creativity criteria, different geometric forms used in facade and interior designs made using the Midjourney artificial intelligence program have different effects.

H2: In the context of the flexibility principle, one of the creativity criteria, different geometric forms used in facade and interior designs produced by the Midjourney artificial intelligence program have different effects.

H3: In the context of the originality principle, one of the creativity criteria, different geometric forms used in facade and interior designs produced by the Midjourney artificial intelligence program have different effects.

H4: In the context of the elaboration principle, one of the creativity criteria, different geometric forms used in facade and interior designs produced by the Midjourney artificial intelligence program have different effects.

H5: In the context of the freedom from creativity criteria, various geometric forms used in façade and interior designs produced by the artificial intelligence program Midjourney have varying outcomes.

3. Research Method

In order to test the research hypotheses developed in accordance with the study's objectives, information about the research model, universe, sample group, data collection tools, experimental environment design, and analysis process is provided in this section of the study.

3.1. Research Model

The general purpose of this research is to determine the position of artistic spaces created by designer Hassan Ragab using Midjourney, one of the artificial intelligence technologies whose importance is increasing day by day, in the intersection of architecture and art. It was questioned whether the facade and interior designs made using various geometric forms through Midjourney significantly differed from the creativity criteria within the context of the study. To test the created research hypotheses in this direction, the study was structured per the relational screening model, one of the general screening models.

3.2. Research Population and Sample

The research sample consists of individuals who have pursued or are currently pursuing education in any of the design disciplines. The survey was conducted using random sampling methodology and included 200 designers who have received or are currently receiving design education.

3.3. Data collection tool

The study's data collection method was a questionnaire. The parameters of the Torrance Creative Thinking Test, which were discovered to be valid and reliable in studies conducted by Torrance (1966), were used during the design phase of this questionnaire. The three (3) part questionnaire was submitted online between July and August 2023. The questionnaire is divided into three sections: the first asks about the participants' demographics; the second gauges their knowledge of Midjourney artificial intelligence and creativity; and the third meters their interest in the facade and interior designs made using various geometric forms according to Midjourney and creativity criteria.

3.4. Creation of the Experimental Setting

As an experimental environment, Hassan Ragab's triangular, circular, and rectangular artistic interiors and facades created with the aid of Midjourney artificial intelligence were used in this study. Using the random sampling method, a total of six space models from the artistic spaces developed by Hassan Ragab using Midjourney artificial intelligence were chosen for the study. These models had three different forms and two different functions. Figure 1 illustrates how the experimental environment was preferred to be the perspectives of the chosen facade and interior spaces with three different geometric forms.

Figure 1 Facade and Interior Perspectives Designed by Hassan Ragab Using MidJourney Artificial Intelligence (Ragab, 2023).

3.5. Data Analysis

The necessary statistical analysis was performed on the data using the SPSS 22.0 package program after they had been collected using the measurement tools. Before beginning the statistical analysis for the study, demographic variables were grouped. After that, the survey participants' responses to the scales' items were scored using a 5-point Likert scale. The distribution within the groups was first examined during the data analysis, and the Single Sample Kolmogorov-Smirnov (K-S) Test was used to determine whether the data from the research scale fit the particular distribution (Baştürk, 2010). As a result of the analysis, it was determined that the data obtained from the research scale showed normal distribution (p>0,05). To verbally express the numerically calculated means of the dimensions related to the descriptive statistics methods (5-1=4; 4:5=0.80), mean weight values were then calculated. According to Günaydın and Dalkıran (2021), the interval values are as follows: 1.00-1.80 for Strongly Disagree-Low; 1.81-2.60 for Disagree-Below Intermediate; 2.61-3.40 for Undecided-Intermediate; 3.41-4.20 for Agree-Above Intermediate; and 4.21-5.00 for Strongly Agree-High.

4. Research Findings

The research data obtained through Midjourney was tested with suitable statistical methods in order to determine the difference between the facade and interior designs created using different geometric forms and the creativity criteria, and the research findings are given below in a systematic order.

4.1. Reliability Analysis

The Cronbach alpha reliability coefficient was looked at in the reliability analysis of the scale used within the parameters of the study. According to earlier research by Cronbach (1951), Panayides (2013), and Müezzinoğlu (2020, 2021), a scale is deemed to be highly reliable if its alpha coefficient is between 0.80 and 1.00. According to this standard, the scale included in the study's scope had an internal consistency coefficient of Cronbach Alpha of 0.960. In this situation, it is possible to state that the study's scale is very trustworthy.

4.2. Demographic Characteristics of Survey Participants

The study involves 200 participants, with 73.5% of them being female and 26.5% being male, as indicated in Table 1. It is believed that half of those with design education have completed their undergraduate degrees.

Table 1 Demographic characteristics

Variables		f	%
Gender	Female	147	73.5
	Male	53	26.5
	Total	200	100
Trained in design	Graduate	100	50
	Student	100	50
	Total	200	100
Name of department studied	Interior Architecture / Interior Architecture and Environmental Design	118	59
	Architecture	82	41
	Total	200	100

Note: f: Frequency Number, %: Percent Value

4.3. Findings on Midjourney Artificial Intelligence and Creative Design

Table 2 displays the frequency numbers and percentages of the participants' responses to the queries intended to gauge their level of familiarity with Midjourney.

Table 2 General evaluations about Midjourney

Evaluations of Midjourney artificial intelligence	Strongly Disagree		Disagree		Undecided		Agree		Strongly Agree		Total
	f	%	f	%	f	%	f	%	f	%	-
Question 1	16	8	12	6	24	12	113	56.5	35	17.5	200
Question 2	10	5	7	3.5	65	32.5	95	47.5	23	11.5	200
Question 3	17	8.5	17	8.5	35	17.5	92	46	39	19.5	200
Question 4	12	6	25	12.5	50	25	80	40	33	16.5	200
Question 5	72	36	62	31	23	11.5	34	17	9	4.5	200

Note: f: Frequency Number, %: Percent Value

According to the survey results, 56.5% of respondents agreed with the statement in Question 1 that artificial intelligence allows individuals without artistic abilities to access art. For Question 2, 47.5% of participants agreed that Midjourney, a research lab, has developed its own AI program. In Question 3, 46% of respondents agreed that Midjourney's online platform produces art based on text entered into the software. For Question 4, 40% of those surveyed agreed that using Midjourney can transform an architectural design into an artistic work. In Question 5, 36% of participants strongly disagreed with the statement that they have used the Midjourney platform multiple times to create spatial designs. Based on these findings, it appears that designers have some understanding of the benefits and drawbacks of Midjourney, but they haven't used it extensively in the design process.

Table 3 shows the frequency distributions and percentages of participants' responses regarding their understanding of the effects of Midjourney AI on creative design.

Table 3 Evaluation of the effects of the Midjourney artificial intelligence program on creative design

Evaluations on Creative Design Principles		f	%
What are the effects of using Midjourney's artificial intelligence program on creative design?	Fluency (generating lots of ideas)	153	31.9
	Flexibility	88	18.3
	Originality	70	14.6
	Elaboration	102	21.3
	Freedom	67	14

Note: f: Frequency Number, %: Percent Value

According to the responses from Table 3, the Midjourney artificial intelligence program has a significant impact on creative design principles. The majority of respondents noted that the program's fluency (31.9%), elaboration (21.3%), flexibility (18.3%), originality (14.6%), and freedom (14%) have assisted in making more accurate and creative decisions. This is due to the program's ability to process data and information faster than humans.

4.4. Evaluations of Creative Design Principles

At this point in the study, statistical techniques were used to compare participant evaluations of the parameters of the Torrance Creative Thinking Test, which were discovered to be valid and reliable in studies conducted by Torrance (1966).

Using statistical techniques, the architectural designs of the research participants were compared and contrasted with the fluency principle, which is one of the parameters of the Torrance Creative Thinking Test. Table 4 presents the mean and standard deviation values of the data, along with the results of the single-factor analysis of the variance test.

Table 4 Single-factor analysis of variance of the fluency principle

Fluency Principle	N	M	SD	DoF	F	P
Space - 1	200	3.87	0.960	5.195	1.434	0.209
Space - 2	200	3.78	1.047			
Space - 3	200	3.71	1.105			
Space - 4	200	3.74	1.099			
Space - 5	200	3.91	1.052			
Space - 6	200	3.68	1.115			

Note: N: Number of samples, M: Mean, SD: Standard deviation, DoF*: Degree of Freedom, F: F value, P: Significance value*

The Single Factor Analysis of Variance results show that there are no statistically significant differences between participant perspectives on the fluency principle, one of the creativity criteria for the various geometric forms used in facade and interior designs developed using Midjourney, according to the spaces (F(5.199)=0.209, p>05). To put it another way, there is no distinction between the concepts of fluency and spatial designs. The H1 hypothesis cannot be backed up by this result. This outcome demonstrates that, generally speaking, the principle of fluency does not reveal a glaring difference in the application of various geometric forms.

In a different analysis, statistical techniques were used to examine the discrepancies between the participants' assessments of architectural designs and the flexibility principle of the Torrance Creative Thinking Test parameters. The results of the single-factor analysis of variance, the Tukey test, and the analysis's mean and standard deviation are shown in Tables 5 and 6.

Table 5 Single-factor analysis of variance of the flexibility principle

Flexibility Principle	N	M	SD	DoF	F	P
Space - 1	200	3.69	1.010	5.195	5.621	0.000
Space - 2	200	3.87	1.019			
Space - 3	200	3.50	1.165			
Space - 4	200	3.49	1.160			

Space - 5	200	3.86	1.049			
Space - 6	200	3.49	1.125			

Note: N: Number of samples, M: Mean, SD: Standard deviation, DoF: Degree of Freedom, F: F value, P: Significance value

The flexibility principle, one of the creativity criteria of various geometric forms used in the facade and interior designs created using Midjourney, is one where the perspectives of the participants differ significantly, as shown by the results of the Single Factor Analysis of Variance (F(5.199)=0.000, p<05). In other words, their perspectives on the flexibility principle in relation to spatial designs differ. The H2 hypothesis is supported by this finding.

Table 6 Multiple Comparison Tukey Test Results

Evaluation	Space - 1	Space - 2	Space - 3	Space - 4	Space - 5	Space - 6
Space - 1						
Space - 2			x	x		x
Space - 3		x			x	
Space - 4		x			x	
Space - 5			x	x		x
Space - 6		x			x	

Note: X: Multiple Comparison Tukey Test Results

Table 6's multiple comparison Tukey test results illustrate which two groups the differences originate from, and it was found that Space-2 (M=3.87; SD=1.019) was the most flexible space.

In a different analysis, statistical techniques were used to compare how participants rated the parameters of the Torrance Creative Thinking Test in terms of the principle of originality. Tables 7 and 8 provide the data's mean and standard deviation values as well as the results of the single-factor analysis of variance and the Tukey test.

Table 7 Single factor analysis of variance of the originality principle

Originality Principle	N	M	SD	DoF	F	P
Space - 1	200	3.80	0.987	5.195	4.937	0.000
Space - 2	200	3.88	1.015			
Space - 3	200	3.77	1.026			
Space - 4	200	3.50	1.143			
Space - 5	200	3.94	1.016			
Space - 6	200	3.64	1.032			

Note: N: Number of samples, M: Mean, SD: Standard deviation, DoF: Degree of Freedom, F: F value, P: Significance value

The originality principle, one of the creativity criteria of various geometric forms used in the facade and interior designs created using Midjourney, is one where the perspectives of the participants differ significantly, as shown by the results of the Single Factor Analysis of Variance (F(5.199)=0.000, p<05). In other words, the concepts of originality vary depending on the layout of the space. The H3 hypothesis is supported by this finding.

Table 8 Multiple Comparison Tukey Test Results

Evaluation	Space - 1	Space - 2	Space - 3	Space - 4	Space - 5	Space - 6
Space - 1				x		
Space - 2				x		
Space - 3						
Space - 4	x	x			x	x
Space - 5				x		
Space - 6					x	

Note: X: Multiple Comparison Tukey Test Results

Space-4 (M=3.50; SD=1.143) was identified as the least unique space after taking into account the multiple comparison Tukey test results shown in Table 8, showing which two groups the differences originate from.

In a different analysis, statistical techniques were used to examine the discrepancies in the participants' assessments of the elaboration principle. Tables 9 and 10 provide the mean and standard deviation values of the data obtained from the analyses, results of the single factor analysis of variance, and the Tukey test.

Table 9 Single factor analysis of variance of the elaboration principle

Elaboration Principle	N	M	SD	DoF	F	P
Space - 1	200	3.71	1.060	5.195	2.635	0.022
Space - 2	200	3.55	1.129			
Space - 3	200	3.88	1.082			
Space - 4	200	3.71	1.164			
Space - 5	200	3.86	1.066			
Space - 6	200	3.67	1.067			

Note: N: Number of samples, M: Mean, SD: Standard deviation, DoF*: Degree of Freedom, F: F value, P: Significance value*

A significant difference exists between the perspectives of the participants regarding the elaboration principle, one of the creativity criteria of various geometric forms used in facade and interior designs created using Midjourney, according to the spaces, as shown by the results of the Single Factor Analysis of Variance ($F(5.199)=0.022$, $p<05$). In other words, there are various detailing concepts depending on the space designs. The H4 hypothesis is supported by this finding.

Table 10 Multiple Comparison Tukey Test Results

Evaluation	Space - 1	Space - 2	Space - 3	Space - 4	Space - 5	Space - 6
Space - 1						
Space - 2			x		x	
Space - 3		x				
Space - 4						
Space - 5		x				
Space - 6						

Note: X: Multiple Comparison Tukey Test Results

Table 10's results of the multiple comparison Tukey test identify Space-3 (M=3.88; SD=1.082) and Space-5 (M=3.86; SD=1.066) as the two spaces with the greatest level of detail.

In a different analysis, statistical techniques were used to examine the discrepancies in the participants' assessments of the principle of freedom. Tables 11 and 12 provide the mean and standard deviation values of the data obtained from the analyses, single factor analysis of variance, and results of the Tukey test.

Table 11 Single factor analysis of variance of the freedom principle

Freedom Principle	N	M	SD	DoF	F	P
Space - 1	200	3.79	1.036	5.195	4.042	0.001
Space - 2	200	3.93	1.022			
Space - 3	200	3.81	1.031			
Space - 4	200	3.61	1.120			
Space - 5	200	3.99	1.005			
Space - 6	200	3.65	1.050			

Note: N: Number of samples, M: Mean, SD: Standard deviation, DoF: Degree of Freedom, F: F value, P: Significance value

The freedom principle, one of the creativity criteria of various geometric forms used in the facade and interior designs made using Midjourney, is one where the perspectives of the participants differ significantly, as shown by the results of the Single Factor Analysis of Variance ($F(5.199)=0.001$, $p<05$). In other words, different concepts of freedom exist depending on the layout of a space. The H5 hypothesis is supported by this finding.

Table 12 Multiple Comparison Tukey Test Results

Evaluation	Space - 1	Space - 2	Space - 3	Space - 4	Space - 5	Space - 6
Space - 1						
Space - 2				x		
Space - 3						
Space - 4		x			x	
Space - 5				x		x
Space - 6					x	

Note: X: Multiple Comparison Tukey Test Results

Space-5 (M=3.99; SD=1.005) is regarded as the freest space, while Space-4 (M=3.61) was assessed as the most unfree, as can be seen in Table 12 when the results of the multiple comparison Tukey test show which two groups the differences originate from.

5. Conclusion and Recommendations

The primary focus of this study has been on determining whether there are any appreciable differences between the facade and interior designs produced using various geometric forms using Midjourney and the creativity criteria. Its goal is to provide direction to designers and users so that they can design.

Through the evaluation of creative design principles, it was discovered that there are four significant results for architectural spaces and Creative Thinking parameters. It was found that, apart from fluency, the principles of flexibility, originality, elaboration, and freedom are perceived and evaluated more positively in terms of facade and interior design. The geometric shapes used in the facade and interior designs created by Midjourney have no noticeable impact on the fluency principle. Therefore, it can be concluded that the designs are successful in incorporating these principles effectively.

The study discovered that people had varying perceptions of the facade and interiors of buildings with different geometric shapes, depending on how the flexibility principle was applied. The results showed that Space-2, which had a circular shape, was considered the most flexible based on the averages. The second most flexible space was Space-5, which also had a circular form. This finding suggests that circular designs are generally viewed more positively when considering the flexibility principle. This supports the findings of previous studies by Yılmaz (2004) and Watson et al. (2012).

Another finding showed that the perceptual assessments of facades and interior spaces with various geometric forms varied depending on assessments of the principle of originality. Accordingly, when we look at the averages, we can see that Space-5, which belongs to the circular-form interior perspective, is the most original space, and Space-4, where triangular forms are frequently used, is the least original space. This finding demonstrates that designs with circular geometric forms are viewed more favorably when viewed in the context of the originality principle. This finding confirms the findings of earlier studies by (Yıldırım et al. 2021; Çırak et al. 2021; Aydın 2021; Yılmaz 2004).

In a different finding, it was established that there are differences between the perceptual assessments of facades and interiors with various geometric forms according to the assessments of the elaboration principle. As a result, it can be seen from the averages that Space-3, which has a rectangular shape and belongs to the facade perspective, is the most elaborate space. This finding indicates that, when considering the elaboration principle, designs with rectangular geometric forms on the facades are viewed more favorably. This finding confirms the findings of studies by Çırak et al. (2021) and Yılmaz (2004).

Another finding found that there were variances in the perceptual evaluations of facades and interiors with various geometric forms based on assessments of the freedom principle. Accordingly,

it can be seen from the averages that Space-5, which belongs to the interior perspective with a circular form, has the freest space, while Space-4, where triangular forms are used the least, has the least free space. This finding demonstrates that designs with circular geometric forms are viewed more favorably when viewed in the context of the freedom principle. This finding confirms the findings of the studies conducted by (Yıldırım et al. 2021; Çırak et al. 2021; Aydın 2021; Yılmaz 2004).

This research showcases how artificial intelligence can bring art within reach of those who lack natural artistic abilities. Midjourney is a research lab that has developed its own AI program, which operates as an online platform creating art from given text. It could be argued that Midjourney could transform architectural designs into works of art. However, it has been found that most designers have yet to utilize Midjourney in their spatial design creation. The research also indicates that the creative criteria and facade designs produced by Midjourney's AI program, using various geometric forms, can be useful tools for spatial evaluations.

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Resume

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Family photos and architectural representation: Using photo-collage sketchbook to understand behaviour patterns in family apartment buildings

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Abstract

This article presents a three-step process of collecting, deconstructing and reconstructing family photos in ethnographic research investigating the sociocultural aspects of behaviour patterns in family apartment buildings. The first author conducted the study for her Ph.D. thesis in architectural design, supervised by the second and third authors. As an architect, the first author created a photo collage sketchbook, combining various representational techniques of her profession with family photographs. While observing the family apartment building and trying to understand the *"gecekondu"* where the participants lived before the family apartment building, the researcher realised that the interviews were insufficient, and this problem forced the use of a photo collage sketchbook. To synthesise ethnographic knowledge, research started with obtaining family photos. After extracting and grouping, the deconstruction process began. Deconstructed layers are then reconstructed by using various architectural representation techniques and text. This photo collage sketchbook has helped us understand various aspects of the family apartment buildings related to architecture and culture. While doing this, the sketchbook prepared with visual contents combined with short notes represents the data collecting, organising, analysing, interpretation, knowledge-making, and presentation stages. In working with a photo collage sketchbook, obtaining family photographs and overlapping the photographs and interviews' narratives appear challenging. Therefore, collective interviews have been a critical move to compare and verify the memories recalled by the participants. While interviewing, it is vital to show the photos to every participant from a particular age group because they contribute differently to the photo components because of the place experience. So, this study is not about a set of instructions or tools but experiences about the process or approach to constructing ethnographic knowledge.

Keywords: architectural research, family apartment buildings, family photos, qualitative inquiry, visual ethnography

1. Introduction

In the last decades, architects have become more familiar with ethnography than in the past and ethnographic methods are used in architectural research (Schön, 1987; Cuff, 1992; Jacobs &

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Merriman, 2011). The use of ethnographic tools in architectural research has increased as a result of the studies exploring design-making processes in architecture (Yaneva, 2009a & 2009b; Loukisass, 2012; Cayer, 2018; Gottschling, 2018; Malinin, 2018; Mommersteeg, 2018; Sharif, 2018; Smitheram & Kidd, 2018; Stender, 2018; Van der Linden, Dong & Heylighen, 2018) and architectural drawings (Ferracina, 2018). To understand and investigate the emergence and design of domestic spaces, not only architects but also researchers from a variety of fields, including anthropology and sociology, explore ways to understand the relationship between spaces and daily life practices of people (Rapoport, 1969; Rapoport, 1980; Rapoport, 1988; Lawrence, 1987; Rakoff, 1979). However, using ethnography as a methodology is still uncommon in architectural research. Therefore, there is a need to use architectural ethnography to allow the development of an intimate understanding of everyday life and space.

Images and drawings interweave the realities of space, history, and everyday life and definitions of culture, lifestyles, narratives, and identities (Pink, 2001). They also play a central role in the lives of architects and are the essential way of expressing their work. Pink (2013) stated that new knowledge-producing and presenting techniques can be developed with the involvement of the researcher's personal and professional approaches during the production of ethnographic knowledge, which contributes to the production of ethnographic meaning. Based on this, I argue that in this study, a toolkit will be created appropriate to the nature of each research and unique to it in producing ethnographic knowledge. In the emergence of this discourse, the relationship between the researcher and the researched stands at a critical point. If an architect conducts ethnographic research, one of the topics of curiosity is what kind of effect this situation has on the research process or what difference it makes. How do architects, as people who tend to think visually, follow a path when studying visual materials? How can the photographic frame, representing a frozen moment as a visual material, be transformed into a live story of space and carried beyond its boundaries? To find answers to all these questions, as architects and designers, we used a combination of visual representation techniques related to architecture and family photographs in this study. This mixed approach formed photo collage sketchbooks, allowing us to understand the field and represent what is understood visually. This paper represents our three-step approach to creating these photo collage sketchbooks developed throughout working in the field with family photos and architectural drawings.

This paper is organised into four sections. First, we briefly lay out a short literature review on visual ethnography and using family photos and sketchbooks in research. Second, we give information about our field, which is a low-rise family apartment building. Third, we focus on deconstructing and reconstructing family photos to form what we call 'an architect's photo-collage sketchbook.' We give details on the three-step approach to creating these sketchbooks. In the fourth and final section of the paper, we reflect on how this approach might extend architectural ethnography.

2. Visual Ethnography, Family Photos and Sketchbooks

Visual ethnography is defined as "*the study and use of visual media and material, but also the incorporation of a visual lens into mainstream ethnography*" (O'Reilly, 2009). O'Reilly (2009) states that visual ethnography *"opens up whole new ways of seeing the worlds we study, enabling a focus on the emotions, the sensual, the artistic, and creative elements that digital media, especially, are providing entire new ways to represent"*. Since images are easier to produce, use, and even share, thanks to technology, people use them in more diverse ways, and ethnographers are creating many ways to involve visuals in their research. However, as Pink (2001) stated, the ethnographic value of any image depends on how it is used, how it is interpreted, and what meaning and information is used to invoke what.

Photography has long been used in various ways in ethnographic research. Mainly, photography shows itself in two ways: either as a methodological or as a presentation tool (Schwartz, 1989). As a methodological tool, photographs can invoke comments, memory and discussion during a semi-

structured interview (Banks, 2001) in "photo elicitation", for example. In this method, photographs can clarify vague memories by creating a "*flood of detail*" (Banks, 2001). Canal (2004) states that the photographic content and the narratives evoked by the photographs convey information that cannot be obtained through verbal communication. As a presentation tool in research, Banks (2001) underlines that photography should not be included lightly or as an afterthought and should convey narratives transparently and naturally.

There are two ways that ethnographers obtain photographs during research: The first is the creation of images by the researcher either to document or to analyse, and the second involves collecting and studying images produced or consumed by the research subjects (Banks, 2007). Byers (1966: 31) states that "*the photograph is not a message in the usual sense. It is, instead, the raw material for an infinite number of messages which each viewer can construct for himself*". Obtaining or producing the photograph is essential for a living relationship. In the phase of searching for or evaluating a photograph, ethnographic knowledge starts forming. Not only obtaining but also talking about these photographs and producing ethnographic knowledge is a process that requires attention and time. Using participants' photographs helped Pink's (2001) research go beyond the boundaries of the past narratives because talking about photographs has helped the participants construct and convey their own life and past. Similarly, Schwartz (1989) states that the dynamism and interaction between the photograph, the viewer and the photographer create photographic meaning. The meaning is not passive but an active relationship between these three components in the monitoring process.

Researching family photographs emerges as a rich field of study that combines visual sociology, visuality, family memory, culture, trauma, time, stories, narratives and testimonies (Doucet, 2018). Kuhn (2007), in his study entitled "*Photography and Cultural Memory",* mentions that family photos are like a store of memory. Examining family photographs discusses how the memories interact individually and socially and what kind of cultural memory they reveal. Kuhn (2007) expresses it: "*Work on personal and domestic photography and memory can unlock doors to understanding not only the ethnography of everyday memory talk but also the workings of cultural memory across wider social-historical spheres*." Kuhn (2007) adds that producing new knowledge is an experimental process. In producing new knowledge, the cooperation of the researcher and the researched person or community is essential.

Drawing in visual ethnography is quite common, and it offers the researcher unlimited interpretation opportunities at the points where words or writing are missing. Ingold (2011) sees drawing as a potential to use the act of observing and describing together and supports using drawing as a knowledge production practice. This practice of knowledge production offers the researcher a broad perspective in ethnographic studies examining spatial behaviour because visual representations allow capturing multiple perspectives and subjectivities. Ingold (2013) also refers to drawing as 'knowledge from the inside.' Bayre, Harper and Afonso (2016) consider this inside knowledge a bidirectional, immersive, and never-ending mental process. Here, Bayre, Harper and Afonso (2016) mentioned two directions: the outside world and the researcher's brain and hand. They added that the drawings may help make the researcher's subjectivity visible, which can contribute to the opening of new dialogues by increasing cooperation with the participants. Bonanno (2019) expresses that the visual representations in ethnography *"…enable capturing both the coexistence of multiple perspectives, bodies and subjectivities and the simultaneity of events, relations, and interactions: those lie at the very core of any ethnographic encounter and define its intersubjective nature"*. Oppitz (2001) states that drawings have a conceptual abstraction ability that visually presents symbolic significance and depicts reality beyond realism.

While discussing the use of sketchbooks in design, geography, architecture, and anthropology, Kuschnir (2016) aims to evaluate ethnographers as visual thinkers and presents the benefits of using sketchbooks and drawings in ethnography. Kuschnir (2016) states that by generating closeness and empathy, openly drawing in a sketchbook in the field promotes conversations and generates collaborative research. Similarly, Ramos (2004) explains that in fieldwork research, drawing is a

documentation activity and a creative tool for interacting with people from different cultures and languages. He also states that 'a trained eye and a skilled hand' are helpful tools for documenting the material culture and everyday life. Although the use of drawings in ethnographic research has been discussed in visual ethnography, combining sketchbooks with photographs or other mixed techniques has not been explored enough. Moreover, sketchbooks are mostly a concrete output of the documentation process, not a form of constructing ethnographic knowledge. The fact that architects and/or designers think visually has led to the emergence of a sketchbook prepared with mixed techniques during the documentation of this study. With this aspect, this study presents an experimental approach that combines the stages of documentation, construction, and presentation of ethnographic knowledge.

Banks (2001) states that visual research methods should not be an end but a means to an end, a step along the way. This article explains an example of how visual research methods are used as a 'step' in understanding the field during a research study in architecture.

3. The Field: A Low-rise Family Apartment Building in Istanbul

For her Ph.D. study in architectural design, supervised by the second and the third authors, the first author investigated the sociocultural aspects of behaviour patterns in family apartment buildings in Istanbul. She had chosen the family apartment building where her husband lived before their marriage as the case study and research area.

Before writing about family apartment buildings as the research subject, making the semantic expansion of the home in Turkey would be correct. Bachelard (1996) states that the home is the first universe of the people living in it and a real cosmos. In addition, he says that the home offers us both scattered images and a holistic imaginary value. With this aspect, the concept of home can have different symbolic meanings between societies or cultures due to different life experiences. However, it is a reality that the home has the most symbolic meanings in all societies or cultural environments (İnceoğlu, 1999). İnceoğlu (1999) states that: "*Houses symbolically communicate one's contradictions with oneself, one's qualities, social status, group membership, and also establish relationships between people and encourage socialization."* The first psycho-social area surrounding a person is her/his home. Therefore, it has not only physical control but also psychological and social control over this person. Today, as a global society, even if similar lifestyles, places, or objects are seen worldwide, the meanings attributed to these places, forms, or objects can differ on a social or individual scale (İnceoğlu, 1999).

The home and the items that organise it produce discourses about the people's identity, lifestyle, and behaviour. These discourses are the starting point of looking at home in the context of the culture-space-behaviour relationship. From a similar point of view, Uraz and Turgut (1997) state that the meaning of home can change and develop according to the interactional process between the people living in the home and the home. They also added that the essential components of this transactional relationship that affect the house's meaning are time, user, and space (or environment). Within this aspect, the home is in a constant transformation, and it is an organism that lives as a holistic structure within this transactional system (Yılmaz Kılıç, 2021). Regardless of the economic situation, the home contains objects or forms of use that will give clues about the people's identity, social group, and culture. Considering the squatter as the home of low-income families, we can say that it is a sheltering place shaped by the cultural core elements of the social groups migrating from the countryside to the city.

In Turkey, many people migrated to the metropolitan cities from the countryside due to industrialisation and mechanisation in agriculture that occurred after the 1950s. Migrant families often settled in squatter settlements (known as *"gecekondu"* in Turkish: a shanty, squat, or slum dwelling; 'Gece' means 'night' and 'kondu' means 'was built/was put') on the city's periphery. Arslan (1989) defines squatters as the transition place of people who migrated from rural to urban life. In time, these families established themselves in the city, and with socio-economic change, they started to live in their apartment buildings. These families, who migrated from the countryside to

the city and lived in the squatter areas, built or had their multi-story illegal apartments constructed by their means. These buildings, built without the support of a professional designer or architect, are generally used by the extended family typology as if they were a single house (Sağlamer et al., 1994). In other words, we can say that the family apartment building concept emerged due to the large family's tendency to live together in a multi-story, low-rise, urban apartment. This type of configuration caused the spatial distributions and behaviour patterns of particular actions to be privatised. Family members live with their core families in every block of this type of apartment, but the larger family uses the block's common areas. For example, rugs in the stair halls and communal cupboards are not seen in the typical multi-story apartment typology, or walking between floors in the apartment hall with house slippers is not common. In the traditional extended family typology, there is a greater tendency to keep the culture they belong to alive, and the role of elders is generally at a critical point in raising grandchildren and children (Yılmaz Kaynar, 2014). Eating, sleeping, raising children, and privacy concepts usually create different behavioural settings in these family apartment buildings. Therefore, this apartment building, perceived as a regular city dwelling or multi-story apartment, has a different meaning for those living here (İnceoğlu, 1999).

The first author's husband's parents came to Istanbul in the 1960s, settled on the city's periphery, and built their *gecekondu* (Figure 1). Patriarchal large family typology as a dynamic of rural life led them to live together in the city. The *gecekondu* they lived in was replaced by the family apartment building in the 1990s (Figure 2). The first author entered the family structure of the given case as a daughter-in-law, where she had the challenge of understanding the spatial equivalents of this 'coexistence' as a researcher and an architect.

As she started observing the field's daily routines and activity patterns, she found that the information and forms of knowledge taught in architectural schools did not fit the facts of the case study apartment building as a domestic space. This incongruent relationship often occurs through family apartment buildings in Turkey, where cultural codes of rural lifestyle shape daily life and reflect the extreme character of the domestic space formation. Observing this lifestyle's physical, cultural, and social counterparts led her to inquire as an architect with a varying concept of spatial organisation.

Figure 1 The squatter family in their street in Istanbul, with their cultural instrument “bağlama” in the early 1970s, is on the left, and they were in front of their squatter on the right

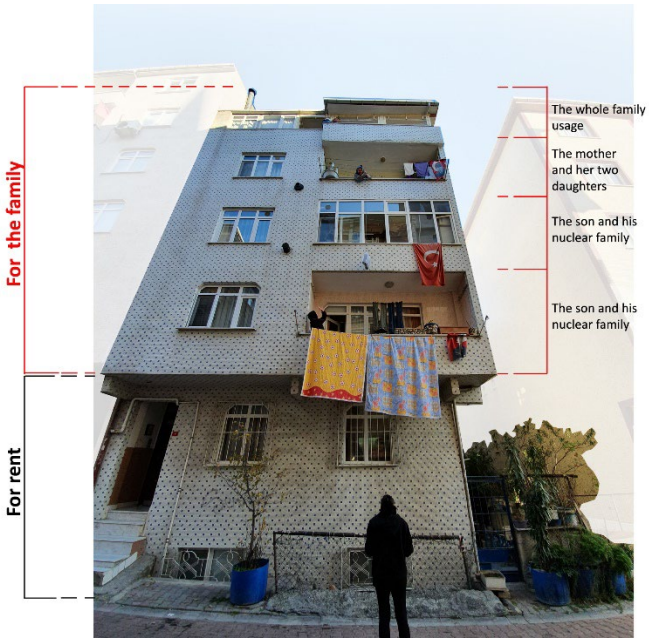

Figure 2 The low-rise family apartment building where the extended family that was transformed from the squatter family over time live together in the city and the usage diagram of it (The first author, 2020)

The starting questions of the research are how vertical and horizontal spatial relations and activity systems have changed due to coexistence and how the cultural background of a rural lifestyle may affect the emergent lifestyle in the metropolitan city area. Family apartment buildings contain intensive indicators in terms of the culture-space-behaviour relationship. To investigate these indicators, the researcher needs to spend sufficient time in the family apartment building to discover the ordinariness of daily life and learn about the cultural background.

The first author, who has a kinship relationship with the family, established a direct relationship with the field. This situation brings up the issue of positionality and reflexivity in ethnographic research. Weber (1949) states that different social positions affect not only the findings of the study but also the choice of the subject or problem to be investigated because each researcher's interests, values, cultural backgrounds, and experiences are different. Özlem (2015) states that empiricism and cultural and historical meaning effectively produce scientific knowledge in social studies. For this reason, it is critical for the researcher to constantly question and discuss the position of the researcher, who has a direct relationship with the field, in terms of producing scientific knowledge through ethnographic research.

Researchers' identity, approach to the research problem, and position(s) in the field directly affect the phases of the research. Therefore, a researcher's insider or outsider position may affect the quality and quantity of the research data (Breen, 2007). However, in qualitative research, not only does the researcher affect the researched people and the researched object, but participants also affect the researcher and the research process. Kaçar Tunç (2020) says that the perspective of the researcher and all the decisions she/he will make impact on his/her positionality. Qin (2016) defines qualitative research as a *'dialogical process'* between the researched and the researcher. This multi-factor relationship between the researcher and the researched affects the research process, so the researcher must constantly evaluate her/his position. Furthermore, researchers must consider their existence's inevitability and cultural, social, and political realities. Also, they need to think about how these realities affect the interactional relationship in the field and must control their positionality accordingly (Denzin & Lincoln, 2003).

As an insider, the first author has a command of the field, and although this often seems like an advantage, in some cases, it might create blindness in research that seeks to explore the ordinary. Similarly, the fact that the researcher is over-experienced in the field may cause the dominance of her/his own experiences in the interpretation part (Greene, 2014). Sometimes, being an insider

might prevent the researched community from telling as a result of thinking that the researcher already knows everything (Chavez, 2008). All of these make the reflexivity of the first author critical in this study. Berger (2015) describes reflexivity as *"turning of the researcher's lens back onto oneself to recognize and take responsibility for one's own situatedness within the research and the effect that it may have on the setting and people being studied, questions being asked, data being collected and its interpretation."*. In addition, he states that reflexivity cannot be considered independent of the knowledge producer. Therefore, reflexivity is also essential for the researcher's internal control. In the context of this study, for the researcher's reflexivity, it is crucial that the first author sometimes moves away from the field, re-evaluates her position each time in the interviews, constantly evaluates the viewpoint of the researched person or community, and designs an ethnographic toolkit accordingly.

4. Developing an Architect's Photo-collage Sketchbook: Deconstruction and Reconstruction of Family Photos

In 2019, as a pilot study, the first author started to observe the family members living in the family apartment building: one day on the weekdays (Thursdays) and once on the weekend (Sundays) to understand different patterns. To support the observation, she conducted semi-structured interviews.

During the observations, the production of visual material was needed:

"I wanted to have a sketch of the old gecekondu. However, my mother-in-law was not eager to draw. I think this is because she was an illiterate woman. I saw how she was anxious about holding the pen. So, I never insisted. Finally, two of my husband's sisters drew a sketch. I asked them the questions I was curious about and made them think more about their past".

(Field notes, 2019)

The first author's boundaries due to her different identities in the field, her curiosity about the space as an architect, and the family's unwritten rules push her to use various visual tools to learn more. This trial-and-error process directed the emergence of photo collage sketchbooks. Searching for a place the researcher (first author) had never been to and had not had a chance to be in was quite a challenge. She interviewed the participants to investigate how cultural codes from the past affect space and behaviour and what behavioural codes have survived or not and benefited from life narratives. The information she gathered created a pile of data in her head, but it was insufficient. Photographs of the family houses where the family lived in the past were needed to explore the roots of daily life in the current family apartment building. The researcher aimed to understand how the family uses the spaces with photographs by looking at the photos taken in the houses they lived in, how they communicate with the items and the place itself, and to discover what cultural core elements are important to their cultural background. While doing this, open-ended interviews were conducted with the researched family while obtaining the photographs. Combining the information of the places in the obtained photos like a puzzle and turning it into a movie scene constructed the ethnographic data.

The researcher could embody the information in her head when she looked at the family photos. It is not easy for a researcher to quickly access family photos, but being in close contact with the family as an insider gave the first author an advantage in accessing family photos. She gained access and made the family members happy for being interested in these photos. One of the family members said during the photo-seeking:

"While we constantly migrated from one place to another, one of our photo albums was lost during each move. How sad we were with each one of them. If it was not, there were more photos to show you. I wish they had not disappeared, too. However, thanks to you, we also remembered our memories".

(Field notes, 2020)

The family mostly has joint albums for their photographs. However, one family member said that she has a unique album apart from the family's joint albums. She showed the researcher this special album herself. When the researcher asked why, she expressed this situation as:

"We are still nomads anyway. Things are constantly going up and down from here to there, from this floor to that floor. I will not let these photos disappear."

(Field notes, 2020)

While the above quotes reveal the importance of photos for families, they show how gaining trust accelerates sharing these personal items for a researcher.

While collecting and talking about the family photographs, the researcher felt the urgent need to sketch together with the photos. Determining the relationship between the places in the photographs, the things found there, and the people who experience those places requires a multifaceted study. Many approaches to producing scientific knowledge can be envisaged in qualitative research. The path used in this study, from getting the photos to their transformation into information, interpretation, and presentation, was also designed specifically for this study. The first author adopted an approach appropriate to the nature of her research, consisting of three steps.

4.1. Step 1: Getting, extracting, and grouping family photos

To obtain the photos, the first author identified family members with a photo archive and visited those people individually. Then, by scanning the photographs together with each person, the images were weeded out according to places. This job required time and effort, but since the researcher was also a family member, the family showed patience and faced her struggles.

Extracting was done by describing each place visible in the photographs, and family members drew sketches to define the homes they lived in the past. This process also required throwing away some photos. This subtraction was made according to whether the relationship between space and behaviour setting is observable or whether there are similar photographs from the same perspective. The photos selected were then grouped spatially according to the homes where the family moved over time.

With the space-based and chronological ordering of the photographs, the aim was to reveal the family's relocation process into the city after the migration and to present data about the places they use in the culture-space-behaviour relationship (Figure 3).

Figure 3 Weeding out and grouping the family photos collected from the family members according to the time and space-based ordering

While the researcher grouped the photographs taken in the houses where the participants moved in the city spatially and chronologically, one-on-one interviews were conducted with the participants who owned the photos. Afterwards, all the collected and grouped images were shown to the participants who shared the same place, and the interviews continued. It was seen that group interviews produce more information than one-on-one interviews. Photography as an object opens the door to the past, brings the participants back to their history, and creates a chained flow of information by reminding each other of their memories. In these interviews, data was obtained on where the photographs were taken and the people's actions in the photos.

Doing interviews with the participants as a group has helped the researcher check the narratives' reliability. For example, for some photos, while participants were unsure about the details in one-on-one interviews, the ambiguous information about these photographs was clarified in the group interviews.

The people who photographed or took the photo were important in group interviews because they usually started the narratives and told the story about that photo. The story of a photograph consists of the story of the person/ people, the story of the place, and the relationship between these two. Within the scope of this study, the combination of person/people and place stories has particular importance. This combination also has a dynamic character. For example, different participants looking at the same photo can talk about other photo parts. Mainly, suppose the speaking participants belong to different age groups. In that case, these narratives become more prosperous because the relationship that people of varying age groups, who are in a particular place at a specific time, establish with that place is different. The differentiation of experiences enriches the spatial narratives and transforms the frozen moment as a photograph into a multi-layered moving film. Although photos are thought of as images in which a single moment is frozen, the conversations of the people who look at the photograph bring to life the shot and take that image out of being a 'single frozen moment.' Pink (2001:74) mentions this process *"By paying attention to how people interweave such images with verbal narratives, researchers may learn about how these individuals construct their lives and histories*." This multi-layered dynamism has been exciting for the researcher and has ignited the architect's identity at this stage, where reflexivity gains importance. Audio recordings were taken while participants and the researcher discussed the photographs. It is critical for the researcher to obtain objective data, so after the interviews, she listened to the audio recordings many times and checked whether she asked a guiding question. This multi-layered dynamism is how the infrastructure of the multi-layered structure of the photo collage sketchbook was formed as a visual representation tool.

4.2. Step 2: Deconstruction of family photos

Family photographs from the first step were deconstructed to form multi-layers in the second step. In this process, it was necessary to go beyond the images. More than one photograph belongs to the same place, and they all have different meanings. Therefore, each semantic piece in the photos had to be deconstructed to interpret all the meanings in the image. The researcher started by layering components that might give her clues to socio-spatial behaviour patterns for each photograph. The details that grab the researcher's attention at first sight are processed to a transparent layer. Spatial behavioural information related to the stories about the space found in the photographs and expressed in the interviews is processed in another transparent layer. At this stage, interviews were critical to go beyond the scene that fits in a single photo frame: it is the element that animates the photographic frame, which is a frozen moment. There were other stories told, but which were related to places outside the photographic frame. These stories were represented by objects, actions or notes completed by drawing as an extension of the photo frame. Since it is space-based research, 'writing' started to fall short both in the research process and in revealing the data. The data presented by the photographs began to form some relationships within itself.

In the photos, many layers were formed chronologically: *'the gecekondu'* during the first period of migration to the city, the temporary home during the construction of the apartment, and the floors of the family apartment building as an organism that develops from the bottom up after the transition to the apartment. The houses the family lived in the city from the first migration to the present day can be expressed as chronological displacement. During these displacements, the behavioural patterns that survived or ended due to the cultural background were investigated. The photographs were also deconstructed according to this chronological displacement (Figure 4).

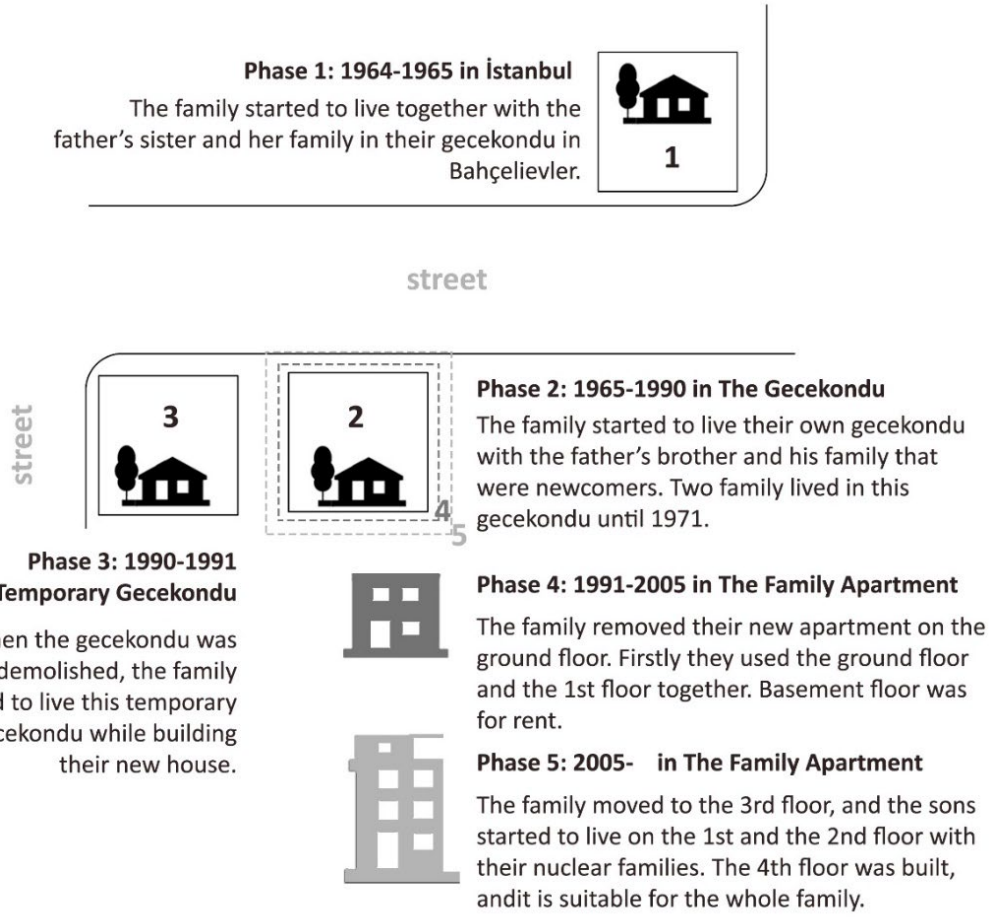

Figure 4 Historical displacements of the family in Istanbul

The photos taken in the same place sometimes formed a whole and almost created a 360-degree panorama of that space. These spaces were represented with small plan sketches supported by perspective drawings, detailed object drawings, or drawings describing actions (Figure 5).

The data that came out with photos, short chats, and interviews constituted a story in the end. The researcher tried to visualise this story in the photo collage sketchbook. This sketchbook consists of photographs, drawings, collage layers, and short notes but does not contain a single production technique; as the researcher's vision improved and parts of the story were completed, the sketchbook evolved its approach.

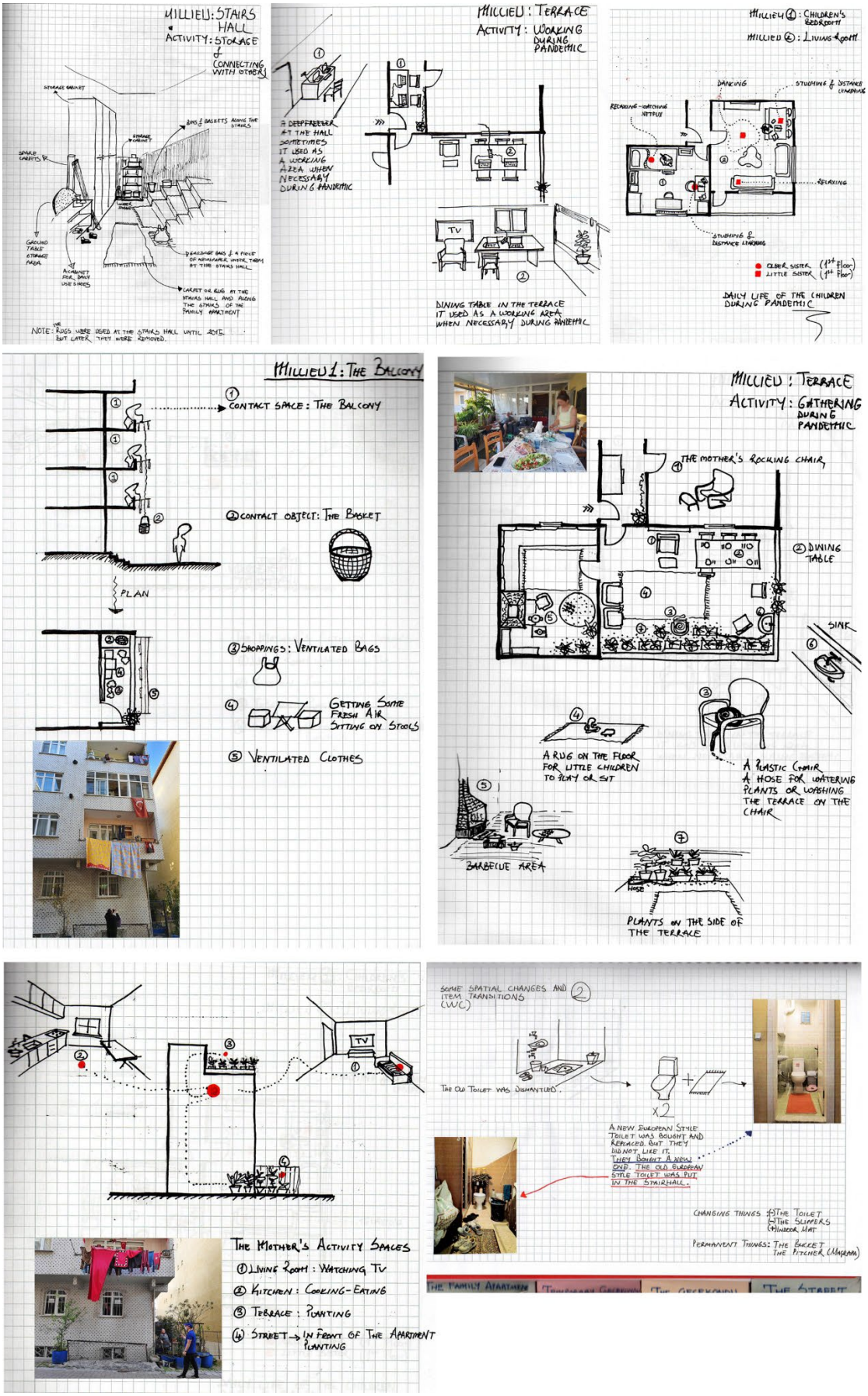

Figure 5 Observation sketch examples contain small plan sketches, perspective drawings, detailed object drawings or drawings describing actions, and photos. (The first author, 2020)

In this process, the approach of the photo collage sketchbook, the production techniques, and the collage materials have evolved. Hence, this paper describes an approach, rather than a method, to use family photography and architectural representation techniques for gathering and representing data.

4.3. Step 3: Reconstructing the deconstructed layers: synthesis of the ethnographic data

At this stage, the photo collage sketchbook, which emerged as a chronological displacement album, took the researcher to a place she had never been. The photographs, enriched with drawings, collages, and short notes, went beyond their frames and brought to life the space with daily life inside (Figure 6-7).

Figure 6 Collage examples with family photos, sketches, and text from the Sketchbook. They also contain transparent layers to deconstruct the spatial and cultural components of the images. (The first author, 2020)

Firstly, the researcher sought the spatial and cultural equivalents of the layers separated from each photo frame. Each spatial and cultural layer in the photographs was transferred and marked on transparent layers. These layers may appear as how people use the space or the object, the alternative relationship models with the outer space, and different meanings attributed to the place or the object. In addition, these layers show certain common features as the number of photographs increases over time. These features appear as a visual code, and each piece of content in the photo collage sketchbook has ceased to be an object that made contact with the researcher. Instead, each layer communicating with the researcher and the researched community has become a building block to construct holistically ethnographic knowledge. The production of ethnographic knowledge has been tried to be represented through photographs. However, the resulting picture

is no longer just a photographic frame. The researcher's interviews and short conversations with the participants, combined with the participants' drawings, the researcher's sketches, and notes, thickened with transparent layers, turned into a collage that transcends borders.

Figure 7 Mixed technic sketches for understanding the experiences before the family apartment building life. (The first author, 2020)

Banks (2007) defines the terms figure/ground as things that appear significant and those that seem incidental. In light of the narratives and visuals in this third stage, the ground in some family photographs was transformed into a figure; in others, the background was wholly erased or sometimes transformed.

The photo collage sketchbook, which acts as a visual living organism within the framework of the culture-space-behaviour relationship, has built its production approach and the ethnographic meaning it wants to reach and convey.

At the end of this stage, the researcher met the participants again and gave them a presentation of the photo collage sketchbook. Because each participant had many fragmented and scattered photographs, seeing them chronologically within the framework of a particular story gave them emotional moments. One of the participants said, *"As if my life has become a movie and I am sitting and watching it"* during the sketchbook examination. It reveals the importance of the story for them.

The big picture built with each piece of photography is the story itself. The participants stated their positive feelings about the photo collage sketchbook made with their photographs, and the researcher made a presentation to them with the sketchbook. Photographs were part of them and a familiar object. They indicated they were tense, thinking that only a long paper would be the result, and stated that they were relieved that the researcher told their story visually.

5. Conclusion

This study presents photo collage sketchbooks that emerged while doing ethnographic research to examine the relationship between culture and the spatial configurations of family apartment buildings in Turkey. The three-step process presented in this paper constitutes only a specific part of the main research. Photo collage sketchbooks helped the researcher create a visual story of the field while conveying the relationship between the places where the participants lived in the past and their cultural behaviours.

Interviews with the participants were insufficient to fully understand a place the researcher had never been before, and this problem forced the use of photo collage sketchbooks. While creating these sketchbooks, the photographs obtained from the participants were grouped chronologically and spatially. One-on-one interviews were held with the participants during this process. At this stage, some photos acted as a trigger for the participants to remember the past. Photographs were used as visual representations during the data collection phase, but simultaneously, the participants tried to convey information through drawings. In addition, the data was enriched by the drawings in the field and supplemented with short notes. Therefore, the photo collage sketchbooks were created with a mixed technique. The use of photo collage notebooks in this research is a trigger that transfers the story, a tool to manage the visual data analysis process, and a tool to transform the data into an analysable, understandable, and transferable form. The photo collage sketchbook was deconstructed, but then a new ethnographic knowledge was built with all the deconstructed building blocks.

During the research process, family photographs served as objects that embodied the data obtained by the researcher in the pre-interviews and observations. For example, while living in the squatter, the lack of water infrastructure made water valuable. For this reason, spare water bins were seen all over their homes in the photographs. After the family moved to their apartment, they had a water infrastructure in their house, with no frequent water cuts. Nevertheless, it was seen in the observations and family photos that there were still water-filled bins in all the rooms of their houses. How the absence affects the storage habits has emerged by considering the photographs and observation data together. The spatial equivalents of this behaviour in the family apartment building have been discussed by trying to make a sociocultural expansion with open-ended interviews. The researcher's tendency to think visually as an architect constructed this approach while observing the cultural expansion of the behavioural patterns in the family apartment building. For this reason, the photographs were enriched with drawings and short notes, and the behavioural patterns were first deconstructed and transformed into layers and became analysable. Later, they were brought together again and tried to be associated with their spatial counterparts.

Ethnographers' own experiences consider observable, recordable, and translatable realities and the intangible and sensory nature of human experience and knowledge, objects, and images (Pink, 2001). While trying to understand the space in the culture-space-behaviour triangle, looking at the photograph and listening to the life narratives of the participants made an essential contribution to the research.

In the context of this study, some limitations were encountered while conducting visual ethnographic research. First, it is not easy to access the photographs of the participants while conducting the research. As mentioned in the previous sections, family photos are private, and it is difficult for the participant to share them with someone they do not know. Being an insider, of course, provides an advantage in gaining that trust. While obtaining the photographs, one-on-one interviews with the owners of the photos were one of the primary sources of information. However, to increase the reliability of the data, collective interviews were conducted in the second stage. Collective interviews have been a critical move to compare and verify the memories recalled by the participants. In addition, joint interviews created a chain of memory storms among the participants, revealing more data. While interviewing, it is vital to show the photos to every participant from a

particular age group because they contribute differently to the photo components because of the place experience.

Kuschnir (2016) expresses that hand drawing and using a sketchbook in ethnographic research humanise the researcher in the eyes of the participant. In addition to the fact that the researcher was a family member, drawing something instead of writing via a computer or a sketchbook beside the participants reduced the tension of the interview. Going beyond words or writing, collages as a new expression technique facilitated access to sensitive sensory areas for the participants and contributed to collective knowledge production. Photo-collage sketchbooks were used to overcome difficulties encountered during data collection due to the ambiguous role of the researcher.

Berger (1972) mentions that we always look at an alive and active relationship between people and objects. It is not an isolated thing. Completing existing photographs with drawings and trying to combine the invisible parts of the space made it easier to see the interactions between people, space, and objects. The aim is to expand the physical boundaries of the place visible in the photographs, read them in the context of culture-space-behaviour, and imagine daily life. While doing this, being there as an architect has some advantages. Being accustomed to working with visuals and drawings made it easier to reveal the data. Thinking with lines and supporting them with texts has created a coding language. Unlike the photo transcription method, widely used as a visual ethnographic research method, the synthesis of ethnographic knowledge is also expressed visually. The data gained from the moment the researcher met the family and the information obtained from the photos and life narratives quickly became inter-related. As a diachronic flashlight, photo collage sketchbooks shed light on the narratives while revealing how this story has developed and evolved through time.

Banks (2001) expresses visual images' complex and problematic nature and underlines that they are an omnipresent aspect of almost all human social relations. It is possible to say that visual images are a complex but indispensable aspect of architecture and design. Collier and Collier (1986) state that technical skills alone do not enable the collection of readable data and underline the difficulty of observing meaningfully. Although the researcher's familiarity with using visual images as an architect helped her in this study, it was initially difficult for her to find an architecturally correct representation technique in the sketchbooks. Over time, this problem has been solved using a mixed technique appropriate to the nature of the research, not from an architectural point of view.

The production technique of the collage sketchbook is entirely dependent on the researcher and the researched subject. This study used photographs, drawings of the participants and researcher, short notes and transparent layers while deconstructing the visual items. The technique used while creating these collages can evolve according to the time the researcher spends in the field and the quantity and quality of the text and visual documents obtained. For example, while the deconstruction of the family photos was done by dividing them into layers in the early stages of the study, the researcher encountered similar layers in the photographs over time, and her brain doing this automatically changed the collage sketchbook's production technique. Powell (2015) mentions that the researcher's personal experiences come into play when analysing, interpreting, or presenting a space. She adds that, as an insider, looking at a photo and understanding what is behind it, discovering the contradictions, and learning what to look for to see what is behind the present moment is essential. With a similar approach, Berger (2005:71) states: *"The drawing of a tree does not show a tree but a tree-being-looked-at."* So, this study is not about a set of instructions or tools but experiences about the process or approach to constructing ethnographic knowledge.

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A timeless journey of strength and beauty: The potentials of the use of stone in architecture

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Abstract

Use of stone in architecture has been an enduring and timeless tradition throughout history, withstanding the test of time from ancient civilizations to today's architecture. The durability, versatility and aesthetic appeal of stone make it an exceptional material for creating striking architectural designs. Stone has been used for centuries, as an integral part of architecture since ancient times and its importance still holds true in contemporary architecture being a popular building material today. In this context, this study examines the key features of stone that make it such a vital material for architectural design by exploring the advantages and disadvantages of using stone for architecture. The paper examines the role of stone in architecture and explores how contemporary projects have utilized stone in innovative and creative ways also delves into the significance and beauty of stone architecture, highlighting its history, durability and aesthetic appeal. The research methodology includes the analysis of case studies of contemporary projects crafted from stone, examining the design process, materials and techniques used. The case studies analyzed in this paper demonstrate the versatility of stone in contemporary architecture. The projects showcase how stone can be used in innovative ways, including the creation of sculptural forms, the incorporation of technology and the utilization of sustainable materials. The paper argues that stone's timeless qualities, durability and versatility make it an ideal material for contemporary architecture, particularly in achieving sustainability and aesthetic appeal. The study concludes that the use of stone in architecture remains crucial in creating robust, sustainable and attractive structures that stand the test of time.

Keywords: architectural image, stone material, use of stone in architecture, picturesque buildings, timeless structures

1. Introduction

In the realm of architecture, the choice of materials carries profound significance, shaping not only the aesthetics but also the very essence of the built environment. From ancient civilizations to modern-day construction practices, materials have been instrumental in defining the visual, functional and experiential qualities of architectural spaces. Materials have always played a crucial role in the expressive language of architecture. Their inherent qualities, such as color, texture and transparency can evoke emotions and create sensory experiences (Biçer & Erdinç, 2023a; Öktem Erkartal, 2022). However, among the myriad options available, few materials possess the timeless allure and inherent strength of *stone*.

Throughout history, various civilizations recognized the qualities of stone and harnessed its potential in architectural design. Stone possesses exceptional strength, making it an ideal material for creating sturdy and long-lasting structures. Dal and Tokmak (2020) also states since it is an original, aesthetic, durable, healthy and sustainable material, it has been used in different forms in the past and today. 'Stone's allure extends beyond its utilitarian aspects. Its unrivaled durability and

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weathering resistance ensure that stone structures persist through the ages, testifying to the indomitable spirit of their creators. Furthermore, its innate thermal properties offer natural insulation, fostering energy efficiency and sustainable design. The aesthetic appeal of stone lies in its ability to evoke a sense of timelessness and authenticity. Whether it manifests as the grandeur of ancient Egyptian pyramids and Roman temples, the delicate tracery of Gothic cathedrals or the sleek lines of contemporary edifices, stone brings a sense of permanence and gravitas to architectural compositions (Figure 1 & Figure 2).

Figure 1a Egyptian Pyramids (Stewart, 2018) & **Figure 1b** Roman Temple (Ambler, n.d.)

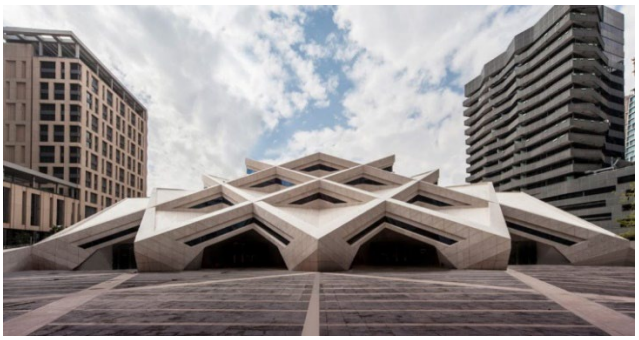

Figure 2a Gothic Cathedral (Steves, n.d.) & **Figure 2b** King Abdullah Grand Mosque (Sawantt, 2021)

Moreover, stone serves as a testament to the harmonious relationship between human creativity and the natural world. Its extraction and transformation require a delicate dance with nature, striking a balance between preservation and utilization. The marriage of human ingenuity and the earth's ancient resources gives birth to structures which survive the judgment of time, embodying the spirit of civilizations past and present. From ancient civilizations such as the Egyptians and Greeks to modern architectural marvels, stone has played a significant role in shaping the built environment. For centuries, architects and builders have harnessed the potentials of stone, utilizing its unique properties to create monumental structures that stand as testaments to human ingenuity.

In this context, this study embarks on an exploration into the world of stone in architecture, unveiling the immense possibilities and inherent beauty that lie within its rugged embrace. By delving into the rich history of stone as a building material, its origins from ancient civilizations to today marvels will be traced. The primary objective of the study is to unearth the potentials of the use of stone in architecture and demonstrate how it can surpass conventional expectations and to shed light on the enduring appeal of stone and its ability to transcend time, culture and architectural styles.

The study aims to captivate readers with the unparalleled potentials of stone in architecture and serves as a gateway to this captivating journey by unraveling the qualities origins of stone, marveling at the intricate processes that shape its composition and imbue it with remarkable resilience. By investigating various aspects such as structural performance, sustainability, aesthetics

and cultural significance, it is aimed to provide a comprehensive understanding of the benefits and opportunities stone presents in contemporary architectural practice. Moving beyond its origins and qualities, the myriad virtues that make stone an exceptional choice for architectural expression will be explored.

To achieve the objectives, this study employs a multidisciplinary approach, encompassing literature review and case studies. Historical examples of stone architecture and contemporary projects that showcase innovative use of stone will be analyzed. To unravel the multifaceted aspects of stone in architecture, the research adopts a comprehensive and interdisciplinary approach. The study delves into an examination of literature, examining historical accounts, architectural theories and case studies that showcase the diverse utilization of stone across different eras and cultures to collage valuable insights into the technical aspects, challenges and innovations related to incorporating stone in contemporary architectural designs.

By undertaking a comprehensive exploration of the potentials of stone in architecture, it is aimed to inspire architects, students and enthusiasts alike, urging them to embrace the transformative possibilities offered by this “noble material” (the description as ‘noble’ was introduced by Assoc. Prof. Dr. Murat Dal in his study titled ‘The Noblest Building Material of Architecture: Natural Stone'). In this enlightening exploration, the readers and researchers are invited to join in unraveling the secrets and embracing the timeless allure of stone in architecture.

2. The Use of Stone in Architectural Compositions

The use of stone in architectural compositions has a rich history spanning thousands of years and continues to be a prominent material in contemporary architecture. Stone offers various attributes that make it desirable for architectural applications, including durability, strength, versatility and aesthetic appeal. Agarwal and Dogne (2016) note that stones are used in different constructions purposes such as for the construction of foundations, walls, columns and arches; for flooring; as damp proof courses, lintels and even as roofing materials; for the face works of buildings; for paving of roads, footpaths and open spaces round the buildings and in the constructions of piers and abutments of bridges, dams and retaining.

Dal (2011) states that the fact that natural stone is resistant to adverse weather conditions, has high load-bearing power and is abundant in nature has enabled it to be used as the noblest building material in architecture for centuries. The fact that natural stone allows building solid structures is one of the most important features that make natural stone superior to other materials.

Stone is a natural material formed over millions of years through geological processes. It possesses inherent *strength and resilience*, allowing buildings constructed with stone to withstand the test of time and environmental challenges such as weathering, earthquakes and fire. This durability has made stone a choice for the construction of long-lasting structures, monuments and historical landmarks. Stone's *versatility* is another factor that contributes to its use in architectural compositions. It can be produced in different dimensions, forms and patterns, allowing architects to create diverse and unique designs. Stones can be produced into intricate details, enabling the creation of ornate facades, decorative elements and sculptural features. Moreover, stone can be used in combination with other materials like glass, metal or wood, offering opportunities for innovative and visually striking architectural compositions.

Aesthetic appeal is a significant aspect of stone's usage in architecture. The natural beauty of stone, with its range of colors, patterns and textures, adds a sense of elegance and timelessness to buildings. Different types of stone, such as marble, granite, limestone and sandstone, each possess distinct visual characteristics, allowing architects to select a stone that aligns with their design intent. Beyond its technical and visual qualities, stone also carries *cultural and symbolic significance*. Throughout history, stone has been associated with stability, permanence and craftsmanship. The use of stone in architectural compositions can evoke a sense of tradition, cultural heritage and a

connection to the past. This symbolic value makes stone a compelling material choice, particularly for projects that aim to convey a sense of timelessness, prestige or reverence (Figure 3).

Figure 3a Roman Water Channel, Pont du Gard, France (National Geographic, n.d.) & **Figure 3b** Rajkumari Ratnavati Girl's School (Crook, 2021)

In a word, the use of stone in architectural compositions offers a multitude of benefits. Its durability, strength, versatility, aesthetic appeal and symbolic value make it a favored material for creating enduring and visually captivating structures. Whether in ancient civilizations or contemporary designs, stone continues to have a significant part in composing the built environment and leaving a lasting impression on architectural compositions.

2.1. Strength, Durability and Constructional Attributes

Stone is a widely used material in architecture due to its strength, durability and various constructional attributes. In ancient times it was chosen for its abundance: As a natural material, it was readily available and dependable. But there's a lot more to the material than one might expect and there's a reason why architects continue to build with it, around it and in it. It's no wonder that it's the chosen material for important monuments and buildings such as places of worship, castles and palaces, as it will outlast almost any other material (McGrath, 2019) (Figure 4).

Figure 4a Middle Age Church, France (Pxhere, n.d.) & **Figure 4b** Steen Castle, Belgium ("Steen Kalesi", n.d.)

Stone exhibits impressive *strength, hardness and toughness* which contributes to its structural integrity. The compressive strength of stone is crucial in load-bearing applications. Different types of stone possess varying strength properties, with igneous rocks typically having higher compressive strength than sedimentary or metamorphic rocks. Balasubramanian (2017) states that factors such as hardness or softness of the components, proportions of the hard and soft minerals, size and shape of the minerals, cohesion, porosity, density and cementing material affect strength, hardness and toughness of stone material. Tensile strength, however, is generally low in stone, making it susceptible to cracking under tension. Its density and compressive strength make it capable of withstanding immense loads and resisting weathering effects. Stone structures have demonstrated remarkable resilience throughout history, enduring nature and the test of time.

Stone is renowned for its exceptional *durability*, making it suitable for long-lasting structures. It is resistant to weathering, erosion and decay, allowing stone buildings to withstand the test of time. The composition and structure of stone play a crucial role in its durability. For instance, igneous rocks like granite are known for their high resistance to wear and tear. Strength and durability are essential properties of building stone.

Stone offers several advantageous *constructional attributes*. Stone is a heterogeneous substance characterized by a wide range of mineral compositions, textures and rock structures. Consequently, the physical and chemical properties and the resulting durability are quite variable. The suitability of a stone for a given building can be easily tested in the laboratory (Winkler, 1997). Some physico-mechanical properties to determine where to use natural stones are needed to be known. For example, while density and porosity negatively affect some physical and mechanical properties, they positively affect heat and sound insulation. Those properties are more critical when it comes to the construction of outdoor spaces and large structures under different climatic conditions (Biçer, 2022).

In addition to being long-lasting and magnificent, buildings made of stone materials also have thick walls that provide many advantages in terms of maintaining *thermal comfort*. While these buildings generally do not need air conditioning in the summer, they can be heated with much less energy in the winter. Today, when considered in terms of increasing environmental pollution and energy use policies, stone buildings are considered to be very healthy and environmentally friendly structures. Stone has excellent *heat resistance* properties, making it efficient for applications involving high temperatures. Stone materials generally require minimal maintenance. They are resistant to staining, scratching and fading and can be easily cleaned with mild detergents and water. This attribute contributes to the longevity and cost-effectiveness of stone installations. Stone exhibits high *thermal mass* that provides absorbing, storing and releasing heat slowly which also helps energy efficiency. This attribute helps adjustment of indoor temperatures, contributing the energy efficiency by reducing the exorbitant heating regulation.

Each stone possesses unique characteristics due to *natural variations* in mineral composition, texture and geological formation. This variation adds an element of distinctiveness to stone applications, ensuring that no two stones are exactly alike. It also allows for customization and selection based on specific aesthetic preferences. Moreover, stone can be laid in different patterns, such as ashlar (rectangular blocks) or rubble (randomly shaped stones), providing a wide range of aesthetic possibilities. Stone possesses excellent *sound insulation* related with its density and natural composition that allows it to reduce noise transmission, making it suitable for applications in sound-sensitive environments like recording studios or concert halls. Stone materials are generally resistant to chemicals, including acids and alkalis. This attribute ensures their suitability for applications that involve exposure to potentially corrosive substances.

2.2. Natural Beauty, Aesthetical Appeal and Visual Attributes

The natural beauty, aesthetical appeal and visual attributes of stone material in architecture are derived from unique colors, patterns, textures and veining. By incorporating stone into architectural designs, architects can create visually captivating spaces that evoke a sense of timelessness and elegance while benefiting from the durability and longevity provided by these materials.

One of the key attributes of stone is its *natural beauty*. Different types of stone possess unique colors, textures and patterns, allowing architects to create visually stunning structures. The use of stone in architecture provides a sense of timelessness and permanence, as it ages gracefully and retains its elegance over centuries. This enduring quality has made stone a preferred choice for the construction of iconic landmarks like the Great Pyramids of Giza (see above Figure 1), the Parthenon and medieval cathedrals (Figure 5). Stone materials, such as marble, granite, limestone and sandstone are formed over thousands or millions of years through geological processes. Their natural beauty lies in their diverse colors, patterns, textures and veining, which are influenced by

factors like mineral composition, sedimentation and metamorphism. These characteristics make each block unique, adding a sense of authenticity and timelessness to architectural structures.


Figure 5a Parthenon, Greece (Sawe, 2018) & **Figure 5b** Duomo di Milano, Italy (Medieval Chronicles, n.d.)

Stone has long been favored in architecture for its *aesthetic appeal*. The use of stone imparts a sense of grandeur, elegance and sophistication to buildings. The rich colors and intricate patterns found in stones like marble create visually striking surfaces that can be used to enhance the overall design and atmosphere of a space. Stone's ability to reflect light can also contribute to a building's visual allure, particularly when it interacts with natural or artificial lighting.

The *visual attributes* of stone materials play a crucial role in their appeal. Stones exhibit a wide *spectrum of colors*, ranging from pure white to deep blacks and everything in between. Variations in color can be attributed to the presence of different minerals or impurities within the stone. Architects can leverage these color variations to create contrasts or harmonies within a design, enabling them to evoke specific moods or aesthetics. The color of structural and monumental stone has challenged the architect for the most effective and harmonious appearance in architectural design since ancient times. The utilization of different color shades of stone has given new life to many existing structures. Stone colors are influenced by the color of the predominant mineral, but also by the adjacent minerals, grain size and grain cement (Winkler, 1997).

The *texture of stone*, such as smooth, rough or textured surfaces, adds depth and tactile interest to architectural elements. Texture influences how light interacts with the stone, contributing to the overall visual experience. Rough textures can create a sense of ruggedness or organic connection, while polished surfaces can convey a more refined and contemporary feel. Many stones exhibit unique *veining patterns*, such as the characteristic marbling in marble. These patterns add visual interest and create a sense of movement and flow within the stone. Architects often use the natural patterns of stones to create focal points, feature walls or statement pieces, enhancing the overall aesthetic appeal of a space.

3. Exploring the Historical Context and Cultural Significance of Stone in Architecture

The historical context and cultural significance of stone in architecture unveils a rich tapestry of human ingenuity, artistic expression and cultural identity. From ancient civilizations to the present day, stone remains an enduring symbol of architectural excellence and a testament to the lasting impact of human creativity on the built environment. Exploring the historical context and cultural significance of stone in architecture provides valuable insights into the evolution of human civilization and the intrinsic relationship between culture and the built environment.

For man, stone represented a basic material that enabled him to express his thoughts in shapes and structures that would facilitate his life and activities. Stone has represented for man a basic material to manifest his ideas in shapes and structures that facilitated activity and life. From this early moment until today, stone in building has had a central role in how man has conceived his built environment, shaped his world and represented the idea of it to others (Karakuş, 2014). As Pereira and Marker (2016) states, collections of samples of natural stones are an important source

of information especially if they are accompanied by information on buildings and structures in which they have been used, technical properties and aesthetic characteristics. Stone has played a pivotal role in architecture throughout history and its usage has varied across different cultures and time periods.

The historical context of stone in architecture spans ancient civilizations like Egypt, Greece and Rome, while its cultural significance is evident through symbolism, architectural expression, cultural identity and periods of revival. Notable examples include the Great Pyramids of Giza, the Parthenon, the Taj Mahal, Gothic cathedrals and the Palace of Versailles (Figure 6) (see above Figure 1 & Figure 5). These structures stand as enduring testaments to the historical and cultural importance of stone in architecture.

Figure 6a Taj Mahal, India (Unesco World Heritage Convention, n.d.) & **Figure 6b** Palace of Versailles, France (Chateau de Versailles, n.d.)

3.1. Historical Context

The history of man reveals clearly that the origins of architecture are deeply intertwined with buildings in stone (Karakuş, 2014). The use of stone in architecture allowed the creation of permanent structures, marking a significant shift from temporary shelters to enduring monuments. The construction of megalithic structures, such as Stonehenge or the Pyramids, showcases the awe-inspiring capabilities of early civilizations in manipulating and utilizing stone. Natural stones, with their elegance, durability and potential richness, have been one of the indispensable branches of art and building elements of humankind for centuries; Hittites, ancient Egyptians, Phrygians, Mesopotamian Civilization, Persians, Lydians, Ancient Greeks, Romans, Seljuks, Ottomans and many other civilizations used it in their sculptures, monuments and magnificent structures that have survived to this day and shed light on their era (Dal, 2011) (Figure 7).

Figure 7a Yakutiye Madrasa Erzurum, Türkiye (TRT Haber, n.d.) & **Figure 7b** Great Ziggurat of Ur, Iraq ("Sumerian Period", n.d.)

Ancient Civilizations: Stone has been a fundamental material in architecture since ancient times. For instance, in ancient Egypt, the use of stone was prevalent due to the abundance of limestone along the Nile River. The Great Pyramid of Giza, exemplify the remarkable mastery of stone construction during this period (Figure 8). All three of Giza's famed pyramids and their elaborate burial complexes were built during a frenetic period of construction, from roughly 2550 to 2490 B.C. The pyramids were built by Pharaohs Khufu, Khafre and Menkaure (Handwerk, 2011) (see above Figure 1).

Classical Greece and Rome: Stone played a pivotal role in the architectural achievements of ancient Greece and Rome. Parthenon, temple that dominates the hill of the Acropolis at Athens. It was built in the mid-5th century BCE and dedicated to the Greek goddess Athena Parthenos ("Athena the Virgin"). The temple is generally considered to be the culmination of the development of the Doric order, the simplest of the three Classical Greek architectural orders ("Parthenon", n.d.). The Parthenon utilized marble to create an iconic temple. Colosseum, also called Flavian Amphitheatre, giant amphitheater built in Rome under the Flavian emperors. Construction of the Colosseum was begun sometime between 70 and 72 CE during the reign of Vespasian. It is located just east of the Palatine Hill, on the grounds of what was Nero's Golden House. The artificial lake that was the centerpiece of that palace complex was drained and the Colosseum was sited there, a decision that was as much symbolic as it was practical ("Colloseum", n.d.). The Colosseum showcased the grandeur of Roman architecture, with its massive stone structure and arches (Figure 8).

Figure 8a Great Pyramid of Giza, Egypt (Stokel-Walker, 2023) & **Figure 8b** Roman Colosseum ("Roma Kolezyumu", n.d.)

3.2. Cultural Significance

Stone, the oldest building material in human history, is found in nature as a mineral. Natural stone, which can be used in more than one area as a construction material, affects the appearance of the architectural products and the atmosphere of the created space with its characteristic features. Natural stone has different properties depending on the region where it is extracted. Thus, every building built carries the character and spirit of the region, as it is created with the materials of the region (Korkmaz & Özcan, 2021). Throughout various cultures, stone has been revered for its symbolic and cultural significance. In ancient Egypt, for example, stone, particularly limestone and granite, was believed to possess divine qualities and was used extensively in the construction of temples and tombs for pharaohs. The intricate carvings and hieroglyphics on stone surfaces conveyed religious beliefs and historical narratives.

Symbolism and Prestige: Stone carried symbolic meaning and represented prestige in architectural contexts. The Taj Mahal in India, built in the 17th century, is a prime example (Figure 9). Constructed primarily using white marble, it symbolizes love and devotion, while the use of stone emphasizes its immortality and enduring beauty.

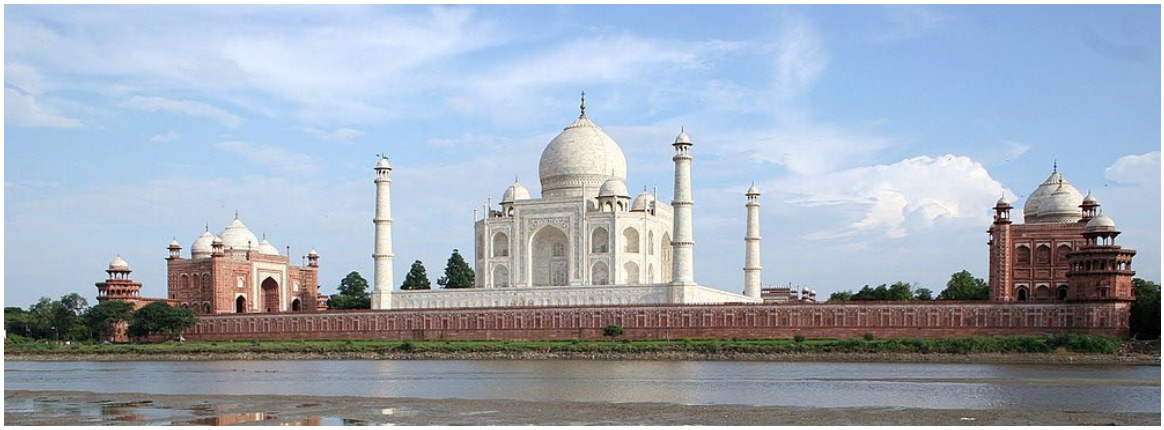

Figure 9 Taj Mahal (Handicrafts, 2019)

Architectural Expression: Stone allowed architects to express their artistic vision and showcase their skills. The intricately carved stone facades of the Gothic cathedrals in Europe, such as Notre-Dame Cathedral in Paris (Figure 10), exemplify the level of detail and craftsmanship achieved by stonemasons. Constructed between the 12th and 14th centuries, Notre Dame de Paris has borne witness to countless historical events, wars and revolutions. The cathedral's breathtaking stained-glass windows, elaborate stone carvings and soaring spires, which reach heights of over 100 meters (Friends of Notre-Dame de Paris, n.d.). This structure served as spiritual and architectural masterpieces, integrating sculpture, stained glass and flying buttresses.

Figure 10a Notre-Dame Cathedral (Afar, n.d.) & **Figure 10b (**Friends of Notre-Dame de Paris, n.d.)

Cultural Identity: The use of stone in architecture often reflected regional resources and cultural identity. For instance, the Inca civilization in South America employed massive stone blocks, precisely carved and fitted together, in structures like Machu Picchu (15th century) (Figure 11). The buildings were given walls of drastically different sizes, each made up of stones that had been stacked with impeccable accuracy. It's just one example of the Inca's specialty when it came to construction: ashlar or dry stone masonry. The masonry might sway and move, but it wouldn't topple, always settling back into place (Tour in Peru, n.d.). These constructions demonstrated the Inca's sophisticated understanding of stone craftsmanship and their deep connection to the natural environment.

Figure 11a Machu-Picchu ("Machu Picchu", n.d.) & **Figure 11b** ("Machu Picchu Gateway", n.d.)

Revival and Reinvention: Stone experienced a revival during the Renaissance and Baroque periods. Palace of Versailles, former French royal residence and center of government, now a national landmark. It is located in the city of Versailles, Yvelines department, Ile-de-France region, northern France, 16 km west-southwest of Paris. As the center of the French court, Versailles was one of the grandest theatres of European absolutism ("Palace de Versailles", n.d.). The Palace of Versailles in France (17th century) (Figure 12) (also see above Figure 6) showcases the grandeur and opulence of this era, with its extensive use of stone in the palace's façade, interior and gardens. Stone was chosen for its association with classical aesthetics and the desire to evoke the glory of ancient Rome.

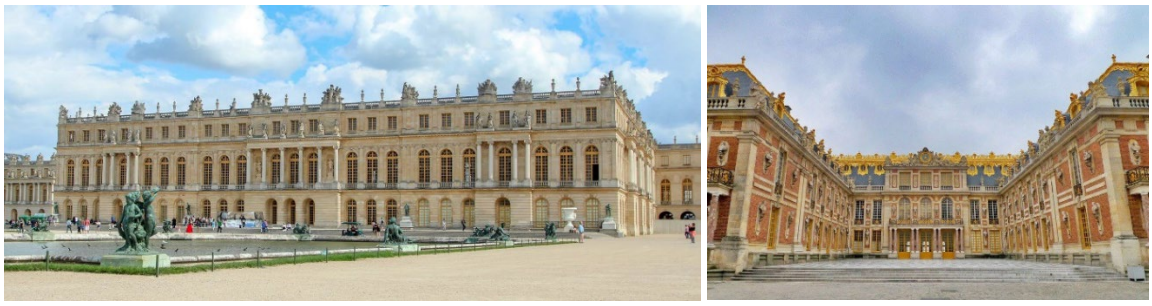

Figure 12a Palace Versaiiles (Palace of Versailles, n.d.) & **Figure 12b** (World in Paris, n.d.)

4. Seamlessly and Aesthetically Blending with the Surroundings

The use of stone has a long-standing history and remains popular due to its unique qualities, including strength, durability and aesthetic appeal. When strategically utilized, stone can create visually striking buildings that seamlessly blend with their surroundings (Figure 13).

Stone has been a preferred building material for centuries due to its inherent strength. Its capacity to bear heavy loads makes it suitable for constructing large and structurally complex buildings. Additionally, stone's durability allows structures to withstand the test of time, often lasting for centuries without significant deterioration. When it comes to visually striking architecture, stone offers a diverse range of textures, colors and patterns. This versatility enables architects to design buildings that harmonize with their natural or urban environments. By selecting stone that align with the surrounding landscape or urban context, architects can create structures that blend seamlessly with surroundings, enhancing the visual appeal.

Figure 13a & Figure 13b Sancaklar Mosque, Türkiye (Mairs, 2015)

To achieve a seamless integration with the surroundings, architects consider various factors. They analyze the local geology and select stone types that are indigenous to the region, ensuring a harmonious connection between the building and its environment. Careful attention is paid to the building's scale, shape and material composition to ensure that the stone elements complement the natural or urban landscape. The use of stone in architecture offers a unique opportunity to create structures that seamlessly blend with their surroundings, both aesthetically and functionally. Stone has been utilized in architecture for centuries due to its durability, versatility and natural beauty. When employing stone in a way that harmonizes with its environment, several key factors come into play.

Firstly, the choice of stone type is crucial. Different varieties of stone possess distinct characteristics such as color, texture and veining. Architects must carefully select a stone that complements the surrounding natural or built environment. For instance, if the surroundings feature predominantly earthy tones, a warm-hued stone like sandstone or limestone could be chosen to achieve visual integration. Next, the design and placement of stone elements should reflect a deep understanding of the site's context. Architects must consider the topography, vegetation and existing structures to ensure a seamless blend. By utilizing stone in a way that follows the natural lines and contours of the land, the architecture can appear as if it is emerging organically from the environment.

Figure 14 Oslo Opera House, Norway (Swegon Air Academy, 2022)

Furthermore, the size, shape and arrangement of stone elements play a significant role. The scale of stones should be in proportion to the overall structure and its surroundings. Carefully crafted stone walls, facades, or pathways can mimic the patterns found in the adjacent landscape, creating a sense of harmony. Additionally, irregularly shaped stones or a mix of different sizes can mimic the randomness found in nature, enhancing the aesthetic appeal. The craftsmanship involved in working with stone is also critical. Attention to detail is essential to achieve a seamless integration. Skilled stonemasons can create precise joints, intricate carvings, or textured surfaces that mimic natural formations. This craftsmanship helps establish a tactile connection between the architecture and its surroundings, enhancing the overall aesthetic experience.

Lastly, the long-term maintenance and preservation of stone elements should be considered. Regular cleaning and maintenance are necessary to prevent weathering or staining that could disrupt the intended blend with the surroundings. Architects should also pay attention to sustainability by sourcing stone locally, minimizing transportation impacts and considering the life cycle of the materials used. The use of stone in architecture allows for the creation of visually striking buildings that seamlessly blend with their surroundings. By capitalizing on the material's inherent strength, durability and aesthetic qualities, architects can design structures that both stand the test of time and enhance the beauty of their environment. The careful selection of stone types, attention to detail in construction and consideration of the building's context all contribute to achieving a harmonious integration between architecture and nature or the urban fabric.

In summary, seamlessly and aesthetically blending stone with the surroundings in architecture requires careful consideration of stone type, design, placement, scale, craftsmanship and long-term maintenance. By incorporating these elements thoughtfully, architects can create structures that not only harmonize with their natural or built environment but also evoke a sense of timelessness and connection to the surrounding landscape.

5. Picturesque Buildings Showcasing the Brilliant Use of Stone Material

The use of stone in architecture has been celebrated for its brilliant combination of design flexibility and architectural freedom. Stone is a versatile and durable material that offers a wide

range of aesthetic possibilities, allowing architects to create stunning structures while ensuring longevity and stability. Design flexibility is one of the key advantages of using stone in architecture. Additionally, stone offers a wide variety of colors, textures and finishes, providing architects with a diverse palette to work with. Architectural freedom is another benefit of using stone. Its strength and durability ensure the longevity of the building, while also providing a sense of permanence and stability. With stone, architects can create grand structures that stand the test of time, evoking a sense of awe and admiration.

The examples below demonstrate how the brilliant use of stone in architecture, considering design flexibility and architectural freedom, can result in awe-inspiring structures that stand as testaments to human creativity and ingenuity.

Taj Mahal, India: The Taj Mahal (Figure 15) (also see above Figure 6 & Figure 9) is a masterpiece of Mughal architecture and an enduring symbol of India. Constructed in the 17th century, it showcases the exquisite use of white marble. An immense mausoleum of white marble, built in Agra between 1631 and 1648 by order of the Mughal emperor Shah Jahan in memory of his favorite wife, the Taj Mahal is the jewel of Muslim art in India and one of the universally admired masterpieces of the world's heritage (Unesco World Heritage Convention, n.d.). The primary stone used in the construction of the Taj Mahal is a white marble. The choice of white marble was deliberate, as it symbolizes purity and serves as a canvas for the intricate decorative elements. The stone's durability and resilience have played a crucial role in preserving the Taj Mahal's grandeur over the centuries. The marble used in its construction has withstood the test of time, despite exposure to environmental factors. However, pollution, weathering and human activity have posed challenges, necessitating conservation efforts to maintain the monument's splendor.

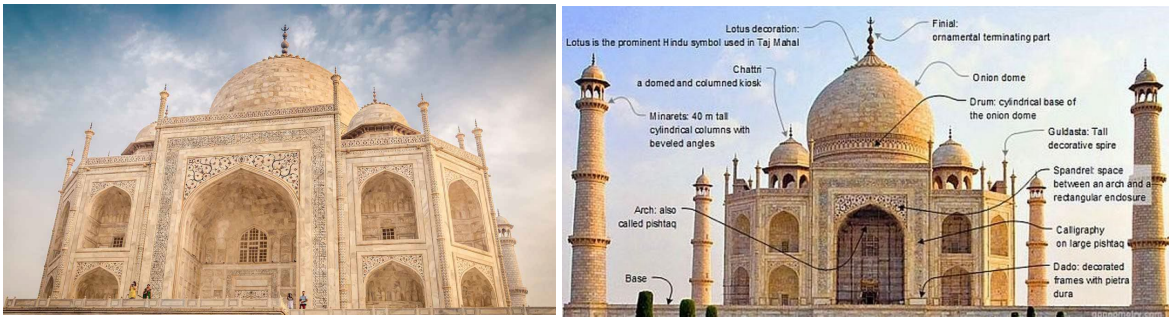

Figure 15a Taj Mahal, India (Gritora, 2022) & **Figure 15b** (Handicrafts, 2019)

Sagrada Familia, Spain: Designed by Antoni Gaudí, the Sagrada Familia in Barcelona (Figure 16) is an architectural marvel that showcases the exceptional use of stone. The Sagrada Familia in Barcelona, designed by Antoni Gaudí, is a prime illustration of this. Gaudí's dream-like vision combined Gothic and Art Nouveau elements, resulting in a transcendent and otherworldly atmosphere within the cathedral (Biçer & Erdinç, 2023b). The basilica features a combination of materials, including limestone, granite and basalt. The stone elements are intricately carved and sculpted, creating a dynamic and organic appearance. The various textures and colors of the stone enhance the building's visual complexity, while the strength and durability of the materials ensure its longevity.

Figure 16a Sagrada Familia, Spain ("Sagrada Familia", n.d.) & **Figure 16b** (Spain Official Tourism, n.d.)

Petra, Jordan: Petra is a UNESCO World Heritage Site an ancient city and a remarkable example of the use of stone in architecture. The availability of high-quality sandstone in Petra was a key factor in its architectural design. The sandstone cliffs provided a readily accessible and durable material for construction. The Nabateans skillfully carved and shaped the stone to create intricate facades, temples, tombs and water channels. The reddish hue of the sandstone adds to the unique aesthetic appeal of the city. Secondly, the use of stone in Petra served practical purposes. The solid stone structures provided stability and strength, allowing buildings to withstand the test of time. Moreover, the choice of stone in Petra also had cultural and symbolic significance. The Nabateans believed that the rock formations held spiritual and religious importance. The integration of natural rock formations into their architecture created a harmonious connection between the man-made structures and the surrounding environment. Lastly, the durability of stone has contributed to the preservation of Petra over centuries. The stone structures have withstood natural forces, including erosion and earthquakes, protecting the legacy of this ancient city.

Figure 17a Petra, Jordan (Gillan, 2020) & **Figure 17b** (Memphis Tours, n.d.)

Fallingwater, USA: Designed by Frank Lloyd Wright, Fallingwater (Figure 18) is an iconic residence that exemplifies the integration of stone and nature. In Fallingwater, Wright anchored a series of reinforced concrete "trays" to the natural rock. Cantilevered terraces of local sandstone blend harmoniously with the rock formations, appearing to float above the stream below (Frank Lloyd Wright Foundation, n.d.). The house is built over a waterfall and the use of local sandstone anchors the structure to the site. The stone walls and terraces echo the geological formations of the area, while large cantilevered balconies create a sense of dramatic suspension. The natural beauty and durability of the stone enhance the building's integration with the surrounding forest and waterfall.


Figure 18a & Figure 18b Fallingwater, Pennsylvania (Gibson, 2017)

The Colosseum, Italy: The Colosseum (Figure 19) (also see above Figure 8) is an iconic symbol of ancient Roman engineering. The massive stone blocks and arched openings demonstrate the architectural freedom provided by stone, enabling the creation of a colossal amphitheater that hosted grand spectacles. The primary building material used in the Colosseum is travertine limestone, a type of sedimentary rock abundant in the region. The extensive use of stone in the Colosseum served multiple purposes. Firstly, it provided a sturdy foundation and structural support. The massive stone blocks formed the base of the amphitheater, ensuring stability and strength. The use of stone also allowed the architects to create a tiered seating arrangement, accommodating a large number of spectators and maximizing visibility. Furthermore, stone was utilized for decorative purposes, enhancing the overall aesthetic of the Colosseum. Elaborate architectural details, such as columns, arches and friezes, were carved into the stone surfaces, showcasing the artistic prowess of Roman craftsmen.


Figure 19a Colosseum, Italy ("Colloseum", n.d.) & **Figure 19b** ("Ruins of Walkway at Colloseum", n.d.)

The Guangzhou Opera House, China: The Guangzhou Opera House (Figure 20), located in Guangzhou, China, is a remarkable architectural masterpiece designed by the internationally renowned architect Zaha Hadid. The use of stone in the opera house's construction and design is integral to its aesthetic appeal and structural integrity, reflecting both cultural and technical considerations. Stone plays a significant role in the exterior facade of the Guangzhou Opera House, contributing to its iconic and futuristic appearance. Large-scale granite panels are meticulously arranged to create a flowing and undulating form, reminiscent of the nearby Pearl River. The use of stone in this manner showcases the architect's vision and the technical expertise required to achieve such a complex design. Beyond its visual impact, stone also serves functional purposes in the opera house. It acts as a protective layer against weathering and provides insulation, contributing to the energy efficiency. The durability and longevity of stone materials ensure the opera house's sustainability and continued structural integrity. The selection of stone materials in the Guangzhou Opera House is also influenced by cultural context. The use of granite and marble,

traditional materials in Chinese architecture, pays homage to the country's rich cultural heritage while blending harmoniously with the contemporary design language of the opera house. This fusion of traditional and modern elements creates a unique architectural identity.

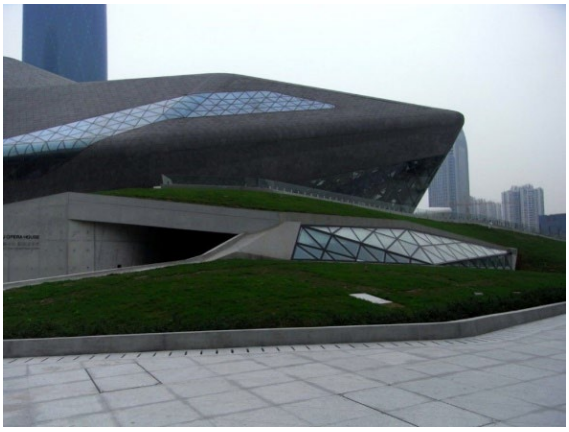
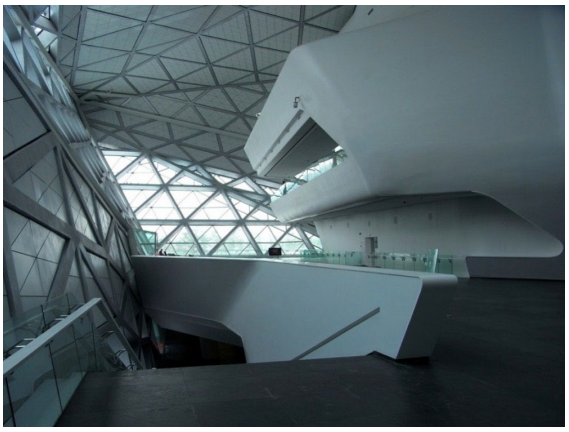

Figure 20a & Figure 20b Guangzhou Opera House, China (Sawantt, 2021)

King Abdullah Grand Mosque, Saudi Arabia: The King Abdullah Grand Mosque (Figure 21) is a prominent religious landmark in Saudi Arabia. The mosque is renowned for its grandeur and architectural magnificence, with the use of stone playing a significant role in its design and construction. Stone has been utilized extensively in various elements of the King Abdullah Grand Mosque, imbuing it with a sense of solidity, timelessness and reverence. The predominant stone material employed is marble, known for its durability, elegance and association with luxury and opulence. Marble is renowned for its ability to be carved and polished into intricate patterns, making it an ideal choice for intricate architectural details. The carefully selected stone cladding enhances the building's aesthetics while serving as a protective layer against environmental factors, ensuring the longevity of the structure. The contrast between light and dark shades of stone adds depth and visual interest to the external appearance of the mosque.

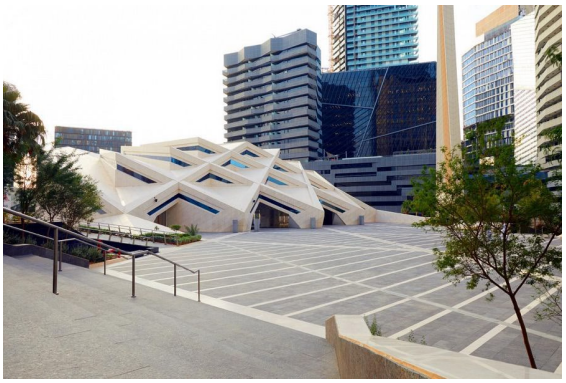
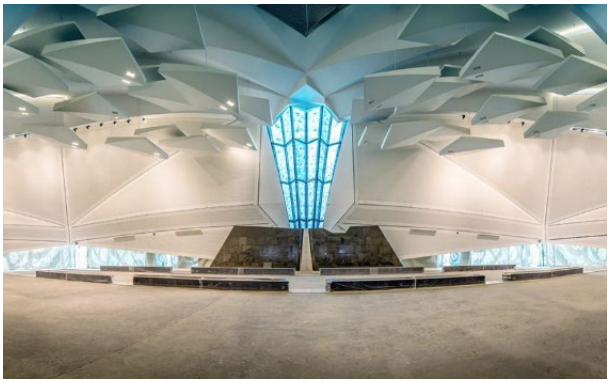

Figure 21a King Abdullah Grand Mosque, Saudi Arabia (Al-Saleh, 2022) & **Figure 21b** (Sawantt, 2021)

6. Timeless Power of Visual Expression of Stone Material

In all the iconic and visually stunning examples below, the effective and powerful use of stone in architecture is evident through the careful selection of materials, attention to craftsmanship and integration with the natural or cultural context. The stone enhances the buildings' aesthetic appeal, durability and visual expression, creating architectural masterpieces which inspire and captivate.

6.1. Casa Mila, by Antoni Gaudi

Casa Mila (Figure 22), also known as La Pedrera, is a renowned architectural masterpiece in Barcelona, Spain, designed by the renowned Catalan architect Antoni Gaudi. It exemplifies the exceptional use of stone, showcases a unique aesthetic and possesses a timeless power of visual expression.


Figure 22a Casa Mila, Spain (Arkitektuel, n.d.) & **Figure 22b** (La Pedrera, n.d.)

Designed by the world-famous Catalan architect Antoni Gaudi, Casa Mila is one of the most iconic buildings in Barcelona. Casa Mila, meaning House of Mila, was designed in 1912 for the use of Roser Segimon and Pere Mila. The building, also known as La Pedrera, is considered one of the most important representatives of the Modernista movement, the Spanish interpretation of Art Nouveau, in Barcelona. Casa Mila is an organic building. The building looks as if it has been carved from the ground and is trying to get away from the artificial appearance of architectural works. In order to achieve this structural organicity, the building is divided into two: structure and shell. The stone walls on the facade of the building have no load-bearing properties. Steel beams, which follow the same path as the inclined shape of the building, transfer the load of the facade to the columns (Arkitektuel, n.d.).

One of the most striking features of Casa Mila is its innovative and imaginative use of stone. Gaudi utilized limestone, a locally sourced material, to create a sense of harmony with the surrounding urban fabric. The stone is skillfully employed throughout the building, both in the load-bearing structure and the ornamental elements, showcasing its versatility and strength (Figure 23).


Figure 23a & Figure 23b Casa Mila, Spain (Casa Battlo, n.d.)

The building's facade is a testament to Gaudi's artistic vision and mastery of stone. The undulating organic forms of the exterior walls create a dynamic and sculptural appearance. Gaudi meticulously arranged the stone blocks, carefully shaping each one to fit the desired curves and contours. This attention to detail results in a visually captivating facade that appears almost fluid and alive. Gaudi's use of stone extends beyond the facade. The rooftop of Casa Mila is adorned with a forest of chimney stacks, known as espanta-somnis or “dreamcatchers”. These structures are constructed using stone and exhibit intricate detailing. The chimney stacks not only serve a functional purpose but also contribute to the building's aesthetic appeal, adding a whimsical and surreal touch to the design.

Figure 24a & Figure 24b & Figure 24c Casa Mila, Spain (Knowlton School, n.d.)

Moreover, the stone elements of Casa Mila exhibit a timeless power of visual expression. Gaudi's design embraces the natural qualities of the stone, allowing its texture and color variations to shine. The limestone used in Casa Mila features a warm, golden hue, which enhances the building's connection to the Mediterranean environment and creates a sense of harmony with the cityscape. The stone surfaces of Casa Mila also showcase Gaudi's attention to craftsmanship (see above Figure 24). The intricate carvings and ornamentation found on the balconies, windows and other architectural details demonstrate the meticulous care taken in the execution of the stone. This level of craftsmanship not only enhances the building's aesthetic quality but also contributes to its enduring appeal. Furthermore, Casa Mila's use of stone embodies Gaudi's philosophy of integrating architecture with nature. The fluid lines and biomorphic forms of the stone elements emulate the organic shapes found in the natural world. The building's undulating facade and the sculptural chimney stacks evoke the rugged cliffs and rock formations seen along the Catalan coastline, establishing a profound connection between architecture and its surroundings.

Casa Mila stands as a testament to the quality use of stone, aesthetics and timeless power of visual expression in architecture. Gaudi's innovative approach to stone construction and his careful use of the details have resulted in a building that seamlessly blends with its environment while showcasing the enduring beauty and strength of the material. Casa Mila's organic forms, intricate stone carvings and harmonious integration with nature make it a remarkable example of architectural excellence.

6.2. The City of Culture of Galicia, by Peter Eisenman

The City of Culture of Galicia (Figure 25), designed by Peter Eisenman, is a significant cultural complex located in Santiago de Compostela, Spain. While the complex utilizes various construction materials, the use of stone stands out for its quality, aesthetics and timeless power of visual expression.

Figure 25a & Figure 25b City of Culture of Galicia, Spain (Eisenman Architects, n.d.)

One of the notable aspects of the City of Culture is its extensive use of granite, a traditional and locally abundant stone in Galicia. Eisenman's design incorporates granite as a primary material, reflecting the region's architectural heritage and establishing a connection with the surrounding

landscape. The use of granite not only highlights the durability and strength of the material but also adds a sense of timelessness to the complex.

The hilltop site overlooks the medieval center of Santiago and required new links to the city through vehicular and pedestrian paths. The design of pedestrian caminos, or ways, on the site is derived from the city's historic street pattern. The caminos run between the buildings and lead to a multi-level plaza used for outdoor events. The forms of the buildings, related but different, seem to roll out of the landscape and echo the shape of the surrounding hills. The use of local stone, design of double roofs and an on-site power plant contribute to its environmental sustainability (Eisenman Arhitects, n.d.).

The aesthetics of the City of Culture are characterized by a unique interplay of geometric forms and abstract shapes. Eisenman's design embraces an architectural language known for its deconstructivist tendencies, with fragmented and angular elements that challenge conventional spatial perceptions. Within this framework, the use of stone contributes to the overall visual expression by providing a solid and grounded presence amidst the dynamic and abstract forms (Figure 26). The stone elements within the complex are carefully crafted with attention to detail. The granite surfaces exhibit a refined finish, showcasing the natural beauty and texture of the material. The precision in the stone construction and the meticulous placement of each granite block contribute to the aesthetic appeal and create a sense of craftsmanship.

Figure 26a & Figure 26b City of Culture of Galicia, Spain (Eisenman Architects, n.d.)

Moreover, the City of Culture of Galicia illustrates the timeless power of visual expression through the use of stone. The granite's inherent durability ensures that the complex will maintain its aesthetic integrity for generations to come. The material's natural color variations and textural qualities create a visually captivating environment, evolving with the play of light and shadow throughout the day. The presence of stone within the City of Culture also establishes a dialogue with the historic architecture of Santiago de Compostela. The integration of granite reflects the region's building traditions and pays homage to the rich cultural heritage of Galicia. This connection with the past creates a sense of continuity and contributes to the complex's significance as a cultural landmark (Figure 27).

Figure 27a & Figure 27b City of Culture of Galicia, Spain (Eisenman Architects, n.d.)

Furthermore, the use of stone in the City of Culture serves as a metaphorical representation of the region's identity and geological history. Galicia is known for its granite quarries and the incorporation of this material within the complex reinforces the relationship between architecture, culture and the natural environment. The stone acts as a link, symbolizing the deep-rooted connection between the built environment and the land it inhabits.

The City of Culture of Galicia designed by Peter Eisenman showcases the quality use of stone, aesthetics and the timeless power of visual expression. The extensive use of granite, the careful craftsmanship and the integration with the region's architectural heritage contribute to the complex's enduring beauty. The stone elements establish a sense of solidity and permanence within the abstract and dynamic architectural forms, creating a visually striking environment that reflects the cultural and geological context of Galicia.

7. Conclusion

As Korkmaz (2023) states that it is important for designers to carefully follow the developments in material technology and to reveal the unlimited potential in building design with the right material selection, without consuming natural resources and without harming the nature. In this sense, throughout this study, the vast potentials of the use of stone in architecture and uncovered a myriad of exciting possibilities have been explored. By examining the attributes of stone, historical precedents and contemporary case studies it has been demonstrated that stone remains a material of immense value in the modern era. Its durability, versatility and aesthetic appeal make it a compelling preference for architects to create striking and sustainable structures.

By embracing the potentials of stone, architects can create buildings that not only captivate the eye but also embody durability, sustainability and cultural significance. The integration of stone into contemporary architectural practice can foster a renewed appreciation for traditional craftsmanship, as well as inspire innovative techniques and technologies for stone extraction, processing and installation.

Moving forward, further research is needed to explore advanced engineering methodologies for optimizing stone structures, as well as to develop sustainable quarrying and extraction practices to minimize environmental impact. Additionally, investigations into the application of new technologies, such as digital fabrication and parametric design, can unlock even greater design possibilities and enhance the efficiency of working with stone.

In conclusion, the potentials of the use of stone in architecture are vast and inspiring. This study has underscored the enduring relevance of stone as a fundamental building material, capable of creating striking, sustainable and culturally significant architectural designs. By harnessing its inherent qualities and pushing the boundaries of design innovation, architects can shape a built environment that celebrates the timeless beauty and resilience of stone. By integrating tradition and innovation, architectural marvels that not only stand as testaments to human creativity but also harmonize with our natural surroundings can be created. The potentials of the use of stone in architecture are boundless and it is up to us to unlock them and shape a more sustainable and visually captivating built environment for generations to come.

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Resume

Serkan Yaşar Erdinç was born in 1980 in Istanbul. After graduating from Yıldız Technical University, Faculty of Architecture, Department of Architecture in 2005, he completed his master's degree at Yıldız Technical University, Institute of Science and Technology Architectural Design Program in 2009. He received his doctorate degree from Beykent University, Institute of Science and Technology, Architecture Doctorate Program, upon the acceptance of his thesis titled "A Research on 'Rezidans' Culture: The Case of Istanbul" on 18.05.2017, which he completed under the supervision of Prof. Dr. Şengül Öymen Gür. He has continued his career in various architectural offices since 2005 and worked as a project manager in the concept design and construction stages of projects of different quality and scale. Currently, Serkan Yaşar Erdinç has been working as an Assistant Professor at the Department of Architecture at Istanbul Beykent University, Faculty of Engineering and Architecture and continues to serve as the Head of the Department of Architecture.

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Smart urban management of green space

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Abstract

This paper aims to explore the concept and applications of smart urban green spaces within the context of sustainable cities. It emphasizes the importance of urban green spaces in providing ecological, social, and economic benefits, such as carbon sequestration, air and water purification, and improved well-being. The paper delves into integrating advanced technologies, including the Internet of Things (IoT), sensor networks, and data analytics, to create smart urban green spaces that optimize resource efficiency and enhance maintenance and operations. Sustainable practices, such as water conservation and biodiversity preservation, are examined for their role in ensuring the long-term viability and resilience of green spaces. The challenges and potential barriers to implementing smart urban green spaces, such as funding and governance issues, are discussed, as well as strategies for overcoming them. Additionally, the paper presents case studies and examples from around the world to showcase successful initiatives in creating smart urban green spaces. By exploring these concepts and applications, this paper contributes to the understanding and advancement of smart urban management of green spaces for sustainable cities.

Keywords: smart urban space, green spaces, Internet of Things (IoT), sensor networks, data analytics, sustainable cities.

1. Introduction

Smart urban green spaces and sustainable cities are two essential concepts that are gaining increasing attention in today's world. Cities worldwide face challenges that harm growth and the deterioration of green spaces, which harm the quality of life and the environment. Integrating green spaces into urban areas has become a prominent movement to create sustainable and livable cities (Rachmawati, 2019; Russo & Escobedo, 2022) . Smart urban management has emerged to address this goal effectively, leveraging technology and data-driven solutions to enhance the management and development of green spaces. Smart urban management seeks to improve the accessibility, sustainability, and overall societal benefits of green spaces through enhanced maintenance and administration (Roblek, 2019; Bedi, et al., 2020). This approach encompasses various elements, including technology and data utilization, mobility considerations, energy and resource management, community engagement, and effective governance and policies (Rachmawati, 2019). Smart urban green spaces play a crucial role in promoting sustainable cities and offer a range of benefits, including improved air quality, reduced urban heat island effect, biodiversity preservation, and enhanced well-being for residents (Rachmawati, 2019). However, effective management is essential to maximize these benefits and ensure the long-term sustainability of green spaces. Efficient management practices enable optimizing green space utilization, resource allocation, and maintenance activities. Technology and data-driven solutions provide real-time monitoring and analysis of environmental parameters, enabling proactive decision-making and responsive maintenance practices (Roblek, 2019). For instance, smart irrigation systems can adjust water usage based on weather conditions and plant needs, reducing water waste and promoting water conservation (Bedi, at all., 2020). Similarly, intelligent lighting systems can enhance energy efficiency by adapting to occupancy patterns and natural light availability. Community participation is another vital aspect of smart urban green space management. Engaging residents in the planning,

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design, and maintenance processes fosters a sense of ownership and promotes the community's well-being (Rachmawati, 2019). It allows for incorporating diverse perspectives and preferences, ensuring that green spaces meet the specific needs of the local population. Furthermore, effective governance and policies are critical in supporting smart urban management of green spaces. Clear guidelines and regulations facilitate technology integration, encourage sustainable practices, and promote stakeholder collaboration (Rachmawati, 2019). Public-private partnerships and participatory planning processes can also enhance the effectiveness of green space management efforts. Smart Urban Green Spaces use technology and innovative design to develop visually beautiful green places that are also environmentally favorable and socially inclusive (Liu, et al., 2021; Khan et al., 2022). By incorporating features such as smart irrigation systems, renewable energy sources, and green roofs, these spaces help to mitigate the consequences of climate change, reduce the effects of urban heat islands, and improve air quality (Shan et al., 2021).

On the other hand, sustainable cities are designed and developed to address current demands without jeopardizing future generations' ability to meet their needs (Chang & Das, 2020). This covers energy efficiency, waste minimization, and utilization of renewable resources. Sustainable cities strive to create a balance between economic growth, social well-being, and ecological health (Nitoslawski et al., 2019). Smart urban management of green spaces offers various benefits, including bettering the overall purity of the air and water, reducing the heat island effect, increasing biodiversity, and providing social and recreational benefits (Russo & Escobedo, 2022). Using technology and data, smart urban management improves the efficiency and effectiveness of urban governance, promotes social and environmental sustainability, and enables informed decision-making by city planners and managers to ensure efficient and effective resource utilization. Together, Smart Urban Green Spaces and Sustainable Cities indicate a movement in urban planning toward a more holistic approach, prioritizing the well-being of people and the planet (Bhattacharya et al., 2020). As continue to face the challenges of urbanization, these concepts play an increasingly important role in shaping future cities (Mortaheb & Jankowski, 2023). The absence of effective management in urban green spaces can lead to various risks and damages; without proper management, urban green spaces lack adequate drainage systems, leading to increased surface runoff during heavy rainfall, which results in flooding. Also, inadequate control of energy resources can result in excessive energy consumption, contributing to environmental degradation and higher carbon emissions (Khan et al., 2022). Climate change poses various risks to urban areas, including increased frequency and intensity of extreme weather events such as heatwaves, storms, and heavy rainfall. Without effective management, cities are ill-prepared to mitigate and adapt to these risks, which results in heat-related illnesses, property damage, disruption of infrastructure, and compromised public safety (Razmjoo et al., 2021). Urban green spaces play a crucial role in supporting biodiversity and ecological balance; without proper management, these spaces suffer from habitat destruction, invasive species proliferation, and pollution, leading to biodiversity loss and ecological degradation; this disrupts ecosystem services and negatively impacts the overall health of urban environments (Basnou et al., 2020). The absence of effective management leads to declining residents' overall quality of life and loss of opportunities for recreation, relaxation, and connection with nature. Additionally, inadequate management may result in poor air quality, noise pollution, and limited access to green spaces, which harm physical and mental well-being. The study aims to provide insights into the relationship between smart urban management and green spaces and offer practical recommendations for city planners and managers to enhance the quality of life and environmental sustainability in urban areas; the study holds significant importance in urban development and sustainability. This study addresses the pressing need for effective and sustainable management of urban green spaces. However, while considering this approach's potential benefits and limitations, the research problem lies in understanding the determinants and criteria of innovative urban management and its impact on the city's green spaces.

2. Literature review

Smart urban management, which integrates data-based technology and solutions to achieve city sustainability, has gained significant attention in recent years. Smart urban management substantially impacts urban green space management (Bedi, at all., 2020; Bhattacharya et al., 2020). Traditional approaches to managing urban green spaces were often manual and subjective, resulting in suboptimal outcomes (Masik et al., 2021).

Several case studies have demonstrated the benefits of smart urban management in transforming green spaces and enhancing sustainability. For example, the High Line Park in New York City showcases the successful conversion of an abandoned elevated railway into a vibrant urban park using smart technologies for irrigation, lighting, and visitor management (Chondrogianni & Stephanedes, 2022). The park's smart irrigation system adjusts watering schedules based on weather conditions and soil moisture levels, ensuring efficient water use. Similarly, the Singapore Gardens by the Bay project incorporates smart technologies to optimize energy consumption, climate control, and water management, resulting in a sustainable and visually stunning green space (Michelam et al., 2021). Literature and studies have explored the multitude of benefits associated with urban green spaces, including climate change mitigation, improved physical and mental health, increased biodiversity and environmental resilience, and economic advantages (Liu, et al., 2021; Khan et al., 2022; Masik et al., 2021). However, many studies highlight the challenges of promoting green spaces in cities, such as limited space, maintenance and management, equality and access, and technological integration (Russo & Escobedo, 2022; Bedi, at all., 2020). Strategies such as multifunctional design, community participation, innovative financing, and data-based planning have been suggested to overcome these challenges (Khan et al., 2022; Razmjoo et al., 2021). The implementation of smart urban management of green spaces faces its own set of challenges, including the high cost of technology and the need for skilled personnel to operate and maintain systems (Khan et al., 2022; Hasan & Al-Khafaji, 2021; Toan & Nhu, 2020). It is important to note that privacy concerns related to data collection and usage must be addressed to ensure stakeholders' confidence in the systems (Roblek, 2019; Razmjoo et al., 2021). However, by leveraging smart technologies, cities can optimize resource use, enhance maintenance practices, and improve the overall user experience of green spaces. These technologies enable real-time monitoring of environmental parameters, efficient resource allocation, and data-driven decision-making.

3. Green Spaces

Green spaces are essential components of smart urban management and are commonly called green open spaces, including parks, pastures, forests, grasslands, farmlands, and other natural spaces (Danilina & Majorzadehzahiri, 2020; Parasher et al., 2019). Green spaces refer to vegetation covered in parks, gardens, forests, and other natural areas. These spaces provide a range of benefits to both humans and the environment (Shan et al., 2021). Green spaces are essential for several reasons. Firstly, Green spaces provide various ecosystem services, such as regulating the climate, improving air and water quality, and supporting biodiversity by providing habitats for various plant and animal species.

Additionally, green spaces provide recreational opportunities for people, including physical activity, relaxation, and social interaction options. They also contribute to a community's aesthetic value, enhancing residents' overall quality of life (Danilina & Majorzadehzahiri, 2020; Basnou et al., 2020). In recent years, there has been growing recognition of the importance of green spaces for human health and well-being (Chondrogianni & Stephanedes, 2022). Spending time in green places has been shown in studies to have several significant effects on mental and physical health, including stress reduction and mood enhancement and promoting physical activity. As a result, many cities and communities invest in creating and maintaining green spaces, aiming to improve public health, environmental sustainability, and overall quality of life (Masik et al., 2021), (Chondrogianni & Stephanedes, 2022). A growing body of scientific research supports the

importance of green spaces for human health and well-being. Studies found that exposure to green spaces is consistently associated with favorable health outcomes, including reduced stress, improved mood and cognitive function, and lower Obesity, diabetes, and cardiovascular disease are all on the rise. One mechanism through which green spaces may promote health is by providing opportunities for physical activity (Russo & Escobedo, 2022; Rachmawati, 2019). Green spaces also promote mental health by providing stress reduction and relaxation opportunities. Studies found that spending time in nature reduces cortisol levels, a hormone linked to stress, and improves subjective feelings of well-being. Another study found that exposure to green spaces improves attention and cognitive function, potentially due to the restorative effects of nature on mental fatigue (Danilina & Majorzadehzahiri, 2020). Additionally, green spaces benefit human health by improving air and water quality. Trees and other vegetation help filter air pollutants, minimizing the likelihood of respiratory and cardiovascular disease (Al-Taee, 2021). Green spaces also help to reduce the risk of flooding and improve water quality by absorbing and filtering rainwater (Razmjoo et al., 2021; Mortaheb & Jankowski, 2023). Smart urban green spaces offer a range of benefits to residents and the environment. Using technology to improve sustainability and efficiency, smart green spaces reduce urbanization's environmental impact and decrease climate change's effects (Bedi, at all., 2020). Additionally, by providing residents with more accessible and user-friendly green spaces, smart urban green spaces improve mental and physical health outcomes and enhance the overall quality of life (Ramaiah & Avtar, 2019). As smart technologies develop and become more affordable, I expect to see more cities and communities incorporating smart features into their green spaces (Figure 1). By leveraging technology to create more sustainable and user-friendly urban environments, I create healthier, more livable cities for all (Greopanta, 2020).

3.1. Smart urban governance enhances the management and maintenance of green spaces using data-based technology and solutions as shown 2, such as:

1) Conserving water by utilizing sensors to monitor soil moisture levels and plant health, improving irrigation efficiency, and reducing water waste (Chondrogianni & Stephanedes, 2022; Liu et al., 2020).

2) Enhancing biodiversity and supporting wildlife (Chang & Das, 2020; Nitoslawski et al., 2019).

3) Data-driven decision-making, where data analytics aid in improving maintenance schedules, reducing costs, and enhancing quality (Khan et al., 2022; Bernardo, 2019).

4) Improving accessibility, such as providing safe corridors and entrances (Chang & Das, 2020; Danilina & Majorzadehzahiri, 2020).

5) Promoting economic development by attracting tourists, increasing the value of real estate, providing opportunities for local businesses, and creating jobs in areas such as technology, data analysis, and maintenance (Liu et al., 2020; Danilina & Majorzadehzahiri, 2020).

Figure 1 Green space design as part of the city's urban management

3.2. Smart Urban Management Standards

Smart Urban Management Standards are guidelines and criteria defined in ISO 37120 Standard to ensure the effective implementation of Smart Urban Management practices in cities worldwide (Michelam et al., 2021). The development of standardized approaches and frameworks to guide cities in leveraging technology and data to improve urban systems and services is becoming increasingly important as the concept of Smart Urban Management gains momentum. These standards aim to provide cities with guidelines and criteria to effectively implement smart technologies and data-driven approaches, leading to enhanced urban planning, efficient resource management, and improved quality of life for residents (Bernardo, 2019). The need for such standards arises from recognizing that cities worldwide face similar challenges and can benefit from sharing best practices and adopting common frameworks. These standardized approaches facilitate knowledge exchange, collaboration, and the development of scalable solutions that can be applied across different urban contexts (Liu et al., 2020). By embracing Smart Urban Management standards, cities can pave the way for more intelligent, sustainable, and resilient urban environments. (Mortaheb & Jankowski, 2023). Smart Urban provides a framework for cities to develop and implement Smart Urban Management strategies aligned with best practices and considering each urban context's unique characteristics and challenges (Greopanta, 2020).

The development of Smart Urban Management Standards is a collaborative effort involving multiple stakeholders, including governments, industry, academia, and civil society (Michelam et al., 2021). These standards are designed to be flexible and adaptable, enabling cities to customize their approach to Smart Urban Management based on their specific needs and priorities. By adopting Smart Urban Management Standards, cities help ensure their Smart City initiatives are effective, sustainable, and equitable (Basnou et al., 2020). They also benefit from improved interoperability and data sharing, which lead to more efficient and effective urban systems and services. Smart Urban Management Standards are essential to creating more livable, sustainable, and resilient cities for all (Danilina & Majorzadehzahiri, 2020). The presented table showcases the primary indicators associated with each criterion identified in the review as crucial factors for smart urban management of green spaces:

Table 1 The criterion identified in the literature review for smart urban management of green spaces.

criteria	Main indicators
Efficiency of Energy	• Utilization of renewable energy sources. • Maximize energy consumption. • Energy-efficient lighting and equipment.
Conservation of Water	• Smart Irrigation System. • Water Saving Fittings. • Harvesting rainwater.
Biodiversity	• Selection of native plant species. • Provision of wildlife citizens. • Environmental corridors for the movement of innate life.
Ease of accessibility	• Provide accessible, safe passages and entrances. • Includes persons with disabilities or limited mobility. • Accessible amenities include seats, bathrooms, water fountains, and drinking sources.
Data Traffic Networks	• Use of data analytics for maintenance and management. • Decision-making for Management. • Predictive Analysis for Maintenance and Management. • Real-time monitoring of green spaces.
Skilled Workers	• Skilled personnel and workers are eligible for data analysis and decision-making. • Trained cadres to operate and maintain technology and systems.
Privacy & Data	• Compliance with data protection regulations.
Data Security	• Transparent data collection and management. • Secure data storage and management. • Protection of personal information.

3.3. Smart Urban Management Controls and Determinants for Green Spaces

Smart urban management controls and determinants for green spaces refer to the technologies and strategies used to monitor, maintain, and improve urban green space quality. These controls and determinants use data analytics, sensors, and other tools to optimize the use and maintenance of green spaces, making them more sustainable and user-friendly (Liu et al., 2020).

A smart irrigation system is one example of smart urban management control for green spaces. Sensors are used in this system to monitor soil moisture and weather data to optimize watering, reducing water waste and ensuring that plants receive the right amount of water. By reducing water usage, Smart irrigation systems aid in conserving water resources and reducing the environmental effect of green spaces.

(Russo & Escobedo, 2022; Chang & Das, 2020). Another example of smart urban management control for green spaces is a smart waste management system. This system uses sensors to monitor waste levels and optimize waste collection, reducing waste in landfills and improving the cleanliness of green spaces. By improving waste management, smart systems help to reduce pollution and enhance the environmental sustainability of green spaces (Shaheen & Hasan, 2018).

Determinants for green spaces are significant factors in smart urban management. For example, the design and layout of green spaces affect their accessibility and usability. Smart green spaces should be meticulously designed with well-planned paths, comfortable seating arrangements, and appropriate lighting to ensure inclusivity and ease of navigation for individuals across all age groups and varying abilities (Toan & Nhu, 2020). In addition to accessibility, the location of green spaces is a crucial determinant for effective smart urban management. Green spaces should be strategically situated in areas that are easily accessible to residents, such as in proximity to public transportation hubs or residential neighborhoods. By strategically locating green spaces, cities can encourage greater general utilization, improve public health outcomes, and reduce environmental impact (Masik et al., 2021; Michelam et al., 2021). One approach to mitigating the adverse effects on concrete durability is carefully selecting sustainable construction materials. While green building practices often prioritize environmentally friendly materials, ensuring they possess the necessary durability characteristics for long-term performance is essential. This can involve considering alternative cementitious materials, such as supplementary cementitious materials (e.g., fly ash, slag) or pozzolanic materials, that can enhance the durability properties of concrete.

Furthermore, proper design and construction practices are crucial in mitigating durability concerns. Adequate attention should be given to appropriate mix design, proper curing techniques, and effective quality control measures during construction. This includes ensuring the concrete mixture is proportioned correctly, compacted, and cured to achieve the desired durability performance. In addition, using protective coatings and sealants can offer an extra layer of defense against environmental deterioration. These coatings can help enhance concrete structures' resistance to moisture ingress, chemical attack, and carbonation. Regular maintenance and inspection of green buildings are also essential for identifying and addressing potential durability issues. Implementing a proactive maintenance program that includes periodic inspections, repairs, and necessary rehabilitation measures can help ensure concrete structures' long-term performance and durability. Smart urban management controls and determinants for green spaces are essential for creating sustainable and user-friendly urban environments. By leveraging technology and design to optimize the use and maintenance of green spaces, cities create healthier, more livable communities for all. Green space management encompasses a range of measures and factors essential to ensuring these spaces' effective management and maintenance. These include the use of:

1. Technology, such as sensors, data analytics, and artificial intelligence, to enhance efficiency (Liu et al., 2020).

2. Effective organization: involves defining the roles and responsibilities of various stakeholders, ensuring communication and cooperation among them (Bernardo, 2019).

3. Resource management: involves allocating and using resources, such as funding, personnel, and equipment, to maintain and improve green spaces (Parasher et al., 2019).

4. Dialogue: involves engaging stakeholders to understand their needs and interests and apply them in decision-making to align initiatives with society's needs and priorities (Rachman et al., 2018).

5. Agencies responsible for managing green spaces must ensure equity and social justice, making them accessible to all members of society (Mortaheb & Jankowski, 2023).

6. The research design focuses on the management aspects of green spaces rather than their utilization. It emphasizes that creating green spaces should encompass multiple functions, such as serving as recreational areas, managing rainwater, and enhancing air quality, to maximize their benefits and efficiency. Additionally, the paper suggests the utilization of performance measurements to assess the effectiveness of these green spaces.

4. Theoretical Framework

Smart urban management of green space is essential to sustainable urban development (Bedi, at all., 2020). The theoretical framework for smart urban management of green space draws upon several key concepts from urban planning, sustainability, and technology. The framework emphasizes the need to harness technology and data to optimize urban green space management and operation to achieve sustainability, resilience, and quality of life for urban residents (Rachman et al., 2018). The critical concept of smart urban management of green space is the concept of "smart urban governance," which refers to using technology and data to improve urban systems and services. In green spaces, this means using sensors, surveillance systems, and other techniques to track environmental conditions, monitor plant growth, and manage water levels (Greopanta, 2020; Rachman et al., 2018). Another critical concept is environmental management, which involves using ecological principles and practices to manage resources and promote sustainability (Mortaheb & Jankowski, 2023). This includes techniques such as sustainable landscapes (Basnou et al., 2020), water conservation (Danilina & Majorzadehzahiri, 2020), and integrated pest management (Bedi, at all., 2020), which help reduce the environmental impact of urban green spaces. One key concept is the idea of smart cities, which refers to using technology and data to improve urban systems and services. Smart urban management of green space builds upon this concept by focusing specifically on the management and operation of urban green spaces, which are critical components of sustainable cities (Masik et al., 2021; Greopanta, 2020).

Another essential concept is the idea of green infrastructure, which refers to natural and semi-natural systems that provide a range of ecological, social, and economic benefits. Parks, gardens, and green roofs are examples of urban green areas that represent a form of green infrastructure that helps mitigate the effects of urbanization, such as air and water pollution while providing recreational and aesthetic benefits (Basnou et al., 2020; Ramaiah & Avtar, 2019). The framework also draws upon sustainability principles, emphasizing balancing economic, social, and ecological factors in urban planning and development. Smart urban management of green space seeks to achieve sustainability by optimizing the use of resources, reducing waste and pollution, and promoting social equity (Bhattacharya et al., 2020).

4.1. Smart Urban Management

Smart urban management is a relatively recent concept that has emerged in response to the challenges posed by rapid urbanization and technological advancement (Khan et al., 2022; Nitoslawski et al., 2019; Chondrogianni & Stephanedes, 2022). The idea traces its roots back to the early 2000s when the philosophy of smart cities and the importance of effective governance began to gain traction; effective governance was recognized as a critical factor in ensuring the successful implementation and management of smart urban initiatives. During that time, the focus was on utilizing various technologies such as the Internet of Things (IoT), Data Analytics, and Smart Grids and systems to enhance the quality of life for city dwellers, with a particular emphasis on

sustainability and efficiency (Liu, et al., 2021; Michelam et al., 2021). Over time, the concept of smart urban management has changed when new technologies have emerged, such as the Internet of Things (IoT) (Khan et al., 2022), data analytics (Khan et al., 2022; Liu et al., 2020), and artificial intelligence (Bernardo, 2019). These technologies have enabled urban managers to gather and evaluate enormous amounts of data to make better decisions and choices about urban space management (Chondrogianni & Stephanedes, 2022). Smart urban governance involves using technology and data to manage various aspects of urban life, such as transportation, energy, public services, and environmental sustainability (Danilina & Majorzadehzahiri, 2020). The primary goal is to improve resource utilization, minimize waste, increase efficiency, and improve the quality of life for the city's inhabitants (Parasher et al., 2019).

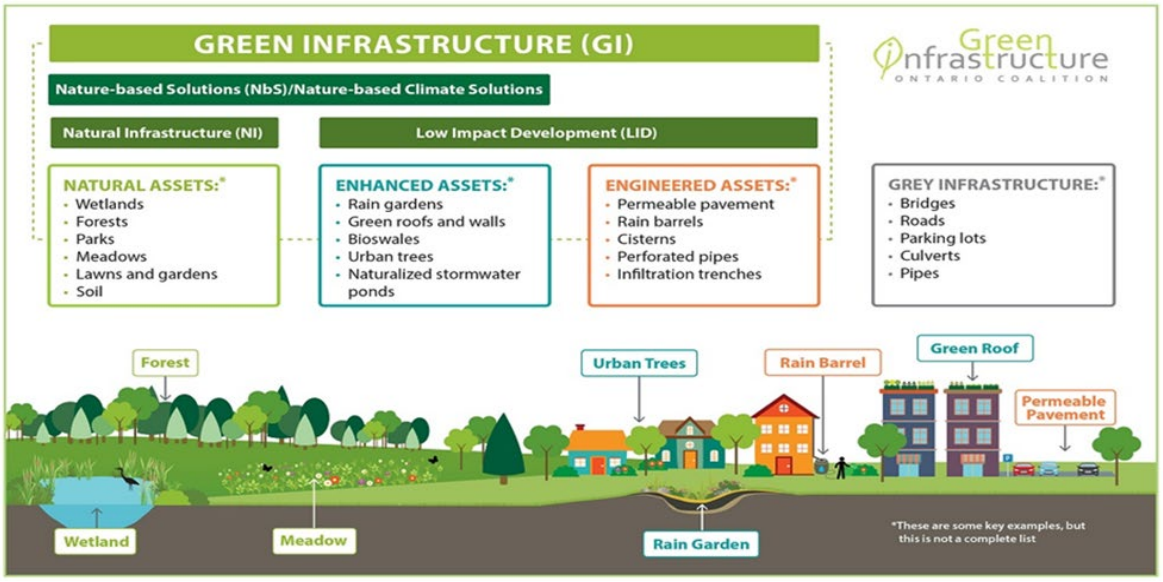

Figure 2 Types of green infrastructure in the City's urban management

Smart Urban Management aims to address these challenges by using data-driven approaches to optimize urban systems, improve governance and decision-making, and enhance the quality of life for urban residents (Russo & Escobedo, 2022; Roblek, 2019). Smart Urban Management is closely linked to the broader field of Smart Cities, which seeks to leverage technology and innovation to create more livable, sustainable, and resilient cities (Figure 2). Smart Urban Management is focused on managing and operating urban systems, including transportation, water and waste management, energy, and public services (Khan et al., 2022). Smart Urban Management uses modern technology such as data analytics, machine learning, and other advanced technologies to optimize these systems in real-time, reducing costs, improving efficiency, and enhancing urban residents' overall quality of life (Toan & Nhu, 2020; Danilina & Majorzadehzahiri, 2020). Smart Urban Management has the potential to revolutionize the way cities are managed and operated, enabling more efficient use of resources, reducing environmental impacts, and improving the overall sustainability of urban areas (Liu et al., 2020). However, there are also challenges associated with implementing Smart Urban Management, including data privacy, equity, and governance issues. As such, it is essential to approach Smart Urban Management with a holistic and inclusive perspective, considering the requirements and viewpoints of all stakeholders in the urban ecosystem (Nitoslawski et al., 2019).

Technology is a crucial enabler of smart urban management of green space, providing data collection, analysis, and communication tools. The framework emphasizes using digital technologies such as sensors, GIS mapping, and mobile applications to monitor and manage urban green spaces in real-time, enabling more efficient use of resources and improved decision-making (Khan et al., 2022; Ramaiah & Avtar, 2019). The Smart Urban Green Space Management Framework also emphasizes the importance of cooperation and community participation (Toan & Nhu, 2020).

This includes working with local stakeholders, such as residents, businesses, and community-based organizations, to identify their needs and priorities and involve them in green space planning and management (Chang & Das, 2020; Nitoslawski et al., 2019). This helps build support for green space initiatives and ensures that they respond to society's needs and preferences (Roblek, 2019; Nitoslawski et al., 2019).

5. Case studies, examples of best practices, and innovative solutions to enhance knowledge and awareness of smart urban management of green spaces in different cities.

These case studies provide practical examples of how smart urban management is applied to improve the availability and quality of green space in the city and to enhance knowledge and awareness of smart urban management of green space among policymakers, planners, and other stakeholders, and how it be effectively implemented in different cities. These include:

1. Singapore City (Singapore): The "City in a Garden" concept in Singapore is a holistic approach to urban greenery, and it involves the collective efforts of various designers, landscape architects, and urban planners. While there isn't a single project or specific designer associated with the entire concept, several notable projects and institutions have contributed to Singapore's green spaces. Gardens by the Bay project was designed by a team of landscape architects from Grant Associates, WilkinsonEyre, and Atelier One. Gardens by the Bay is a sprawling nature park featuring Supertrees, conservatories, and themed gardens. It showcases innovative horticultural and sustainable practices, including harvesting rainwater and solar energy. DP Architects and landscape architects from Atelier Dreiseitl designed the marina Barrage. Marina Barrage is a dam across the Marina Channel that creates a freshwater reservoir; it serves as a recreational space featuring lush green lawns, gardens, and a rooftop park with stunning city skyline views. Punggol Waterway Park project: This waterfront park was designed by landscape architects from Atelier Dreiseitl. It incorporates an artificial waterway, landscaped promenades, and themed zones, providing residents with a scenic and sustainable recreational area. Singapore Botanic Gardens was established in 1859. It is a UNESCO World Heritage Site and one of the oldest tropical gardens in the world. While the original design was influenced by various individuals, including Lawrence Niven and Henry Nicholas Ridley, subsequent additions and enhancements have been carried out by different architects and landscape architects (Toan & Nhu, 2020). This project exemplifies how smart urban management is used to promote sustainability.

Figure 3 Smart Urban Green Space Management in Singapore

2.Copenhagen, Denmark: Copenhagen, Denmark, manages and develops the city's green spaces using smart urban technologies. To improve the city's air and water quality and provide favorable environments for wildlife, these efforts include creating new parks and green areas and improving the design of existing green spaces (Chang & Das, 2020; Greopanta, 2020). Waste-to-Energy Plant Copenhagen is home to the famous Amager Bakke waste-to-energy plant, also known as Copenhill. While primarily serving as a waste management facility, it features a unique design incorporating a ski slope on its roof, allowing visitors to engage in recreational activities such as skiing and snowboarding. The Danish architecture firm Bjarke Ingels Group (BIG) designed the plant, and it has become an iconic symbol of sustainable urban development. Rooftop Gardens Copenhagen has

embraced the concept of urban rooftop gardens, utilizing underutilized spaces on top of industrial buildings to create green areas. While I have yet to get specific information about a rooftop garden covering industrial buildings with a ski slope, fertile hiking trail, and climbing wall, these projects may be conceptual ideas or proposals rather than realized projects. Port Transformation Copenhagen has undertaken various projects to transform industrial ports into vibrant urban spaces. One notable example is the transformation of the Nordhavn industrial port into a new urban district. The development includes public spaces, parks, promenades, and squares, providing residents with recreational areas and enhancing the city's green infrastructure. The specific designers involved in these port transformation projects may vary depending on the individual initiatives.

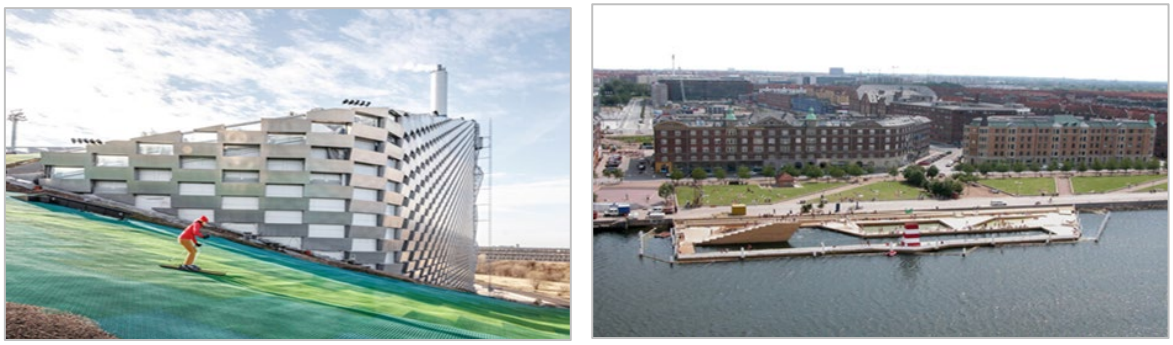

Figure 4 Sustainable urban planning for Barcelona

3.Barcelona City, Spain: Barcelona's "superblocks" concept is a city-wide initiative rather than a specific project with a single designer. The Barcelona City Council and the Institute for Urban Landscape and Quality of Life (IUQB) developed and implemented the concept in collaboration with various urban planning and transportation experts. (Shan et al., 2021; Basnou et al., 2020). The specific implementation of superblocks involves the reorganization of nine-block clusters, limiting vehicle traffic within these areas, and transforming the reclaimed space into pedestrian-friendly zones, green areas, playgrounds, and social gathering spaces. The goal is to prioritize pedestrians, promote sustainable modes of transportation, and improve the overall quality of urban life (Basnou et al., 2020). Garden irrigators also use sensors to track rainfall and humidity levels and adjust the amount of water used in each area.

Figure 5 Green Infrastructure Network of Barcelona (Basnou et al., 2020)

With special needs, Barcelona offers unique trails for the visually impaired, street seats, and metro tunnels, enabling them to walk around unimpeded. The city uses smart technology to

improve lighting poles and control lighting levels based on the number of pedestrians, contributing to energy conservation(Basnou et al., 2020). It encourages using environmentally friendly transportation methods such as electric bikes and clean buses. The city improves parking and parking systems using smart technologies (Razmjoo et al., 2021). Barcelona continues to enhance the quality of life of its residents and visitors and achieve sustainable development in the future.

4.Melbourne, Australia: The Melbourne Urban Forest Strategy is an overarching approach. It is a comprehensive strategy developed by the City of Melbourne, Australia, collaborating with various stakeholders, including urban planners, landscape architects, environmental experts, and community members. The strategy aims to increase tree canopy cover in the city, with a 40% tree canopy cover target by 2040. It encompasses a range of initiatives, including tree planting programs, community engagement activities, and the use of technology for monitoring and managing the urban forest (Mortaheb & Jankowski, 2023; Basnou et al., 2020; Alfriani et al., 2022) application of intelligent irrigation and design programs to improve water and soil quality in green spaces.

Figure 6 Roofs and green spaces in Melbourne

5.Dubai, UAE: Dubai is known for its modern infrastructure and innovative approach to urban development. The implementation of smart urban green space management is one such initiative that highlights the city's commitment to sustainable urbanization. By leveraging the latest technologies, Dubai has managed its green spaces efficiently, using smart solutions and involving residents in managing green spaces (Chang & Das, 2020). Smart irrigation systems in Dubai Parks and Resorts and Dubai Miracle Garden demonstrate the city's commitment to reducing water use and conserving its natural resources. These initiatives improve the city's sustainability and enhance the experience of residents and visitors by creating more livable and attractive urban environments.

6.Portland's Smart Park System: Implementing a smart park system in Portland, Oregon, involves integrating technology and data-driven management practices for the city's green spaces. It is a collective effort involving various stakeholders, including the City of Portland, urban planners, park management teams, and technology providers. The smart park system in Portland utilizes sensor networks to collect real-time data on soil moisture levels, weather conditions, and park usage. This data is then analyzed for informed irrigation, maintenance scheduling, and resource allocation decisions. The goal is to optimize the management of green spaces, ensuring their health and sustainability while maximizing their usability for residents and visitors.

5.1. Analysis of two study examples by specific criteria for smart urban management of green spaces

Smart urban management of green spaces is a critical component of sustainable urban development, and cities worldwide are exploring innovative approaches to optimize resource use and improve residents' quality of life. In this analysis, I examine two case studies of smart urban management of green spaces, Dubai City and Singapore City (Table 2), which are chosen as examples of smart urban management of green spaces based on their notable advancements in

implementing smart strategies and their commitment to sustainable urban development. Dubai City and Singapore City exemplify different approaches to smart urban management, making them exciting and valuable for comparison. By examining these case studies, we can identify key strategies, technologies, and policies contributing to successful smart urban management of green spaces. This analysis highlights the differences and similarities between the two cities, providing insights into effective practices that can be applied in other urban contexts. By focusing on specific criteria such as technology integration, stakeholder engagement, and data sharing, we can better understand the elements contributing to the success of smart urban management strategies for green spaces.

Table 2 Analysis of Two Study Situations According to Specific Criteria for Smart Urban Management of Green Spaces

criteria	First case study: Dubai City	Second case study: Singapore City
Energy Efficiency	Dubai **Green Building Regulations** and invested in renewable energy projects and smart grid technologies.	Singapore **Green Mark Scheme programs**, using energy-efficient appliances, and promoting sustainable transportation options.
Water Conservation	Use of **treated wastewater for irrigation** and promoting water-efficient technologies in buildings.	The city **collects and treats rainwater** and practices water reclamation.
Biodiversity	Many **Initiatives like** the Dubai Desert Conservation Reserve and Dubai Creek Rehabilitation Project.	The city has **designated nature** reserves, such as Bukit Timah Nature Reserve and Sungei Buloh Wetland Reserve, to protect native flora and fauna.
Easy Access	**Modern metro system**, well-connected road networks, and an expanding public transportation network.	The city-state has an extensive **public transportation network**, including a comprehensive subway system (MRT) and a well-connected bus network.
Secure data storage and management	They have invested in digital infrastructure data management systems and data security and have implemented measures to protect sensitive information.	**Robust cybersecurity** measures and data protection regulations: the city has a well-developed digital infrastructure and stringent protection laws.
Decision-making	Dubai employs **data-driven decision-making approaches**.	Singapore places a strong emphasis on **evidence-based decision-making**.
Skilled Personnel	Due to its numerous construction and development projects, **Dubai attracts skilled professionals from various fields**.	Singapore has a highly **skilled workforce with expertise in various sectors** and invests in education and training.
Privacy & Data	Dubai has **data protection regulations to safeguard privacy** and ensure responsible data management.	Singapore has **strict privacy laws and regulations governing** personal data collection, storage, and use.

Dubai City and Singapore City are chosen as case studies because they represent distinct geographical regions and have different approaches to urban development and green space management. Dubai City is known for its rapid urbanization and ambitious infrastructure projects. It has implemented innovative technologies and strategies to address the challenges of limited water resources and extreme climatic conditions. Singapore City, on the other hand, is a small island city-state in Southeast Asia known for its sustainable development practices and efficient urban planning. It has prioritized green spaces, biodiversity conservation, and community engagement in its urban management strategies. By comparing these two cities, we gain insights into different approaches to smart urban management of green spaces and identify best practices that can be adapted and implemented in other urban contexts. These case studies were selected to showcase diverse examples and comprehensively analyze smart urban management strategies. Furthermore, Dubai City and Singapore City are recognized globally for their efforts in sustainable urban development and have received accolades for their green initiatives. This makes them compelling case studies to examine to understand the factors contributing to their success and identify transferable lessons for other cities.

6. Discussion and conclusion

The results of the case study comparison between Dubai City and Singapore City provide compelling evidence for incorporating the "City in a Garden" concept and smart urban green space

management in urban planning and development. The case study comparison reveals that Singapore's holistic approach to urban greenery, embodied by the "City in a Garden" concept, has yielded significant benefits. The presence of well-designed and accessible green spaces has positively impacted Singapore's overall quality of life. The examples of Gardens by the Bay, Marina Barrage, Punggol Waterway Park, and the Singapore Botanic Gardens demonstrate how intentional design and sustainable practices have transformed Singapore into a livable and sustainable city. In contrast, while making strides in various aspects of urban development, Dubai City could benefit from a more comprehensive approach to urban green spaces. The comparison highlights the potential advantages of incorporating the "City in a Garden" concept and smart urban green space management practices in Dubai. By doing so, Dubai can enhance its sustainability efforts, improve residents' well-being, and create a more attractive environment for residents and visitors.

As a result of the analysis, Table 3 presented above offers a concise overview of the essential controls and determinants contributing to the intelligent management of urban green spaces. The rules encompass a range of critical aspects, including integrating technology, data-driven decision-making, stakeholder engagement, development of green infrastructure, efficient waste and water management, energy-efficient practices, and implementation of smart monitoring and surveillance systems. On the other hand, the determinants emphasize the significance of efficient resource utilization, biodiversity conservation, sustainable land use planning, climate change adaptation, community participation, accessible and inclusive design, maintenance and upkeep, and environmental education.

Table 3 Result of Smart Urban Management Controls and Determinants for Green Spaces

Smart Urban Management Controls	Determinants for Green Spaces
Technology integration	Efficient resource utilization
Data-driven decision-making	Biodiversity conservation
Stakeholder engagement	Sustainable land use planning
Green infrastructure development	Climate change adaptation
Efficient waste management	Community participation
Water resource management	Accessible and inclusive design
Energy-efficient practices	Maintenance and upkeep
Smart monitoring and surveillance	Environmental education

Together, these elements play a pivotal role in fostering effective and sustainable management of urban green spaces, ensuring their optimal functionality and long-term viability.

The study's findings emphasize that smart urban green space management contributes to sustainable urban development. It enables cities to optimize resource utilization, reduce environmental impact, and foster resilience in the face of climate change. By adopting sustainable landscape practices and responsible management of natural resources, cities can mitigate the adverse effects of urbanization and enhance their ecological footprint. One key finding is the role of smart urban management in promoting sustainable urban development. The study demonstrates that by adopting smart strategies and responsible natural resource management, cities can achieve sustainable landscape practices and reduce resource consumption and waste generation. This contributes to the population's overall well-being and helps create a more environmentally friendly and resilient city.

Moreover, the study emphasizes the economic benefits of smart urban green space management. Cities can stimulate economic growth and innovation by attracting companies specializing in green and smart technologies. This leads to job creation and the establishing of a sustainable business ecosystem that supports the transition to a greener and more efficient urban environment. Furthermore, comparing case studies underscores the economic benefits of smart urban green space management. Singapore's success in attracting companies specializing in green and smart technologies has stimulated economic growth and innovation. This has resulted in job creation and a sustainable business ecosystem. With its ambitious development projects and focus on attracting skilled professionals, Dubai City can leverage the potential economic opportunities of

investing in smart urban green spaces. The results also highlight the social benefits of well-planned urban green spaces. Accessible and well-maintained green areas promote physical and mental well-being, encourage community interaction, and enhance residents' overall quality of life. By prioritizing the availability and quality of green spaces, cities can create inclusive and equitable environments that cater to the diverse needs of their populations. Starting from the case study comparison results, we can draw a more convincing discussion that advocates integrating the "City in a Garden" concept and smart urban green space management in urban development. By adopting sustainable practices, optimizing resource utilization, and prioritizing the well-being of residents, cities can achieve a more sustainable, livable, and economically vibrant future. The experiences of Singapore and the potential benefits for Dubai highlight the importance of embracing these concepts in urban planning and development strategies.

7. Recommendations

Based on the benefits of smart urban management of green spaces, here are some recommendations for cities looking to implement these practices:

1. Technology and data adoption: Smart urban management should invest in sensors, surveillance systems, and data analysis tools to track environmental conditions, monitor plant growth, and manage resources like nutrient-rich water.

2. Using sustainable landscape practices: Smart urban management should use sustainable landscape practices such as native plant species, rain parks, and green roofs to promote biodiversity and reduce the environmental impact of green spaces.

3. Community engagement: Smart urban governance must engage with local stakeholders, including people, businesses, and community organizations, to understand their needs and priorities and involve them in green space planning and management.

4. Prioritize equality and accessibility: Smart urban governance must ensure that green spaces are available to all populations and prioritize investments in the neediest communities.

5. Monitoring and evaluating results: Smart urban management must use data and metrics to monitor the results of the smart urban management of green spaces, including improvements in air quality, water quality, and overall quality of people's lives.

6. Following these recommendations, cities successfully implement innovative urban green space management and create more livable, sustainable, and resilient urban environments.

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Resume

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Climate resilience and energy performance of future buildings in Nigeria based on RCP 4.5 and 8.5 scenarios

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Abstract

The predicted rise in global temperature by the Intergovernmental Panel on Climate Change IPCC appeals for a review of the methods and materials used for building construction for reduced emissions and comfort in buildings. Buildings account for the most carbon emissions in the globe. This study presents the impact of temperature change across the 36 state capitals in Nigeria, and the Federal Capital Territory, FCT, based on Representative Concentration Pathways, RCPs 4.5 for 2020 and 8.5 for 2090. A simple studio apartment with optimised alternatives for retrofits and new builds was simulated using EnergyPlus for both climate scenarios to determine the strategies for improving the energy performance of future buildings. The result of the study shows a significant increase in mean monthly outdoor temperature of about 5^{o}c across the states, with potential heat stress affecting buildings in future climates. Moreover, about one-third of the locations experience a shift in climatic zones to hotter ones. The impact of this climate drift will be more severe in the Northcentral and Southwest regions of the country. The design strategies recommended to mitigate the effects of a changing climate focused on building envelope insulation, thermal mass, and solar shading. The performance of the optimised models under future scenarios accounts for up to 25% and 73% savings in cooling energy for retrofits and new builds, respectively. To protect existing buildings from the impact of future climates, developers must make massive investments in solar shading of buildings. In contrast, a combination of envelope insulation and solar shading strategies proves effective for new builds.

Keywords: building optimisation, climate scenarios, energy performance, future buildings, representative concentration pathways

1. Introduction

Like its global counterparts, the Nigerian climate is marked by the intrinsic attributes of variability and unpredictability. It is likely to experience unprecedented shifts in temperature levels, rainfall and storms throughout the 21st century (Sayne, 2011). Following climate projections, there will be changes in rainfall patterns with an increase in temperature in the coming decades. The Nigerian Meteorological Agency NiMET warns that the average temperature in cities in Nigeria is likely to increase, which may lead to thermal discomfort (Agabi, 2023; Falaju, 2023). As outdoor temperature increases, the energy performance of buildings will be affected. As stated by (Ramos Ruiz & Olloqui del Olmo, 2022), buildings' energy efficiency is regarded as a critical factor in the move toward a low-carbon economy. Buildings in Nigeria, like other parts of the world, are vulnerable to climate change impact. In the European Union, for example, most regulations to mitigate climate impacts are geared towards fewer consumptions with increased energy efficiency

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(Ramos Ruiz & Olloqui del Olmo, 2022). Precisely, a changing climate leads to increased energy demand for cooling, reduced indoor comfort because of increased outdoor temperatures, and damage to building materials and infrastructure due to extreme weather occurrences such as tropical storms, hurricanes and floods. As temperatures continue to rise, buildings in Nigeria will need increased cooling to keep a comfortable indoor temperature, which can increase energy demand and carbon emissions. Consequently, the demand for energy for cooling can lead to multiple power cuts and collapse on the electricity grid due to strain from system loads (Fabbri et al., 2020).

There are efforts by the Nigerian government through the energy transition programme towards shifting to a low-emission economy to align with the European Union's net-zero target. These government endeavours, perceived as an ambitious target, are greeted with several challenges, including poverty and overpopulation (Abubakar, 2022). Additionally, (Kristl et al., 2020) emphasised that one of the challenges to climate change adaptation in the building sector is the need for more building policies and legislation governing buildings. A study conducted by (Allu, 2014) also opines that the lack of design guides and carbon emissions data in residential buildings in Nigeria is linked with the evidence of the negative impacts of climate change experienced. Likewise, the depletion of natural resources and the lack of re-use in the construction industry are also some of the challenges threatening the future of humanity as far as climate change is concerned (Ahmed et al., 2021). The implications of this temperature rise have far-reaching consequences in the built environment and demand urgent interventions from key players in the industry, including the end users, whose lifestyles need to change for a better quality of life (Kristl et al., 2020). Most of the existing buildings today and currently designed ones will be rendered obsolete in terms of energy efficiency in the future (Escandón et al., 2019), except if a conscious attempt is made to consider their adaptability during their entire service lives (Kristl et al., 2020). Considering the climate crisis in building design development will guarantee the development of an environmentally friendly and resilient building stock (Díaz-López et al., 2021). As purported by (Mutasim Baba & Ge, 2018), buildings designed based on historical weather data will operate differently under changing future climates; it is, therefore, imperative to design buildings adaptable to climate change.

This study shows heat stress is a significant challenge for future buildings, influencing their energy efficiency, occupants' comfort and global warming impact. Effective building envelope insulation and solar shading of buildings are found as crucial elements in reducing energy consumption for cooling. Retrofitting existing buildings with solar shading devices and integrating insulation in the building envelope for new builds can help improve indoor thermal comfort and reduce reliance on mechanical cooling systems.

1.1. Aim and Objectives

1.1.1. Aim

This research aims to assess and enhance the energy performance of new and existing buildings in Nigeria under varying climate scenarios to achieve energy efficiency and reduced emissions in the future.

1.1.2. Objectives

The following objectives have been outlined to improve the Global Warming Impacts, GWI of new and retrofitted buildings in the future.

a. To investigate, using a case building, the correlation between outdoor temperatures in different states of Nigeria and their impact on the energy performance of buildings under RCP 4.5 and 8.5 climate scenarios.
b. To identify specific components of the case building envelope that require modification or alteration to enhance energy efficiency for future constructions in Nigeria.

c. To propose strategies and recommendations for improving the energy efficiency of new and existing buildings in Nigeria, considering the projected climate scenarios.

1.2. Research Questions

a. How do changes in outdoor temperatures in the various Nigerian States affect the energy performance of buildings under different climate scenarios?
b. Which elements of the building envelope need to be adjusted or changed to optimise the energy efficiency of buildings under changing climate conditions?
c. What strategies can be suggested to improve energy efficiency and reduce emissions in both new and existing buildings in Nigeria, considering future climates?

2. Literature Review

Climate change already affects every region globally, with the most significant effects due to anthropogenic activities (IPCC, 2021). Human-induced emissions by developed nations are primarily responsible for the global increases in temperature, while developing countries are at the backdrop of these changes (Akpodiogaga-a & Odjugo, 2010). While no nation will be absolutely spared of the consequences of a changing climate, the impact of global warming will affect the poorest people, particularly those in Africa (Akpodiogaga-a & Odjugo, 2010; Huq et al., 2006; Nyong & Niang-Diop, 2006). The impacts of a changing climate are no longer a subject of debate but a call for solution-based actions (Allu, 2014). The escalating threat of this change has prompted the need for sustainable building practices and urgent consideration of building efficiency, construction methods and materials worldwide. As more buildings are erected to meet the growing population's demand, there will be dramatic heat stress and higher energy demand, particularly for cooling (Dodoo, 2020; Laue et al., 2022; Mahmoud & Ragab, 2021). According to the Intergovernmental Panel for Climate Change IPCC, Urban sprawl intensifies human-induced warming locally. With further urbanisation, the possibility of extreme heat waves is likely to be experienced. Nigeria, despite its middle-income status, has an excessive poverty rate. It is classified as one of the ten most vulnerable countries to the dangers of climate change (WBG, 2019). More worrisome, the country's population amidst the poverty level is expected to double its current number by 2055 (Macrotrends, 2022), resulting in unprecedented warming in urbanised areas. Buildings significantly contribute to global carbon emissions, so understanding climate change's impact on future building performance becomes crucial. With buildings at the centre of systems, a changing climate will alter buildings' energy demand and load factor (Jenkins et al., 2015).

2.1. Greenhouse Gas Emissions & Climate Projections

Like many other countries, buildings make up a significant source of carbon emissions In Nigeria. They are considered long-term investments and key players during climate change adaptation actions (Chmutina, 2013). According to (IUCN, 2022), the greenhouse gas (GHG) emission in Nigeria is about 126.9 million tonnes, with the energy sector amounting to 60% of the overall emissions. Accordingly, in 1999, Nigeria's GHG emission per capita was 0.33 tonnes of CO_2 emissions per capita, below the global average of 7 tonnes. This figure was close to double in 2021 (Figure 1). Further studies show that the country's emission is primarily based on the burning of fossil fuels or cement production (Hannah Ritchie et al., 2020; Ogundipe et al., 2020; Orewere et al., 2022). Although Nigeria's carbon emission levels are lesser than industrialised nations like China and the USA (Figure 2), its impact, if not well managed, will offer the most significant environmental threats (Czechowski, 2020). China and the USA are industrialised nations with significantly higher emission figures compared to Nigeria. However, while both China and the USA have active policies and actions in place to control their environmental impacts, the same cannot be said for Nigeria, which has relatively low carbon emissions. Consequently, the potential impact of carbon emissions is likely to be more detrimental in Nigeria.

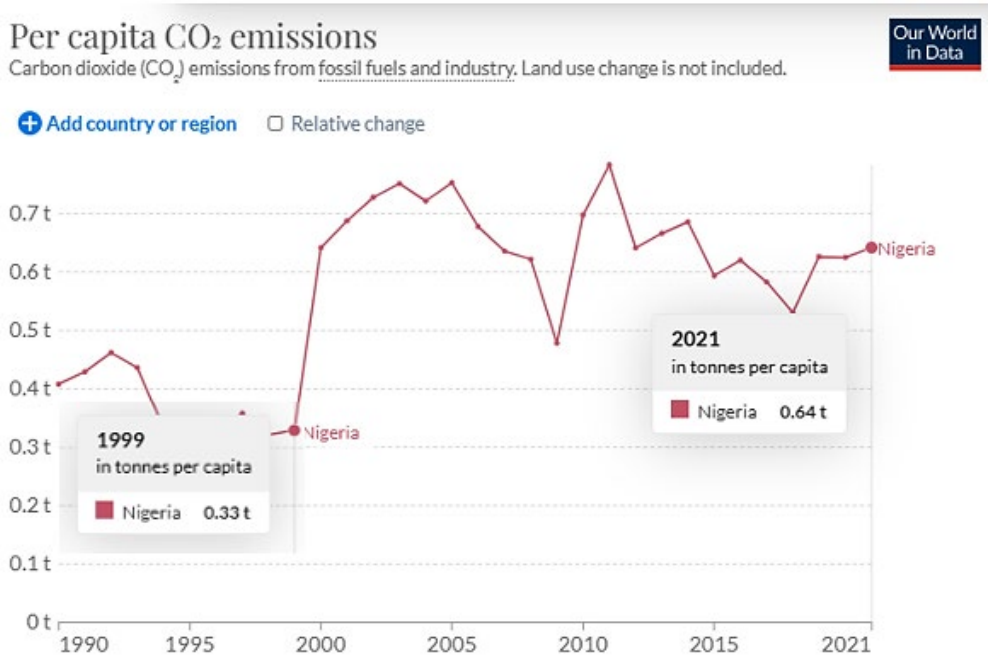

Figure 1 Nigeria's Per Capita Carbon Emissions in 1999 and 2021 (Hannah Ritchie et al., 2020)

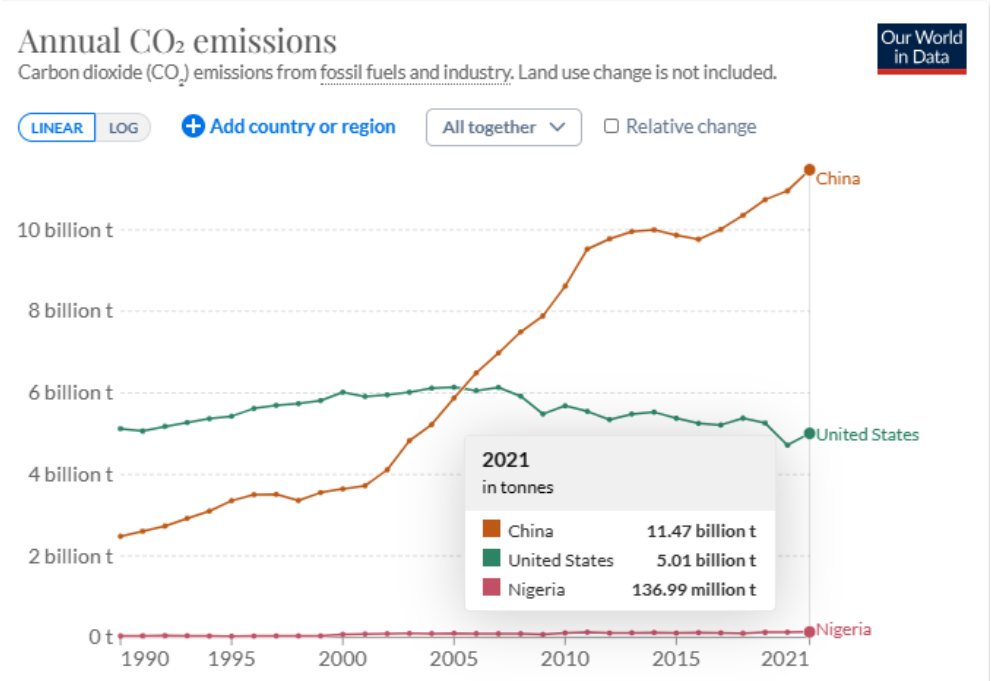

Figure 2 Annual share of Global Carbon emissions. (Hannah Ritchie et al., 2020)

Climate projections indicate that overheating and consistently high temperatures will be prevalent in the future across Africa (Laue et al., 2022); It is essential that while retrofitting existing housing stock remains crucial for buildings to adapt to future climate, the focus for developing countries should be geared towards strategies and policy development (Kristl et al., 2020). One of the concerns for professionals in the built environment, especially architects, is the consideration of the building's energy efficiency, emissions and occupant's comfort in the preliminary stages of building designs. Emissions in buildings primarily emanate from the consumption of electricity generated from fossil fuels. It is estimated that by 2050, GHG emissions will have to be reduced by

50% to avoid the worst-case impact of climate change (UNEP, 2009). With climate change affecting the energy demand for cooling, the performance of future buildings in Nigeria, compared to existing ones, is likely to widen. Understanding the drivers of this gap and implementing targeted strategies is crucial for achieving energy-efficient and sustainable buildings. This section delves into the impacts of projected climate changes on buildings in different climates and explores the design strategies employed to reduce the energy performance gaps in future buildings.

Different studies were conducted using varying climate projections to determine the effects of changing climate on buildings' performances. These investigations encompass several building uses, forms and locations. For example, (Kim et al., 2021) explored the carbon emissions and cooling energy consumption of an office prototype building in the Midwest and Northeast of the US, using RCP 8.5 climate scenario for 2050 and 2080. The investigation suggests that cooling energy consumption will significantly affect GHG emissions while these emissions by electricity consumption will increase in future scenarios. Similarly, an electricity consumption of about 18% increase was observed in a study by (Summa et al., 2020) on a residential net-zero building in Rome, using RCPs 4.5 and 8.5 climate scenarios in 2050. As asserted earlier, no country is spared of the increasing temperature, as overheating hours are also predicted in cold climates under future scenarios. In fact, (Khourchid et al., 2022) suggest that the most significant increase in cooling demand will occur in temperate and cold climates. He further posited that the Cooling demand in the 21st century (2040-2080) will increase by 33%, 89%, 288% and 376% in tropical, dry, cold and temperate climates, respectively, while towards the end of the century, (2080-2100), the energy demand will increase to 55%, 302%, 734% and 1020% for tropical, dry, cold and temperate climates respectively. By implication, the tropics will experience the least demand for cooling energy. Regardless of the building typology, form and location, the effects of a changing climate remain significant. This is further supported by studies carried out by authors for different climates, including heritage buildings in Italy (Huerto-Cardenas et al., 2021), container houses in the subtropical region of China (Suo et al., 2023), and Hellenic non-residential building stock in Greece (Droutsa et al., 2021).

In tropical climates, although limited, similar investigations were conducted to determine the impact of rising temperatures on thermal comfort and carbon emissions in tropical buildings. According to research by (Mourshed, 2012) conducted in Dhaka, the capital of Bangladesh, the impact of increased temperature will amount to a surge in demand for energy for comfort cooling. More so, this stress in energy demand, he noted, will be catastrophic to the deficient energy supply of the country. As a result of overheating and the increased occurrence of hot spells, the design of energy-efficient and low-carbon buildings will be a severe challenge in this climate. Furthermore, there is an expected increase in air temperature of about 3.3^{o}c for 2050 for tropical regions, according to (Callejas et al., 2021) for an investigation conducted in Brazil. If the current trend continues, climate models predict it will be warmer by up to 2^{o}c, with a low precipitation rate due to excess evaporation in Sub-Saharan Africa (Nyong & Niang-Diop, 2006). These investigations, particularly in Africa, show a 2^{o}c increase in temperature every 20 years.

2.2. Strategies for Reduced Energy Consumption in Buildings

Several authors share similar views on strategies for reducing the energy demand of buildings. For example, (Khourchid et al., 2022; Mobolade & Pourvahidi, 2020) suggest the use of thermal insulation and solar shading for cooling energy reduction and thermal mass (earth-sheltered walls) for cooling in tropical regions (Callejas et al., 2021). Harnessing the thermal mass in building design can help moderate indoor temperature fluctuations, reducing cooling energy requirements. Although thermal mass as a strategy for energy reduction is adequate, more is needed to completely negate the demand for cooling under future climates. Also, the reliance on passive ventilation means, and shading of external windows as a strategy to reduce overheating and discomfort levels in buildings was emphasised by (Dodoo, 2020) for a modern multi-storey building in Sweden and by (Huerto-Cardenas et al., 2021) for an investigation on heritage buildings. Additionally, (Fabbri et al., 2020) suggest that strategies for new designs and renovations and

retrofits will be centred on ventilation, thermal insulation and reflectance. The study predicts a considerable risk of multiple grid collapses and blackouts because of a surge in cooling energy demand.

Building form also shows potential for improving the energy performance of buildings. As investigated by (Ahmadian et al., 2022), for future climate scenarios in London, deep plan court and tunnel court buildings with a lower number of storeys are advantageous as regards building energy reduction in the future. In a tropical climate like Nigeria, the use of a courtyard is one of the sustainable ways of improving a building's energy performance whilst ensuring the indoor thermal comfort of occupants (Modi et al., 2022; Nwalusi & Okeke, 2021), provided there are openings to the courtyard and outdoor environment. Likewise, a study conducted by (Callejas et al., 2021) shows the significance of orientation in reducing the energy demand, with a significant reduction of up to 38% achieved under future climate scenarios in the tropics. There is no one-fit-all strategy for optimising the energy performance of a building, as the location and building type will naturally dictate the best approach to overcome heat stress in buildings. Moreover, buildings should not be perceived as permanently sealed entities but as dynamic tools that are constantly in touch with the outside world physically and psychologically. Most strategies for energy demand focus on the building envelope and system, but effective landscaping of the environment using greeneries and water bodies is a good mitigation technique for reducing thermal forces that affect buildings (Croce, 2020).

The climate change act of Nigeria obligates public and private entities to promote a low-carbon economy and sustainable livelihood (IUCN, 2022). Though it is possible to achieve the energy needs of a country while reducing the carbon emissions rate by integrating renewable or green technologies (Nnaji et al., 2013), the greenhouse gas emission trends for different climate scenarios will always follow the same pattern (Kim et al., 2021). According to (Videras Rodríguez et al., 2020), when these strategies are implemented during the design stage, energy saving of up to 14% is expected. To future-proof buildings for the impacts of a changing climate, understanding how buildings will perform in the future and developing climate-sensitive policies and techniques to mitigate climate risks is essential (Yassaghi & Hoque, 2019).

3. Methods and Materials

This research employs a mixed-methods approach, combining experimental data collection and literature review. Weather data was collected using Meteonorm climate data generator for current and future climate scenarios, using RCPs 4.5 and 8.5 across 37 locations in Nigeria, Including Abuja. According to (Droutsa et al., 2021; José et al., 2017), while RCP 4.5 is an assumed imposition of conservative emissions and mitigation policies on buildings and the environment, RCP 8.5 is the highest greenhouse gas emissions with continuing current practices, where little effort is made to reduce emissions. A simplified non-existing test building was drafted in AutoCAD and modelled in DesignBuilder for energy performance analysis. Energy simulations were conducted to assess cooling demand and energy load variations under different building parameters and climate scenarios. The energy performance data was analysed using Excel to quantify differences between climate scenarios and case building models. The results are presented using tables and figures in the succeeding section.

3.1. Weather Data

Weather data generated for this study include Global horizontal radiation (Gh), Diffuse radiation (Dh), Direct normal radiation (Bn), Air temperature (Ta), Dewpoint Temperature (Td) and Wind speed (FF). The data generated using Meteonorm is based on ground data, analysis, and satellite data, with typical years in minutes and hourly resolution based on stochastic generation (Remund et al., 2020).

According to Figure 3 below, the primary data source for Meteonorm includes IPCC scenarios, Global Energy Balance Archive, GEBA of ETHZ, Geostat data and Meteorological stations and ERA5/T.

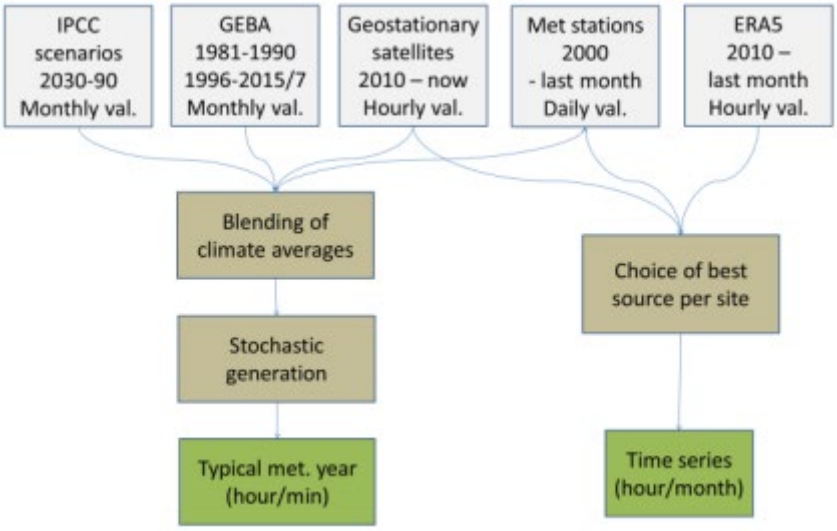

Figure 3 Data Sources and Pathways of Data Selection and Generation in Meteonorm Source: (Remund et al., 2020)

3.2. Test Building

A simple studio apartment (Figure 4) was designed to test the energy performance of buildings across various locations. The apartment consists of a livingroom to the west, a bedroom and toilet facilities to the east, a kitchenette to the north, and the building's entrance to the south. The building fabric comprises contemporary building materials applicable to Nigeria's construction sector. Specifically, the walls are made of 225mm non-insulated hollow Sandcrete blocks with 30mm cement-sand plaster on both the interior and exterior surfaces. The roofing comprises aluminium roofing sheets nailed to timber struts, and the windows feature single-pane glass.

Figure 4 Sketchup Model (Left) and AutoCAD Floor Plan (Right) of Case Building

Three simulations were conducted using the same case building but with different building fabrics and using different climate scenarios, as summarised below;

STAGE 1 (As-Built): The case building, as shown in Figure 4 above, was modelled in DesignBuilder, and the cooling and total energy loads per conditioned building area were collected for the locations using RCP 4.5 for 2020 and RCP 8.5 for 2090. Experimental data collected at this stage informs the energy performance of existing buildings in the future if current building construction trends are sustained.

STAGE 2 (Retrofitted): The case building (as-built) was fitted with shading devices to primarily shade the external walls. In contrast, the exterior windows, except for the north facing ones, were fitted with shading devices with vertical and horizontal fins, as shown in Figure 5 below. Initially modelled as a single pane (u-value = 6.121 w/m²-k) in stage 1, the window glazing was replaced with triple-glazed low-emissivity panes (u-value = 0.786 w/m²-k). Data collected at this stage informs the energy performance of existing buildings when retrofitted to adapt to future climates.

Figure 5 Optimised Model with Shading Devices

STAGE 3 (New Building): This stage focused on remodelling the case building with enhanced building fabrics. The initial wall, which had a thickness of 285mm (u-value = 2.55 W/m²-K) and lacked insulation, was increased in thickness by implementing a cavity wall. This new wall consists of a 200mm layer of brick and plaster on the exterior and a 180mm layer on the interior, separated by a 200mm polyurethane insulating foam, as illustrated in Figure 6c below. The optimised wall has a u-value of 0.128 w/m²-k. Materials for the initial roof (u-value = 2.658 w/m²-k) were also replaced with an added insulation layer (u-value = 0.778 w/m²-k) while glazing and shading for walls, as shown in stage 2 above, were maintained. Energy loads collected for simulations at this stage inform the performance of new buildings under future climate scenarios.

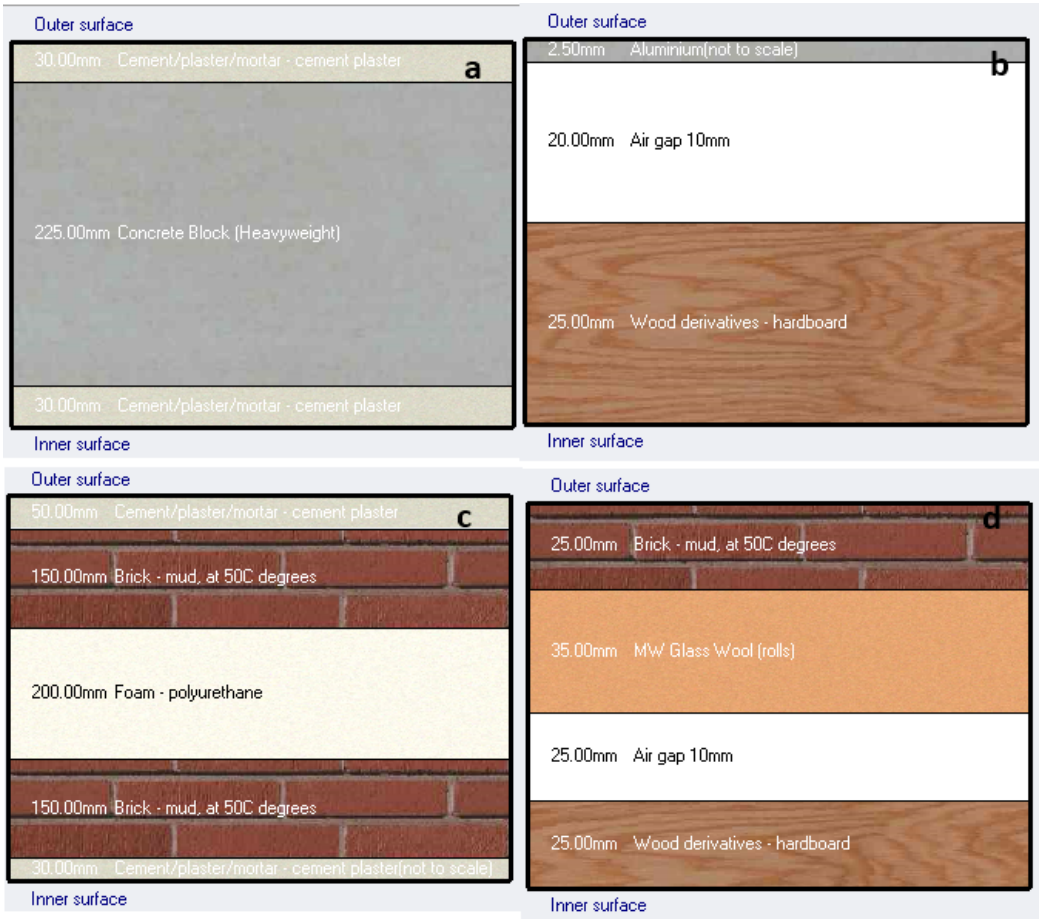

Figure 6 Cross Section of Materials: Wall (a), Roof (b), Optimised Wall (c), Optimised Roof (d)

4. Results and Findings

4.1. Outdoor Temperature Variations

As global temperatures increase, the changes in regional mean temperature, precipitation, and soil moisture get larger (IPCC, 2021). The grouping of climate data presented in this section is based on the climate classification purported by (Mobolade & Pourvahidi, 2020) for the bioclimatic

approach for climate classification of Nigeria, ASHRAE climate classification and geopolitical classification of the state capitals in Nigeria (Chineke & Idinoba, 2011). As seen in Figures 7-11 below, climate change impacts differ with location and climate scenarios. The impact of climate on buildings will require localised interventions for the best energy efficiency (Allu, 2014).

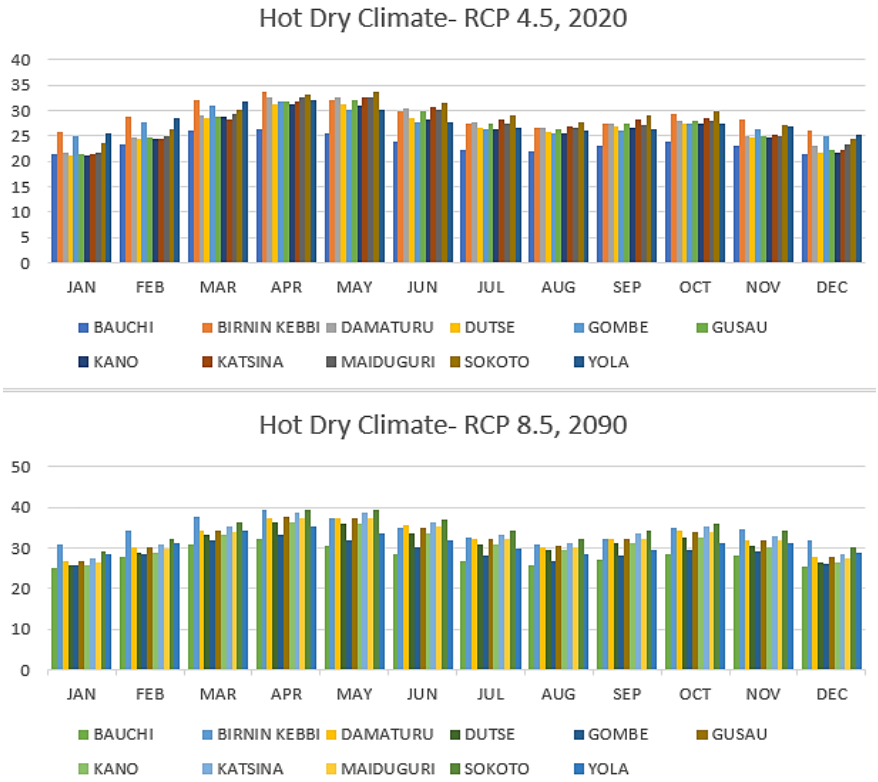

Figure 7 Temperature Variations for Locations with Hot Dry Climate

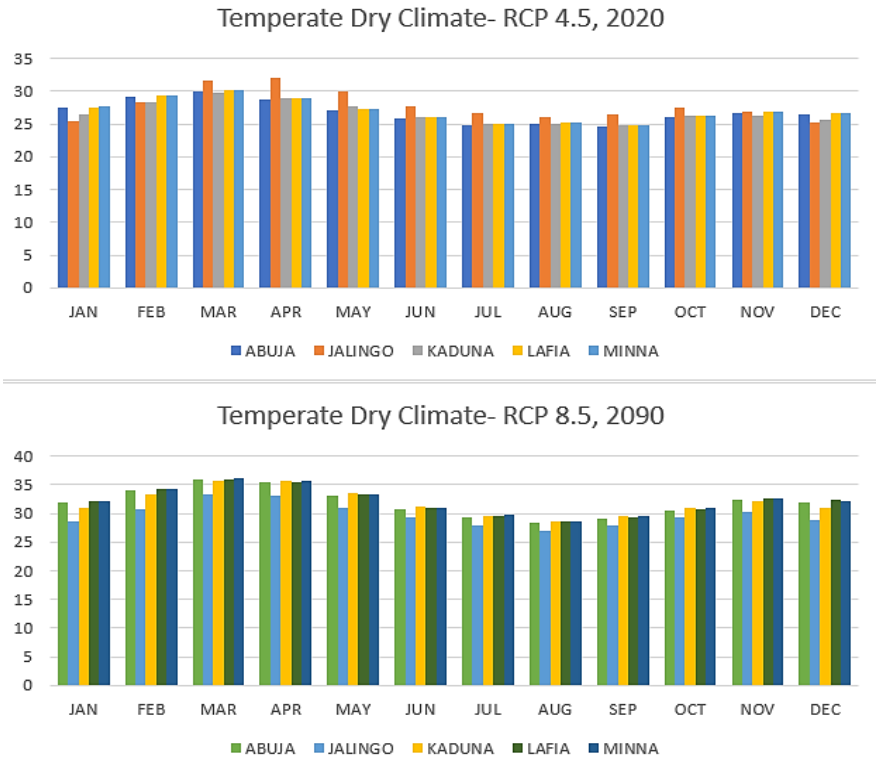

Figure 8 Temperature Variations for Locations with Temperate Dry Climate

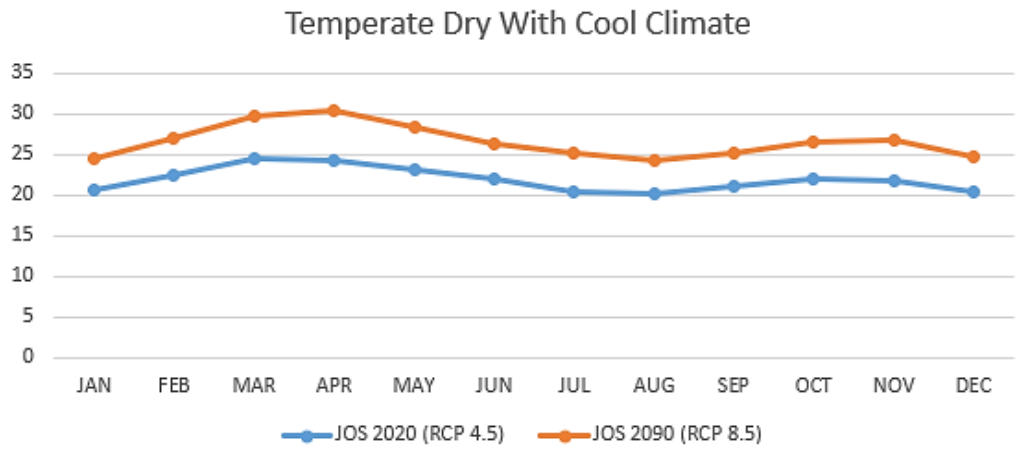

Figure 9 Temperature Variations for Location with Temperate Dry with Cool Climate

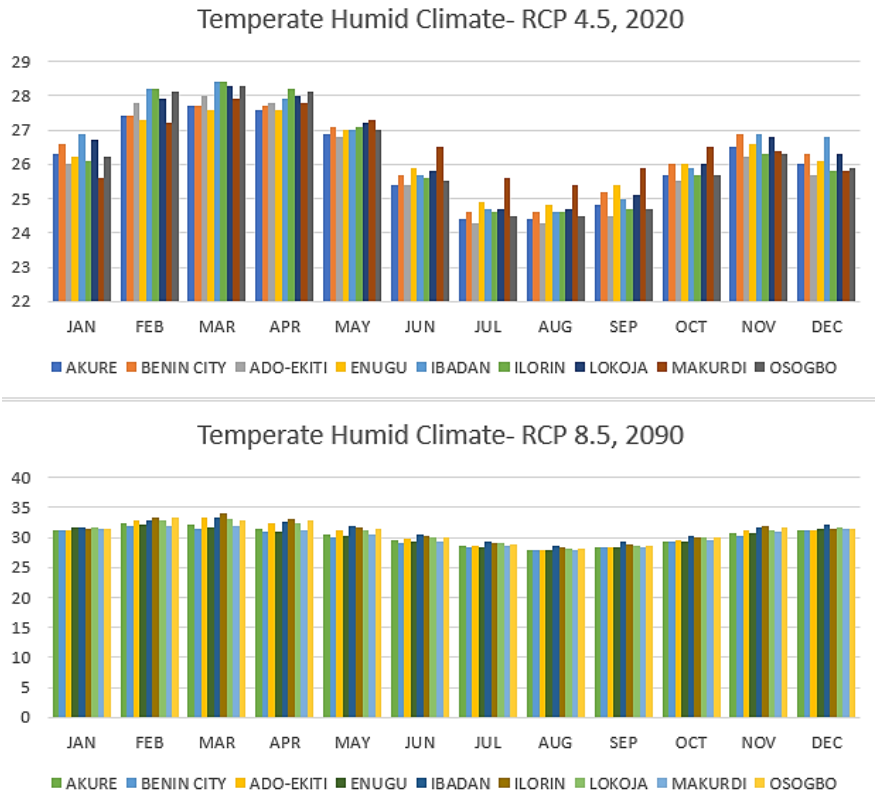

Figure 10 Temperature Variations for Locations with Temperate Humid Climate

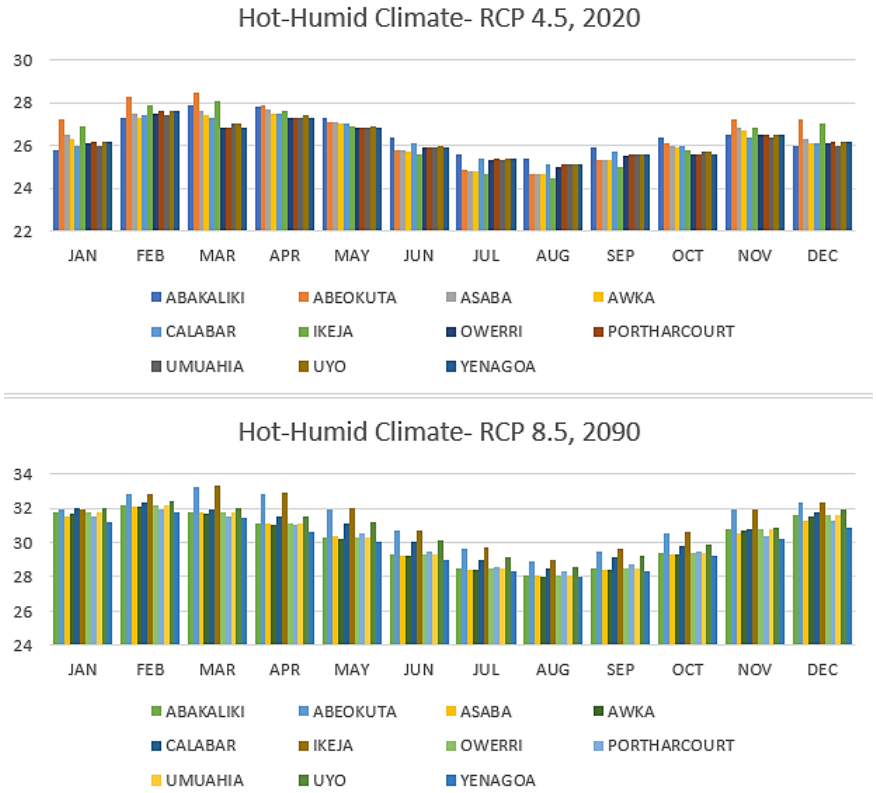

Figure 11 Temperature Variations for Locations with Hot-Humid Climate

4.2. Energy Performance Gap

Table 1 Energy Performance Table for Case Building across Locations and Different Climate Scenarios

S/No	Location	Cooling Load 2020	Cooling Load 2090	% Increase	Energy Load 2020	Energy Load 2090	% Increase
1	JOS	72.06	323.6	349	317.65	569.2	79
2	BAUCHI	135.84	343.74	153	381.52	589.42	54
3	KADUNA	215.09	413.53	92	460.64	659.08	43
4	DUTSE	267.41	364.57	36	513.05	610.21	19
5	KANO	267.4	363.03	36	513.01	608.64	19
6	DAMATURU	288.06	383.05	33	533.17	628.71	18
7	MAIDUGURI	291.69	380.37	30	537.31	625.99	17
8	KATSINA	299.92	383.46	28	545.53	629.07	15
9	YOLA	321.66	406.21	26	567.35	651.9	15
10	GOMBE	294.83	371.11	26	540.5	616.78	14
11	SOKOTO	340.43	401.59	18	586.09	647.23	10
12	GUSAU	322.64	377.23	17	568.24	622.83	10
13	PORTHARCOURT	379.31	439.56	16	624.88	685.12	10
14	BIRNIN KEBBI	359.12	415.46	16	604.77	661.11	9
15	BENIN CITY	375.63	431.51	15	621.25	677.13	9
16	MINNA	369.44	424.35	15	614.99	669.9	9
17	ADO-EKITI	371.83	426.14	15	617.49	671.81	9
18	YENAGOA	380.94	433.78	14	626.53	679.37	8
19	CALABAR	386.63	440.01	14	632.18	685.66	8
20	UYO	388.34	440.78	14	633.87	686.31	8
21	JALINGO	353.86	400.57	13	599.54	646.25	8
22	ABUJA	374.76	423.57	13	620.31	669.12	8
23	UMUAHIA	386.76	436.68	13	632.29	682.21	8
24	AWKA	385.06	434.67	13	630.8	680.2	8
25	OWERRI	386.47	435.93	13	632.03	681.48	8
26	ENUGU	387.05	435.47	13	632.58	681	8
27	ABAKALIKI	389.55	436.43	12	635.08	681.96	7
28	AKURE	383.52	429.64	12	629.18	675.31	7
29	ASABA	389.41	434.32	12	634.98	679.89	7
30	ILORIN	383.27	426.37	11	628.96	672.06	7
31	MAKURDI	391.91	433.26	11	637.45	678.8	6

32	IKEJA	398.03	436.28	10	643.74	681.99	6
33	IBADAN	394.68	432.02	9	640.39	677.73	6
34	LOKOJA	394.2	431.44	9	639.74	676.98	6
35	ABEOKUTA	397.92	433.83	9	643.63	679.54	6
36	LAFIA	392.62	427.89	9	638.19	673.45	6
37	OSOGBO	399.08	426.65	7	634.8	672.37	6

Table 2 Energy Performance Table for Retrofitted and New Buildings in 2090

S/No	Location	Test Building (Retrofitted) 2090				Test Building (New Building Envelope) 2090			
		Cooling load	% Decrease	Energy Load	% Decrease	Cooling Load	% Decrease	Energy Load	% Decrease
1	JOS	243.13	25	488.72	14	86.96	73	343.1	40
2	BAUCHI	265.8	23	511.48	13	117.16	66	373.42	37
3	KADUNA	328.74	21	574.3	13	173.84	58	429.92	35
4	DUTSE	287.77	21	533.41	13	147.46	60	403.66	34
5	KANO	286.01	21	531.62	13	147.5	59	403.66	34
6	DAMATURU	302.95	21	548.61	13	156.7	59	412.91	34
7	MAIDUGURI	300.08	21	545.7	13	156.29	59	412.46	34
8	KATSINA	307.14	20	552.75	12	160.53	58	416.68	34
9	YOLA	317.38	22	563.06	14	167.31	59	423.57	35
10	GOMBE	288.85	22	534.52	13	140.12	62	396.35	36
11	SOKOTO	324.07	19	569.7	12	170.11	58	426.3	34
12	GUSAU	299.62	21	545.22	12	155.98	59	412.12	34
13	PORTHARCOURT	334.41	24	579.97	15	191.56	56	447.66	35
14	BIRNIN KEBBI	336.03	19	581.68	12	182.5	56	438.71	34
15	BENIN CITY	335.26	22	580.88	14	188.14	56	444.31	34
16	MINNA	336.53	21	582.08	13	182.34	57	438.41	35
17	ADO-EKITI	333.98	22	579.65	14	179.22	58	435.44	35
18	YENAGOA	333.57	23	579.17	15	185.39	57	441.52	35
19	CALABAR	334.79	24	580.34	15	194.24	56	450.32	34
20	UYO	335.31	24	580.84	15	195.71	56	451.75	34
21	JALINGO	313.17	22	558.86	14	158.73	60	414.99	36
22	ABUJA	334.87	21	580.41	13	177.81	58	433.88	35
23	UMUAHIA	334.58	23	580.1	15	191.44	56	447.48	34
24	AWKA	335.32	23	580.85	15	191.92	56	447.98	34
25	OWERRI	334.48	23	580.04	15	191.66	56	447.75	34
26	ENUGU	335.97	23	581.5	15	193.08	56	449.13	34
27	ABAKALIKI	336.18	23	581.71	15	195.08	55	451.13	34
28	AKURE	335.32	22	580.98	14	187.8	56	444.03	34
29	ASABA	335.98	23	581.55	14	192.73	56	448.83	34
30	ILORIN	336	21	581.69	13	184.64	57	440.9	34
31	MAKURDI	337.24	22	582.78	14	194.37	55	450.44	34
32	IKEJA	336.89	23	582.6	15	198.72	54	455.01	33
33	IBADAN	336.89	22	582.61	14	192.66	55	448.96	34
34	LOKOJA	337.34	22	582.88	14	191.76	56	447.82	34
35	ABEOKUTA	336.72	22	582.43	14	196.51	55	452.8	33
36	LAFIA	336.5	21	582.07	14	183.39	57	439.48	35
37	OSOGBO	334.69	22	580.41	14	183.06	57	439.36	35

5. Discussion

Despite its location, Nigeria's climate, though generally classified as warm and humid, presents composite climates for different cities (Ajibola, 2001). Based on climate projections and experiments, there would be a shift in ASHRAE climatic classifications of ten locations in the country, which is 27% of the country. The locations include the following capitals; Akure, Bauchi, Ekiti, Ibadan, Ilorin, Jos, Lafia, Lokoja, Osogbo and the Federal Capital Territory FCT, Abuja. These locations, except for Bauchi, would shift from ASHRAE climate zone 1A (very hot and humid) to 1B (very hot and dry), while that of Bauchi will shift from 2B (hot-dry) to 1B (very hot and dry) in 2090. The result (Figures 7-11) shows a relative increase in outdoor temperature of about 5^{o}c across the country under RCP 8.5 in 2090. Increased temperature levels characterise RCP 8.5, according to (José et al., 2017). The changes in climate classifications in some locations follow assertions by (Díaz-López et al., 2021), who opined that climate categories for building locations will likely change in the future, with several cities tending toward warmer classifications.

5.1. Performance of Existing Building

In line with reviewed literature on building performance in future climates, the results of the stage 1 experiment show that existing buildings will consume more energy in the future. Compared to contemporary times, the cooling load in 2090 will increase by 7%-349%, while the overall energy load will also increase by 6%-79%, depending on the location (Table 1). Based on the case building, the most affected states with increased energy consumption are Jos, Bauchi and Kaduna, having cooling load increases of 349%, 153% and 92%, and energy load increases of 79%, 54% and 43%, respectively. Although Bauchi is in a hot-dry climate (Figure 7), it currently experiences temperatures of about 21^{o}c during the cold months of December and January. On the other hand, the city of Jos, situated in a cold climate (Figure 9), is the most affected by a changing climate contributing to the highest increase in energy consumption in the future.

While Climate change affects cooling demand in all climatic zones, its impact differs according to the distinct climatic zones (Khourchid et al., 2022). In this study, the least affected location on cooling load for the building is in Osogbo, with a 7% increase in 2090. In contrast, the locations with the least total energy load in the future are Makurdi, Ikeja, Ibadan, Lokoja, Abeokuta, Lafia and Osogbo, with only a 6% increase. All these state capitals are in the humid region (temperate humid and hot humid) of the country (Figure 10 and Figure 11) except for Lafia, situated in the country's dry climate (Figure 8). Additionally, most of these states with the least energy consumption for future climate scenarios are in the country's Southwest and Southeast geographical zones. It is further deduced that based on current construction practice in Nigeria, where building insulation is underplayed (Alegbe, 2022), an increase in energy consumption, especially for cooling, will affect buildings domiciled in the Northwest and North eastern part of the country. According to (Díaz-López et al., 2021), existing buildings do not match the reality of the current and changing climate, as most buildings are designed and constructed according to obsolete climatic classifications and with no consideration for future climate reality. Hence, climatic design for a sustainable future needs to be a focus during the building design stage because, in a changing climate, buildings considered near-zero energy buildings may lose their viscosity in a short time (Summa et al., 2020).

5.2. Performance of Retrofitted Building

When the case building was optimised by providing shading to walls and windows, the cooling load was reduced to 19-25% (Table 2). These improvements in the building fabric are ideal for building retrofits. The reduction in the performance gap between the various locations signifies an improvement in the building performance compared to the non-optimised case building model. Most of the buildings in the Southwest and Southeast regions recorded decreased in energy consumption. The highest decrease in cooling energy with the optimised building also occurred in Jos, the coldest region in the country. The least savings, on the other hand, occurred in Sokoto and Birnin-Kebbi, two states in the Northwest geo-political zones and hot-dry climate (Figure 7) of Nigeria. On the overall energy performance, there is a 12-15% decrease across all locations compared to the case building under the future climate scenario. This implies the importance of shading exposed wall surfaces and windows to prevent solar gains. According to (Dodoo, 2020), external window shading can reduce overheating and discomfort levels in buildings. The most significant savings in energy occurs in the building sited in Portharcourt, Yenagoa, Calabar, Uyo, Umuahia, Awka, Owerri, Enugu, Abakaliki and Ikeja. These locations form a more significant part of the South South and Southeast zones.

5.3. Performance of New Building- Enhanced Building Envelope

The greatest savings in the energy performance of existing buildings in future climates occur when the building envelope of the case building is completely refurbished. The major refurbishment was in the roof and walls by adding insulation and increasing the thickness and materials of the external wall (Figure 6). This refurbishment is in addition to the changes made at stage 2 of the building simulation experiments (see test building in the methods & materials section). These modifications not only contribute to better energy performance, but the greenhouse gas emissions

of future buildings are also reduced. As corroborated by (Conroy et al., 2021), contrary to current practices, building envelope assemblies with greater insulation levels to meet future low-energy use requirements will result in reduced greenhouse gas (GHG) emissions due to lower thermal energy requirements. However, it is essential to emphasise that the amount of GHG emissions for a building will depend on the climate scenario for the future (Kim et al., 2021).

The stage 3 investigation shows that the greatest savings in cooling energy for the building occurred in the country's coldest parts: Jos and Bauchi (Table 2, new building envelope). This is compared to the 349%, and 153% increase predicted in 2090 for the case building performance in these locations before any modification (Table 1). A lot of energy consumption and emissions can be reduced in the most affected locations using adequate mitigation techniques. Furthermore, the greatest energy savings of the new building model occurs in the North (Northwest and Northeast), with up to 73% savings in cooling energy and up to 40% reduction in overall energy load. In comparison, the most minor energy savings occurs in the Southwest region, with up to 33% in energy consumption reduction. While there are variations between savings in cooling energy and total energy loads in these locations, the optimised models for retrofits and new builds show improved energy performance for buildings in the South than those in the North. This is because of the predicted energy demand for cooling in the Northern states in future climate scenarios and savings recorded for buildings in the South. However, energy savings for buildings with the new envelope in future climate is comparable across all locations, with a 7% difference between the highest and least savings.

According to (UNEP, 2009), the building sector has the most potential for delivering significant GHG emissions; it is only possible to meet emission reduction targets by supporting building energy efficiency. Sadly, most developers do not consider climate-sensitive design a viable option, especially concerning external shading (Karol & Lai, 2014) and building envelope insulation in the tropics. Most architects and contractors replicate the same designs in different climate zones. In the past decades, the challenge with buildings was to improve indoor thermal comfort through increased fabric insulation; however, in the future, the major challenge will bother on how to reduce overheating risks to ensure acceptable comfort conditions (Fabbri et al., 2020) and reduced GHG emissions. To ensure the existing building stock adapts to changing climate, designers will centre strategies for new designs and renovations on air exchange, fabric insulation and optimisation of reflective surfaces (Fabbri et al., 2020).

6. Conclusion

In an era of changing environmental conditions, buildings in Nigeria must adapt, needing modifications to the existing housing stock. Retrofitting and optimising structures for energy efficiency become crucial as climate scenarios evolve. Most buildings are designed with outdated climate data, lacking future energy efficiency considerations. This oversight not only threatens indoor comfort with rising global temperatures but also increases global emissions through excess energy consumption. The lack of consideration for future energy efficiency in building construction is concerning, with implications beyond comfort, leading to heightened energy consumption and elevated global emissions.

This study underscores the urgency of proactive design strategies prioritising building envelope enhancements, thermal mass insulation, and solar shading to bolster energy performance under evolving climates. The utilisation of Meteonorm weather files and EnergyPlus simulations laid the foundation for a three-stage assessment of prototype building energy performance across 37 locations in Nigeria. These stages illuminate a trajectory for existing, retrofitted and new buildings, fostering an informed approach to future climate scenarios.

A summary of the study findings is as follows.

1. By 2090, significant temperature changes are projected, notably affecting the Northcentral and Southwest zones, potentially leading to a climate classification shift.

2. In 2090, outdoor temperatures are projected to increase by up to 5^{o}C nationwide compared to 2020.
3. Simulations show that rising outdoor temperatures will strain building energy loads, particularly cooling systems. While overall energy consumption may surge by up to 79% in the future, cooling energy needs may rise between 7% and 349%, depending on the location, necessitating increased focus on future cooling demands.
4. Optimised glazed surfaces and enhanced insulation within building envelopes consistently reduce energy requirements.
5. Future buildings can achieve up to 40% energy savings in new constructions through solar shading and thermal mass optimisation. Investing in solar shading is crucial to shield buildings from heat stress.
6. Emissions by electricity consumption increase in future scenarios due to rising temperatures. Implementing green technology for electricity generation can reduce future GHG emissions, though it will affect construction costs.

The evident outcomes from optimised building models, as demonstrated through EnergyPlus simulations, emphasise the significant potential for achieving energy savings. Embracing these building optimisation strategies could position Nigeria to develop energy-efficient, climate-resilient buildings that actively contribute to global initiatives in climate change mitigation. However, it is crucial to recognise that regulatory policies, urban environments, and buildings have been identified as pivotal areas requiring comprehensive attention to address adaptability challenges effectively. While natural science approaches have played a role in combating climate change, there is a notable lack of emphasis on the importance of involvement by development policy-makers or practitioners within the climate change community. Immediate actions directed at adapting buildings to future climates may be perceived as costly, it is not to be compared to the long-term cost associated with delayed implementation.

The implementation of design strategies aimed at enhancing building efficiency in a changing climate could face hindrance due to a potential rise in capital costs in tropical climates. As such, governments of developing countries, like Nigeria, must grasp the extent of vulnerability and augment adaptive measures in the built environment, which constitutes a significant contributor to greenhouse gas emissions. This stresses the need for proactive measures and policy interventions to ensure sustainable and resilient building practices amid evolving climates.

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Resume

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The rebasification of the Roman theatre in mediaeval Zaragoza

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Abstract

This study aims to illustrate the formation of the urban tissue over the Roman theatre in the walled core of Zaragoza. Within the scope of the study, the typological plan of the city was prepared using the building surveys taken in 1911, and the plan was interpreted as a historical organism. The basic types in the city are determined, and methods of the process-based typology are used to reveal the formation process of a selected urban tissue that is an example of the rebasification of a specialized building. In this example, a Roman theatre was repurposed as a foundation for constructing residential buildings and affected the formation process of the urban block until its discovery.

Keywords: typological process, building typology, typological plan, rebasification, Caesar Augusta.

1. Introduction

Describing the processual development of the urban form of Zaragoza is the main objective of this work. It hypothesizes that the tissue of the walled centre of Zaragoza shows a continuous transition from the Roman settlement following a subdivision of the original plots, and some of the characteristics of building types come from the transformation of the previously built environment. It describes the territory as a historically identified organism (Strappa, Carlotti & Camiz, 2016), and by mounting the individual building surveys, it prepares Caesaraugusta's typological plan. For the preparation of the typological plan, the building surveys prepared by a team led by topographer Dionisio Casañal y Zapatero in 1911 for the Geographic and Cadastral Institute of Zaragoza were used.

1.1. Methodology

The studies in process-based typology focus on categorizing building types and their synchronic and diachronic variants to interpret the formation process of urban tissues. In this study, the methodological framework developed by Saverio Muratori, Gianfranco Caniggia, and Gian Luigi Maffei (1979) is adopted to reveal the formation process of a selected urban tissue that is an example of the rebasification of a specialized building. Although building typology research has a long history, it appeared as a form of classification focused only on formal features until the 20th century. In the 1950s, it came to the fore with the idea that the modern understanding of architecture was insufficient to produce solutions integrated with the existing urban textures. The research field was further developed under the leadership of Saverio Muratori, with the aim of producing new design proposals that would allow the continuity of the urban texture (Strappa,

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2016). The typo-morphology approach accepts that the built environment emerged as the result of a historical process. Caniggia and Maffei use the term typological process to describe the gradual differentiation between building types in the same cultural area (Caniggia & Maffei, 1979). Defining synchronic and diachronic variants of building type allows for making inferences that are in harmony with the development process of the city.

1.2. Substratum and Rebasification

Over time, due to migrations and changes in social structure, the man-made environment loses its social context. After their significance for the settlers is lost, they become a second nature to men, and he starts transforming and adapting them to his living requirements. Often, pieces from the historical buildings (spolia) were reused as building materials, and the old structures were repurposed as foundations for new constructions. The continuity between the different phases of change and development transfers particular characteristics to these new constructions that arise in that foundation. Particularly in the Middle Ages, the re-functioning of public buildings, the use of spolia as building materials, and the invasion of open spaces for construction transformed the existing texture but ensured that features such as orientation and plot size survived to the present day. The substratum can be a base type, such as in the formation of courtyard houses from the Roman Domus substrata in contemporary Naples (Caniggia & Maffei, 1979) or the transition from Roman Domus to medianum house in Ostia Antica (Barbera, 2018). Substratum can also be a specialized type, such as the Roman theatre that became a foundation for row houses and pseudo-row houses in Zaragoza. The examples of rebasification, the repurposing of a specialized building for constructing an urban tissue of basic types, present themselves as forms that interrupt the uniformity of the urban tissue. These interruptions, when investigated, help to illustrate a fragment of the history of the city.

2. Formation of the urban tissue

The Roman colony Caesaraugusta was built following the Roman Empire's victory in the Cantabrian wars in 14 BC on the site of the Iberian city Saldube (Salduie, Salduba), under the rule of Caesar Augustus. At first Romans considered this culturally mixed city as their ally. Towards the end of the 1st century BC with the settling of Roman military forces to establish Colonia Caesar Augusta, the Sedetani people of Salduie joined the Roman population. The most valuable information about the establishment of the Roman colony on the site of Saldube comes from two epigraphic documents written in Latin. Respectively, Tabula Contrebiensis contains the agreement between Sostenians and those from Saldube that are intended to build a water channel likely for agricultural use. The Bronze of Ascoli contains the names of Iberian horsemen of the Turma (cavalry unit in the Roman army of the Republic and Empire) Salluitana, who received Roman citizenship in 89 BCE after they participated in the siege of Asculum (modern Ascoli Piceno). The Roman colony was an obligatory point for passage for those traveling from Asturica Augusta to Tarraco or Emerita Augusta from the north (Pina Polo, 2005).

The Visigoths settled in the city in the fifth century AD. In 711, Tariq ibn Ziyad’s army crossed the Strait of Gibraltar and entered the Iberian Peninsula. After a few years, they capitulated Caesaraugusta, the most important of the three Visigothic episcopal cities without resistance (Betrán Abadía, 2005), and the town became a part of the Umayyad caliphate. The Umayyads of Córdoba controlled the city from 756 to 1013, the Taifa Kingdom of Zaragoza from 1013 to 1110, the Almoravids from 1085 to 1145, and the Second Taifa era from 1140 to 1203.

Since then, a mixture of these societies has populated the city: those converted to Islam, Mozarabes, Jews, and minorities from North Africa and the Middle East (Betrán Abadía, 2005) and the impact of this diversity in culture of the populations that lived in Zaragoza is still visible in the urban form of the city. Considering the Roman town Caesaraugusta underneath the Muslim Saraqusta and contemporary Zaragoza, this city is a valuable ground for typological studies.

2.1. Rebasification of the block

In 1972, fragments of a Roman theatre were discovered during the construction of a new building on Veronica Street. The Caja de Ahorros de Zaragoza, Aragón y Rioja (Savings Bank of Zaragoza, Aragón and Rioja) had the intention of building its new headquarters on the site between San Jorge and La Verónica, and the discovery of a Roman theatre made it unwise to maintain the construction project. The Roman theatre of Caesar Augusta dates to the 1st century. Construction started during the era of Tiberius (14-37 AD) and was completed in Claudius (41-54 AD). It has 7,000 square meters and seats 6,000 spectators on approximately 30 rows of seating.

The block formed in the same place where the theatre was located is represented differently in maps drawn from 1712 to 1911 (Figure 1). While the map from 1712 shows Zaporta Street as dividing the block, the same street is represented as a short road and a small space in the plan of 1769. While plans of 1769 and 1809 show two short cul-de-sacs connected to San Andres Street, they depict Zaporta Street as a very short cul-de-sac. There is no visible trace of the Roman theatre other than the round corner where Veronica Street and San Pedro Nolasco Street meet.

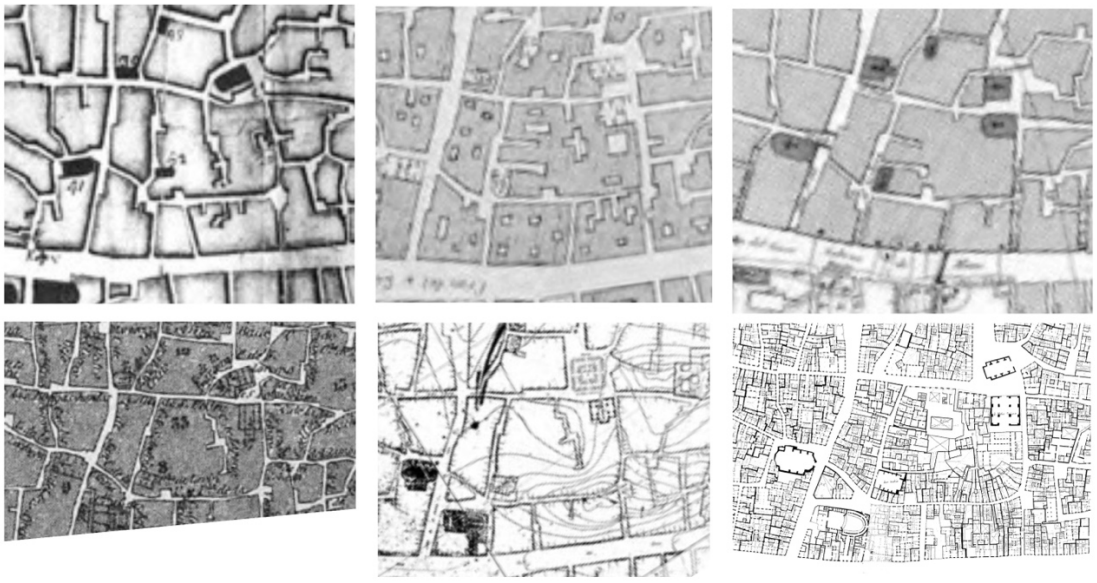

Figure 1 Block 11 in different plans. First row: Parcellation plan of Zaragoza in 1712, Plan of Zaragoza by Carlos Casanova in 1769, Central plan by Ambroise Tardieu h. in 1809. Second row: Plan of Zaragoza by Dionisio Casañal in 1880, Plan of Zaragoza by Dionisio Casañal in 1879, typological plan prepared by the author with surveys derived from Geographic and Cadastral Institute of Zaragoza done in 1911 by Dionisio Casañal y Zapatero.

The aerial photos taken before the partial demolition of the block show the curvature on the corner of the block and the roofs of the narrow houses that accumulated there (Figure 2). The inner part of the block has a similar orientation to the rest of the urban tissue, but the road on the west of the block is slightly angled. The photos taken after demolition reveal that the fragments of the Roman theatre are partially under the street, and the orientation of the narrow houses accumulated along the curvature matches the shape of the Roman theatre (Figure 3).

Illustrating the development phases of the block requires the identification of the block components in the building scale. The building types inside the historical core of the city were defined by analysis of the typological plan. The buildings were categorized based on common characteristics and progressive development phases. The analysis of the typological plan shows that Figure4 most of the urban tissue of Zaragoza consisted of mature diachronic variants of row houses, in-line houses, and a particular type of large house with an ornamented courtyard in 1911. There are two kinds of row houses in the city. The narrow row houses are approximately 3,5 meters wide (Figure 4), and the wide row houses have 5 meters width (Figure 5). The narrow row house type has the following formal characteristics: an entrance hall, a room without any windows but connected to the entrance and the corridor, and a staircase behind that room, which is connected

to the entrance through a corridor on the side. In examples with more plot depth, it is observed that another room, which has a window to the backyard, is formed behind the staircase. This study is limited to the types that existed in the selected block for the purpose of the research.

Figure 2 Block 11 before demolition for a new construction. Source: GAZA, Gran Archivo Zaragoza Antigua

Figure 3 Block 11 before demolition for a new construction. Source: GAZA, Gran Archivo Zaragoza Antigua

The row houses in the block this study focuses on have a different form than the rest of the urban tissue. It consists of a particular synchronic variant of row houses, inline houses, pseudo-row houses, and patio houses that form the urban tissue of Zaragoza. Overlapping the archaeological plan of the Roman theatre with the typological plan reveals that the block was partially formed under the impact of the newly discovered Roman theatre. These recurring characteristics differentiate them from the rest of the urban tissue. The new type of row houses has an approximately 5-meter-wide front façade, and their facades to the backyard are 3,5 meters wide. The inline houses aligned with the walls are aggregations of this synchronic variant of the type. In contrast, the inline houses on the west part of the block, which are not affected by the substratum, are aggregations of the typical row houses.

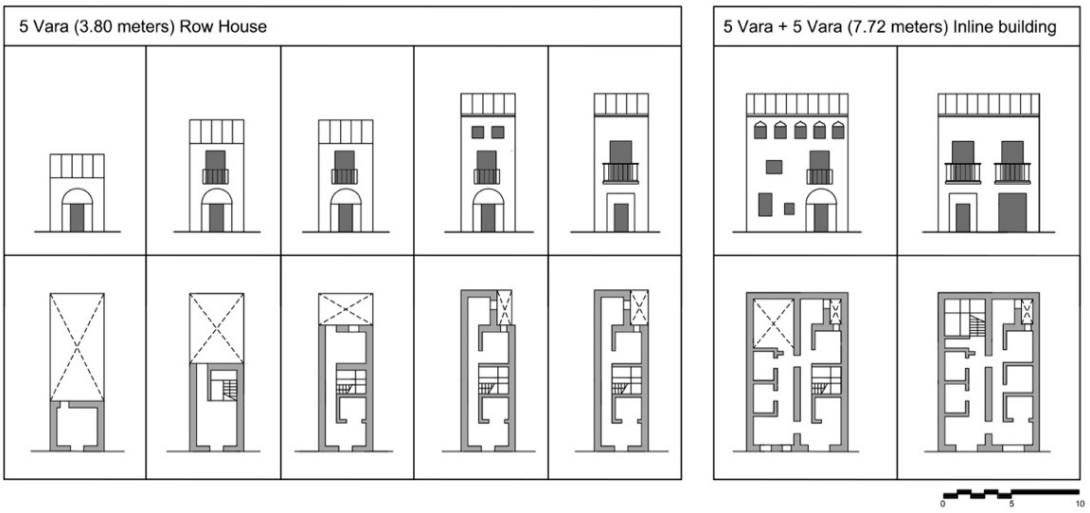

Figure 4 Formation process of narrow (approximately 3.80 meters front width) variant of row and inline house type, author's drawing.

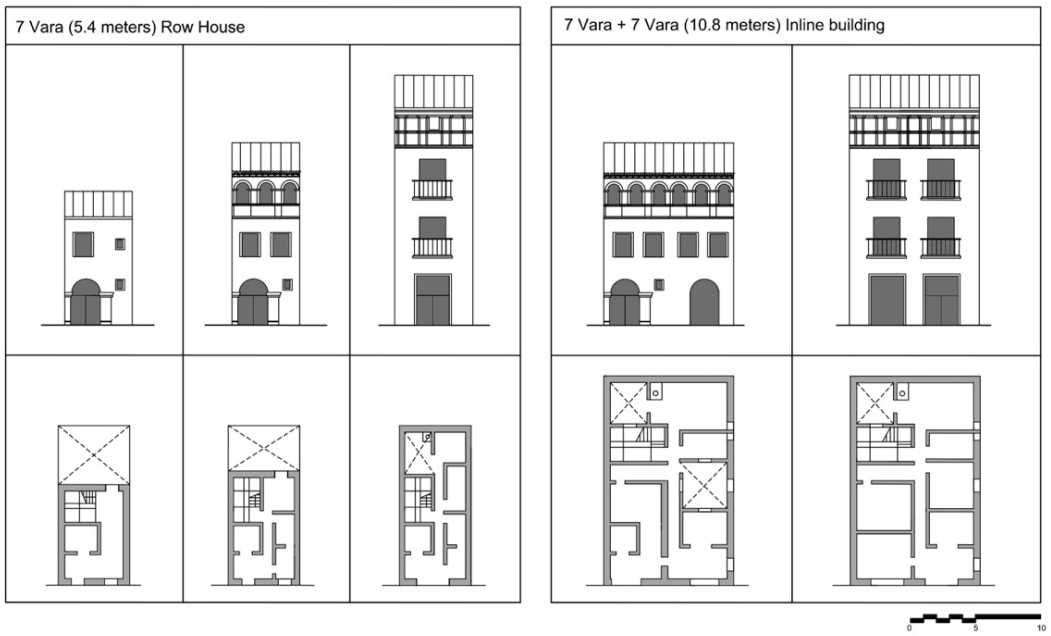

Figure 5 Formation process of wide (approximately 5.40 meters front width) variant of row and inline house type, author's drawing.

The row houses in the block this study focuses on have a different form than the rest of the urban tissue. It consists of a particular synchronic variant of row houses, inline houses, pseudo-row houses, and patio houses that form the urban tissue of Zaragoza. Overlapping the archaeological plan of the Roman theatre with the typological plan reveals that the block was partially formed under the impact of the newly discovered Roman theatre. These recurring characteristics differentiate them from the rest of the urban tissue. The new type of row houses has an approximately 5-meter-wide front façade, and their facades to the backyard are 3,5 meters wide. The inline houses aligned with the walls are aggregations of this synchronic variant of the type. In contrast, the inline houses on the west part of the block, which are not affected by the substratum, are aggregations of the typical row houses.

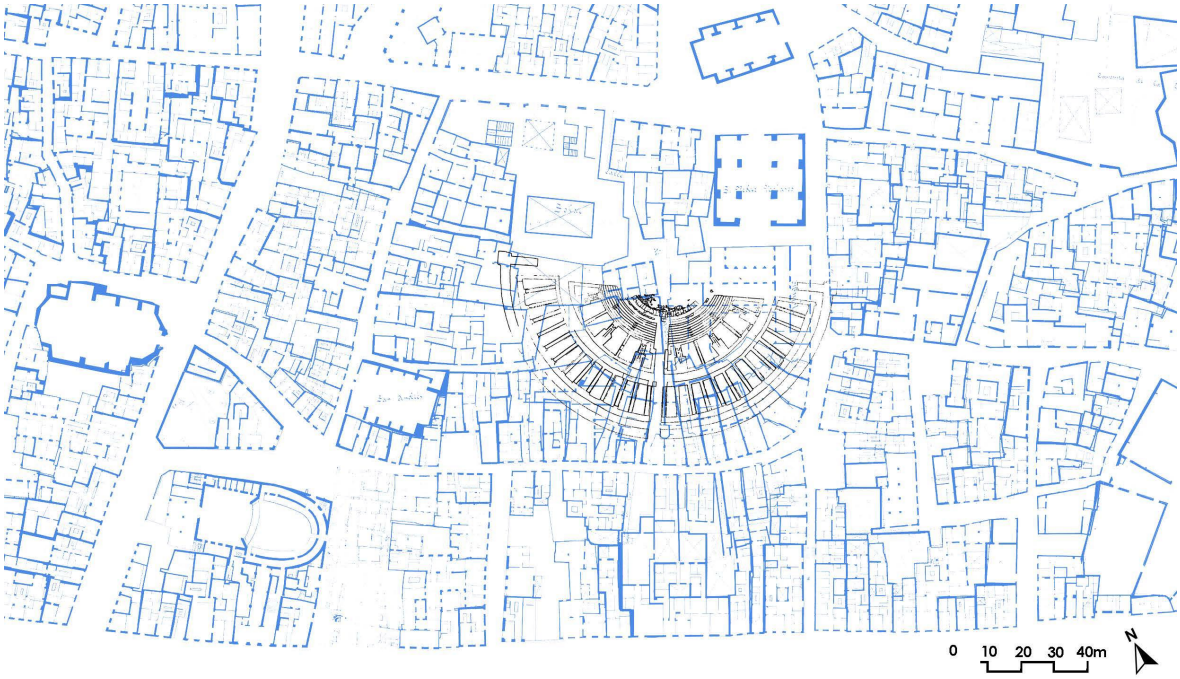

Figure 6 Typological plan of Zaragoza based on surveys of Dionisio Casañal, 1898, superposed with the survey of remains of Roman theater (El Teatro De Caesaraugusta, Estado Actual De Conocimiento, Miguel Beltrán Lloris, 1993), author's drawing.

Zaporta Street, starting after no.12 and 14 on San Jorge Street, reaches the location of the orchestra. At the end of this street, two angled row houses share a semi-circular courtyard, which corresponds to the symmetrical axis of the theatre. The wall covering the backyard of row houses on the right overlaps with the walls of the gate under the seats of the theatre (Figure 6).

The pseudo-row houses located parallel to the stage of the theatre point out the existence of a road perpendicular to Calle de Zaporta. Two other elements follow that indication in the same direction. One of those elements is the alley of house no. 16 on Calle de San Andres, which is occupied by this patio house in later stages. Another element is the outer wall of the patio belonging to San Pedro Nolasco in no. 15 on Calle de San Pedro Nolasco. The other group of pseudo-row houses, in conjunction with Calle de la Veronica and Calle de San Andres, are built on the former border of the block. An empty area follows this same line, the inner walls of row houses, and the back wall of a pseudo-row house in between row houses.

In the current situation, Veronica Street looks as if it is the matrix route for block 11, and San Pedro Nolasco Street and San Andres Street are acting as the planned construction route. Most likely, the pseudo-row houses next to San Andres Church occupied that part of the street in later stages. There are three pseudo-row houses located on the south of the block on the left side, and their wall on the north follows the same line as the wall of San Andres Church. The area between the conjunction of Veronica Street with Don Jaime I Street (so-called cardo) and the street on the north of San Andres Church is the limit where the regularity of the block starts to end. The distortion of the urban tissue in this corner and the form of the triangular building block could be the result of the invasion of the street to build pseudo-row houses. If the limit of block 11 overlapped with the outer wall of the Roman theatre in the first century, the parts of the block on the south that do not overlap with the theatre could be later additions as well. The triangular pseudo-row house located on the southeast limit of the theatre supports this assumption.

The west part of the block consisted of houses that had multiple courtyards and backyards; they were wider than the rest of the buildings in the block, and their orientation followed the rest of the urban tissue. Andre Bazzana (1992) identified two different types of patio houses in the Iberian Peninsula; the first one he named "block-like" and the second "attached." According to Bazzana,

this difference between the two types can be answered with the economies of families: the exterior courtyard was used by semi-nomads; the interior courtyard, patterned after the ksar of the Sahara was originally inhabited by sedentary farmers. Petruccioli (2008) states, “such a schematic analysis is doubtful since it is conducted at an insufficiently low level of typological specificity”. In Zaragoza, it is possible to find both types, whether the building plot is regular or irregular; there are houses with two side patios, two central patios, or both with a side and a central patio. The typological plan revealed that some houses in Zaragoza have a central or a side patio, regardless of the shape or position of the building plot, which can also be observed in block 11. A close look at the room dimensions and inner plan organization of these patio houses reveals their similarities with the row houses. Because of this similarity, this study considers these large structures a synchronic variant of the inline house type.

The roads on the western side of the block most likely follow the streets of the Roman urban tissue. These inline houses on the left expanded and occupied the streets in time, but the limits of streets are still visible as long corridors belong to their interior plan.

3. Conclusions

The excavations in the area revealed that Roman theatre lost significance around the 5th century. During the medievalization process of the block, row houses aggregated on the border of the cavea around the space of the orchestra, and their walls were aligned with the bearing walls of the theatre. The Roman theatre affected the formation of this urban block in a larger area than the theatre itself. This situation shows that besides repurposing the substrata as a foundation for new constructions, the existence of the Roman theatre had an impact on the legal land division and building permissions in the previous centuries. Identifying the components of the urban form in the building scale and exploring irregularities of the urban form based on these assumptions provide a route to light up a small fragment of the long history of cities.

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Resume

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Observing patterns for the urban fabric as a place shaping continuum on the waterfront of the Haliç area, Istanbul

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Abstract

This research paper details a part of a case study exploring placemaking activities and the outcomes of urban design issues in a waterfront area. The fine-grained urban fabric has played an important role in waterfront regeneration schemes globally. Governments try to encourage place-based regeneration activities such as design-led and culture-led strategies addressing social and physical issues in several waterfront areas. Acting towards environmental challenges to provide green spaces has increasingly become a favourable approach since the 2010s. An ideas competition was held in 2020 to address this issue on the waterfront of the Haliç area, which is a post-industrial site today. The seven semi-structured interviews were conducted to explore the competing discourses on each project created by the teams who attempted to deal with the unsolved urban fabric. In this regard, this paper focuses on the examination of the placemaking activities in a situation where there is no urban fabric, by referring to the help of control variables together with semi-structured interviews with academic members of Istanbul Technical University and investigates the existence of the urban fabric as a place shaping continuum in the Halic area.

Keywords: content analysis, pattern-matching, sense of place, streetscape, urban fabric, waterfront

1. Introduction

The Haliç area was deindustrialised through the enactment of the Haliç master plan of 1985, with its primary goal being the design of play areas, parks, and green spaces for recreational use, as well as the repurposing of heritage buildings.

A review of the literature has revealed that among the three categories of regeneration issues, place-based regeneration activities, which are culture-led and design-led, focus on social and physical issues. In the 1980s and 1990s, local governments opted for culture-led regeneration activities to encourage investment.

Culture-led regeneration is the “culture as a catalyst and engine of regeneration” (Evans, 2005). Culture and regeneration together with cultural regeneration are classified as a part of this approach. Culture and regeneration involve in small-scale schemes such as designing a museum or organising a public art programme. The similar approaches were adopted by repurposing heritage buildings to cultural facilities, such as the Koç Museum, Feshane and Santral Istanbul in the Haliç area.

Cultural regeneration focuses on the cultural aspects that deal with the regeneration of a city. For instance, the EU selects a European Capital of Culture every year and Istanbul was chosen in 2010 to celebrate its diverse culture. In the following years, regeneration activities continued with

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repurposing the heritage buildings and designing open-air exhibition spaces, parks, and pedestrian-friendly zones in the Haliç area.

Globally by the mid-1990s, the heritage buildings that made people have sense of place and a connection to the past became the focal point for establishing high-quality public spaces without compromising their culture, heritage, and identity in the form of entertainment. Design-led regeneration activities that focused on placemaking issues began to be seen as a viable solution for enhancing the vitality and viability of post-industrial areas adjacent to city centres. There is a connection between the environment in which we socialise and the economic factors that fund it.

The recent phenomenon aimed at enhancing the attractiveness of areas by regenerating degraded urban environments via creating green spaces or deploying climate-adaptive green infrastructure were taken seriously by European cities during the 2000s and 2010s. However, the spatial patterns of urban greening initiatives within each city can be considered in relation to the city's local context. There are reasons to believe that some common spatial patterns do exist. Anguelovski et al. (2022) stated that the processes occurring in places where new greening activities took place were often close to but generally not within the historic downtown areas of the city. This often indicates the redevelopment activities taking place in post-industrial or underused areas located in nearby city centres.

For example, Today, the Haliç area is viewed as an underutilised post-industrial waterfront area adjacent to the historic city centre. It appears that viability and vitality have not been improved solely through the regeneration activities that have focused on green spaces and parks since 1985.

The scholarly literature on post-industrial waterfront developments indicated that waterfront areas were in a state of constant transition and many post-industrial sites that are located around the waterfronts were involved cultural preservation, public outdoor activities, and parks. Critiques of such developments expressed their concerns regarding green gentrification at the expense of social equity and shared economic prosperity (Evans et al., 2022).

This paper aims to explore potential outcomes for making the waterfront more diverse, variable, and vital. It also tries to find an answer as to whether regenerating this area through placemaking schemes consisting of green spaces would be sufficient. In another aspect, it specifically examines the issues concerning placemaking schemes in a situation where there is no urban fabric by referring to the help of the control variables and the use of semi-structured interviews. Therefore, this effort aims to investigate the role played by the existence of the urban fabric as a place-shaping continuum in the Halic area.

2. Placemaking and Urban Design Issues

The term 'placemaking' has been defined as a reaction to the disappearance of community-focused places since the early 20th century, or it can be regarded as a complex concept within a specific process. This process involves the enhancement of physical spaces, along with the community framework and key actors playing vital roles (Silberberg et al., 2013).

Placemaking can be traced back to the 1960s, as a response to modern planning and its consequences, as well as other issues related to inhabitants, visitors, and employees in towns and cities. During this period, urban thinkers created a new way to describe public spaces that could be designed by communities, which became the focal point.

Lynch (1960) emphasised the importance of how individuals interacted with the urban fabric. Jacobs (1961) highlighted the significance of lively neighbourhoods together with attractive and welcoming public spaces. Lefebvre (1968) introduced the slogan ‘right to the city,' which challenged societal relationships governed by top-down spatial management.

Whyte (1980) focused on social life in public places and other urban environments, exploring the connection between social interaction and design, while Jacobs analysed street spaces and

sidewalks. In the subsequent years, placemaking expanded its focus to include human-centred examples of urban transformations (Batty, 2013).

After the establishment of the PPS, the 'placemaking movement' spread around the world in the 1990s. Shneekloth and Shibley (1993) conducted a comprehensive investigation into 'placemaking,' using case studies from their research to illustrate the significance of integrating design activities and community participation in organising public and private spaces.

Nowadays, the term encompasses from daylong events to the transformation of neighbourhoods that may take several decades to achieve. Some governmental organisations are deeply involved in placemaking, and the field of placemaking has expanded to include public agencies, private sector entities, and non-profit foundations. Durmaz (2012) highlighted the relationship between creative industries and placemaking emphasising the role of creative industries as a catalyst for the transformation of urban areas in cities.

Industrial cities underwent redefinition in terms of their functional and economic aspects. Therefore, urban design became a crucial tool in the renewal, regeneration, and rehabilitation of historic districts, as well as the repurposing of heritage buildings. Urban design experienced significant changes worldwide in the 1990s. However, as the recession of 2008 took place, affecting every nation economically and socially, the results and impact of this approach began to be felt.

Urban design enhances the design and use of public spaces by providing various forms of public space via using mixed use, streetscape, street life, and small blocks 'Urbanism' is the relationship between public spaces. Urban culture is the outcome of the development of mankind, and urban conservation deals with the continuity of urban life. It is essential to assess buildings of historical significance and their locations within urban settings. To integrate what remains as heritage in urban fabric, there should be interrelated efforts to connect the fields of urban archaeology, urban conservation, and planning. Historic city centres comprise groups of buildings and road networks constructed in different periods, which collectively define the urban fabric that is now a part of an urban character and culture. According to Gehl (1989), the success of urban spaces is contingent on street life and the activities that occur within these spaces.

The balance of open space to built form has been a planning issue. The arrangement, appearance, and functions of our suburbs, towns, and cities have changed over the years and are still changing with the application of new design ideas to create localities in which people live.

It is a well-known fact that inequality in access to green spaces creates some downsides among neighbourhoods as people do need socialising. They do this by going to parks, open spaces, and jogging. However, the post-pandemic period has shown the experts that while people working from home or continuing shopping online, these attitudes will give rise to issues in terms of socialising in the future; therefore, shops, cafes, and buildings with active frontages that contribute to enhancing street life are still needed (Donahue, 2021). Designers should have the same concern for the waterfront of the Haliç area.

2.1. Fine-grained urban fabric

Urban grain is 'the degree of mixing of different physical elements in an urban area', sometimes referred to as horizontal subdivision, as it pertains to the role patterns of plots within a block (Lynch, 1981). This term also plays a crucial role in varieties of mixed uses together with the economic opportunities created by diversity.

It began to be used in planning together with urban design in the late 1990s and was defined as 'the pattern of the arrangement of street blocks, plots, and their buildings in a settlement' (DETR, 2000).

In any given area, there can be several categories of urban grain that contribute to the overall urban character. Lynch (1981) further divided urban grain into fine and coarse, describing it as ‘the grain of a mix is fine when like elements, or small clusters of them, are widely dispersed among

unlike elements, and coarse when extensive areas of one thing are separated from extensive areas of another thing'. Recently, it can be said that cities are coarse-grained, and they are considerably rigid because the smallest units are considered as blocks of flats (Habraken, 2003). For instance, according to a study in Detroit, a serious change from a fine-grained city to a coarse-grained urban texture resulted in the city planners being unable to distinguish the potential of the historic fabric that had some economic vitality (Locke, 2019).

It has always been considered to be the term that describes the traditional pattern of plots; although, many contemporary urban fabrics include examples of small plots (Norton, 2016) and are closely associated with the most enchanting streets and spaces (Loci, 2010). The complexity of fine urban grain contributes to increased richness and variety (Campbell, 2012). When places have smaller plots, they are worth more, and the economic condition within an area is resilient enough to sustain the value of such smaller blocks. The block and its pattern continue to exist and reflect the ideologies of the time of its construction by creating patterns based on coherency and repetition. These forms of urban blocks are inclined to be comparatively stable over a period of time. Meanwhile, functional uses change faster. Therefore, the most resilient component of urban fabric is the block and its ground floor plan (Kropf, 1998).

2.2. The conceptual model and the theory of placemaking

Three categories of urban regeneration were found as a result of the literature search. First are the regeneration activities based on governance structures that are state-led (Miller & McTavish, 2013; Smalley 2015), property-led (Turok, 1991; Evans, 1997; Anders, 2004; Raco & Tunney, 2010; Tallon, 2013) and market-led regeneration (Tallon, 2009; Sagan & Grabkowska, 2012; Smith, 2014). Second are place-based regeneration activities addressing social and physical issues that design-led (Roberts & Sykes, 2000; Bell & Jayne, 2003; Garde, 2004) and culture-led (Evans, 2005; URBACT Culture members 2006; Jones & Evans, 2008; Ennis & Douglass, 2011) are classified as this type of regeneration activities. Last are the strategies that provide focus for an activity or event such as art-led (Bridge, 2006; Ewbank, 2011; McCormack, 2013), event-led (Garcia,2005; Smith & Fox, 2007; Evans, 2011; Smith, 2012), housing-led (ODPM 2004; Rosemary et al. 2005), attraction-led (Amion 2010), retail-led (Pacione, 2005; Lowe, 2005; Tallon, 2009), and tourism-led (Williams & Shaw, 1991; Stead & Hoppenbrower, 2004) form this part of regeneration activities.

The literature review revealed that since 2008, some local municipalities have experienced difficulties during the global financial crisis, that weakened the structure of property-led urban regeneration strategies. This is how design-led schemes were established. These regeneration schemes focus on placemaking activities and are also involved in making use of fine urban grain issues (Garde, 2004; Holmes, 2016).

After completing the literature review, a conceptual model was developed. The interdependent variable is urban grain, which relates to fine and coarse-grained urban fabric. The dependent variables are the mixed use, street life, streetscape, and small blocks. The place dependence, place attachment, and place identity are considered control variables. Moreover, the sense of place was created by small urban blocks, mixed use, and streetscape, as this concept is strongly linked to the placemaking process. This strengthens the relationships between the independent and dependent variables and provides the contextual framework (Figure 1).

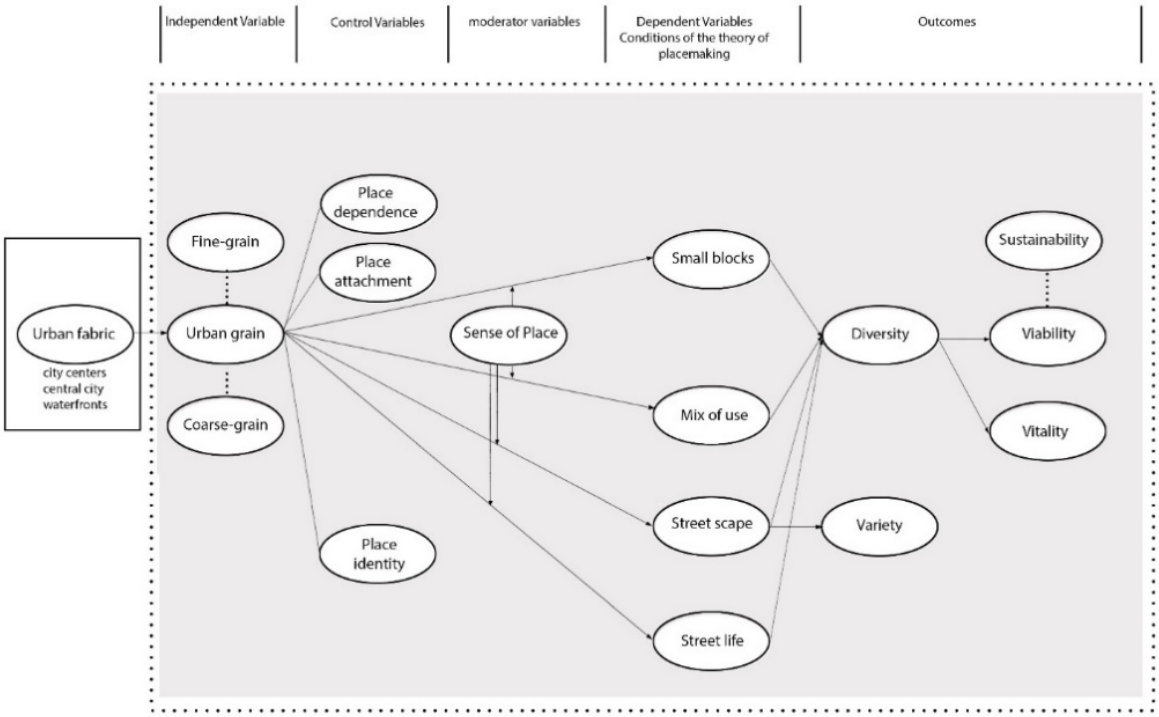

Figure 1 The conceptual model based on the literature review

3. Case Study: The Haliç Area

3.1. Methodology

In this case study concerning the Haliç area, the exploratory sequential design was chosen from the three core mixed methods designs. The three-phase exploratory sequential mixed method is a design that begins by exploring the qualitative data. It later sets up a feature that needs to be tested, then usually continues with a survey in the third phase to test the formulated hypothesis and draw a conclusion (Creswell & Creswell, 2018).

A part of placemaking studies focuses on the examination of the urban grain by analysing historical maps. The first phase of this case study involved the analysis of the historical maps depicting the Haliç area.

The second phase investigated some of the maps by using the character area assessment and the historical-geographical approach to determine the feature to be tested, which was the urban fabric on the waterfront.

Given the sequential nature of such designs, the third phase focuses on collecting quantitative data to test a phenomenon. An alternative application of the third phase involves the use of interviews to explore what is grounded in the data by identifying themes and then clarify the findings before the testing. Therefore, it was designed to conduct semi-structured interviews to obtain experts' views as part of the research objectives. In this case, the data collection took place at two points: one of which was the gathering of initial qualitative data during the interviews and the other was the conducting of the questionnaire survey involving visitors and inhabitants in the study area.

3.2. The Study Area

The 8 km long Haliç (Golden Horn) is the estuary of the Alibeyköy and Kağıthane Rivers and serves as a primary inlet to the Bosphorus Strait. At its widest point, the Haliç estuary is about 700

m between the districts of Cibali in the south and Kasımpaşa in the north. A coastal strip of about 150 meters encircles the Haliç area, which is only a few meters above sea level.

There are four districts located on both banks of the Haliç area. The neighbourhoods of Fatih (Eminönü, Unkapanı, Cibali, Fener, Balat, Ayvansaray), and the district of Eyüp are located on the south bank; the district of Kağıthane together with the neighbourhoods of Beyoğlu (Sütlüce, Hasköy, Kasımpaşa, and Galata) are located on the north bank. The road by the sea that separates the waterfront from these neighbourhoods in the Haliç area defines the study area.

At the outset of the deindustrialisation efforts, to improve vitality, one of the solutions seemed to establish some parks; however, this was insufficient as the absence of mixed-use development projects did not support the public's use of this area more frequently.

In 2020, the architectural ideas competition entitled 'İstanbul Senin Haliç Kıyıları Tasarım Yarışması' was held. The competition focused on the creation of multifunctional green spaces in the Haliç area. The teams participating in this competition comprised a range of design disciplines, including planners, landscape architects, and architects who worked in collaboration as required. The competition site was divided into seven project sites, with six of them bordering the coastal road, a constant that was also mentioned in the character area analysis (Figure 2).

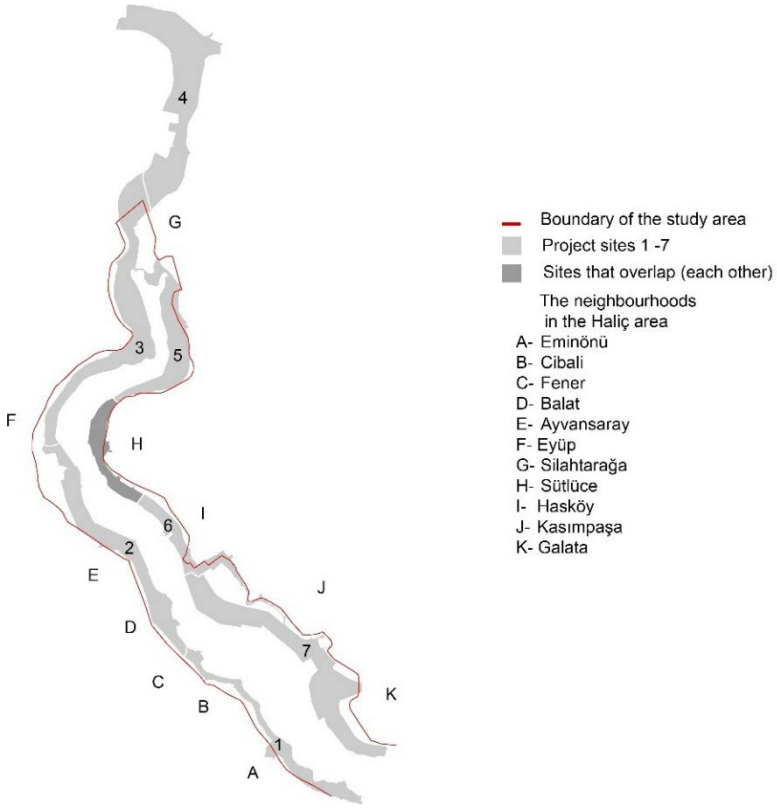

Figure 2 The neighborhoods, the study area (shown in red), and the competition sites of the architectural ideas competition (shown in grey with numbers from 1 to 7)

3.3. The Results of the Case Study

The character areas reflect different historical and current land use issues and physical characteristics of an area where a clear identity emerges instead of dealing with individual site-specific projects. The character areas in this case study provided a basis for the examination of the urban fabric issues relating to the Haliç area.

3.3.1. Determining the Character Areas in the Haliç Area

In order to record the connections between the character areas on the waterfront, some maps were short-listed from the historical maps studied. The six-character areas were chosen by

examining these maps chronologically (Table 1). These are the waterfront areas of the district of Eyüp, the Historic Peninsula, the square of Eminönü, Galata, and the shipyards together with the neighbourhoods of Halıcıoğlu, Sütlüce and Hasköy.

As urban grain is the independent variable, the streets, urban blocks, building types, mixed use and street life are dependent on the conditions of the urban fabric on the waterfront.

Table 1 Maps used for the Character Areas Study

TITLE OF MAP	DATE	AREAS COVERED
B. R. Davies	1840	the Historic Peninsula, Galata and Üsküdar
Moltke Map	1868	the city of Istanbul
C. Stople Map	1882	the Historic Peninsula, Galata, Üsküdar and Kadıköy
Alman Mavileri	1914	the Historic Peninsula; Eyüp, Beyoğlu, Beşiktaş, Kadıköy and Üsküdar
İstanbul Şehri Rehberi	1934	detailing Istanbul and the Bosphorus
İstanbul Şehir Rehberi	1971	A city guide of Istanbul

The Davies map of 1840 was the earliest record that provided sufficient information on the condition of the waterfront. The characteristics that were observed include the location of the coastal road along the sea in front of the city walls and some patches of urban fabric in other parts of the Haliç area.

The Stolpe map of 1882 was the second one where many industrial facilities were located on the waterfront. Over the years, this area became more industrialised and developed into an industrial district, with commercial activities taking place in a fine-grained urban fabric on the waterfront.

The urban fabric was well-established as seen in the map series of 1914 Alman Mavileri, the city guides of 1934 and 1971. The coastal road set off from the Square of Eminönü ran towards Eyüp, circled around the Silahtarağa Power Station, and continued running parallel to the coastline towards Galata, clearly separating the waterfront where the industrial activities were taking place. This road still exists today.

The results of the character area analysis indicated that the situation in the Haliç area was based on the cultural and historical conditions relating to the urban fabric on the waterfront as it was mostly fine grained in the vicinity of the former jetties. Placemaking activities should be taken more seriously in these areas to enhance the viability on the waterfront as well as the neighbours around it. The following map studies demonstrate the relationship between the coastal road and the urban fabric on the waterfront during different periods (Figure 3).

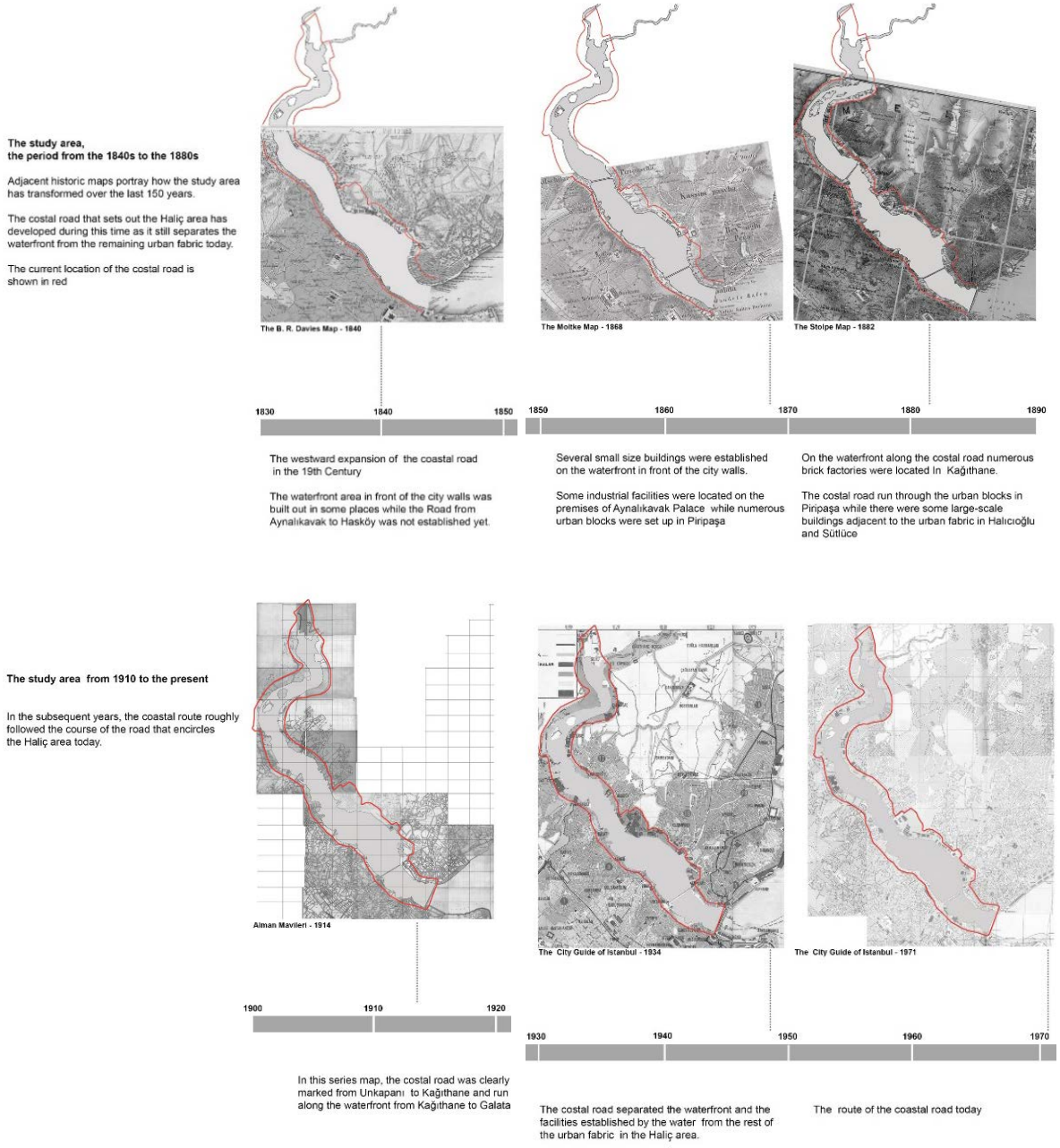

Figure 3 Character areas study (maps depict the Haliç area in chronological order)

3.3.2. Analysing the features of the urban fabric in the Haliç area

In terms of urban fabric, three periods were identified: the first one is after the 1870s, the second one is between the years from the 1900s to the 1920s and the last one is the 1970s.

To analyse the maps for the earlier two periods, it was decided to adopt the historico-geographical approach that was described by Cozen (1960) that stems from the progressive growth of urban fabric and relates to the historical context by focusing from the present to the earlier periods. Nevertheless, there is no established methodology for this approach (Slater, 2009). Furthermore, the map analysis that reveals the conditions in the 1970s is presented as a dot distribution map.

3.3.3. The condition of the urban fabric

The study focused on the analysis of building types and the urban fabric (Levy 1999). Since this area was an industrial district, there was a confirmable relationship between the levels of urban grain and the degrees of land use in the three period maps. The patterns of finer urban grain formations varied depending on their locations on the waterfront. Nevertheless, there was a strong link between the intensity of finer urban grain and a considerable degree of mixed use in the study area (Table 2).

Table 2 Map series used for the analysis of the urban fabric in the Haliç area

TITLE OF MAP	SCALE	DATE	AREAS COVERED
maps covering the period from the 1900s to 1920s			
Goad	1/600	1904	Pera and Galata, Kadıköy.
Alman Mavileri	1/1000	1913-1914	the Historic Peninsula; Eyüp, Beyoğlu, Beşiktaş, Kadıköy and Üsküdar
Pervititch	1/2000	1922	Eminönü, Fatih, Beyazıt, Beyoğlu, Beşiktaş, Kadıköy, and Üsküdar.
map covering the period of the 1970s			
İstanbul Şehir Rehberi 1971	--	1971	-

The 1870s

As the maps of the 1870s do not reveal efficient information, the examination of urban plots and urban grain was not fully analysed. Some small urban blocks were built on the waterfront where the city walls were partially demolished. However, most military establishments and the restricted zone where the shipyards were located can be clearly seen.

The period from the 1900s to the 1920s

The spatial analysis of the industrial facilities in the Haliç area was carried out by using three map series due to data limitations. One of the two fire map series was prepared by Charles Edward Goad in 1904. The second map series was completed in 1914, and locally known as 'Alman Mavileri', these 1/1000 and 1/500 scale maps were used as a general plan of Istanbul covering the historic peninsula and Galata. The third set was the fire map series prepared for the years from the 1920s to the 1940s by Jacques Pervititch. Finally, the three maps analysed separately were superimposed to provide a piece of overall information about the spatial patterns and locations of the industrial buildings in the Haliç area (Figure 4).

Evaluation of the period from the 1900s to the 1920s. The superimposed map revealed that a mixture of fine and mixed-grained urban fabric was found adjacent to the city walls on the waterfront that was separated by the detached streets. The land near these streets was used for public spaces. The coastal road was intersected by the streets connecting the jetties through the gates to the inner parts of the Historic Peninsula. Streetscape wise, this area, where mostly warehouses were located, had an order unto itself, as the width of the warehouses resembled those of the buildings in the fine-grained grid of the city centre. There were several large buildings located on wide plots of land, mostly military warehouses in the inner parts of the Haliç area and the shipyards. The two bridges connected the waterfront areas of Eyüp and Galata, and the urban fabric was expanded on either side of the waterfront.

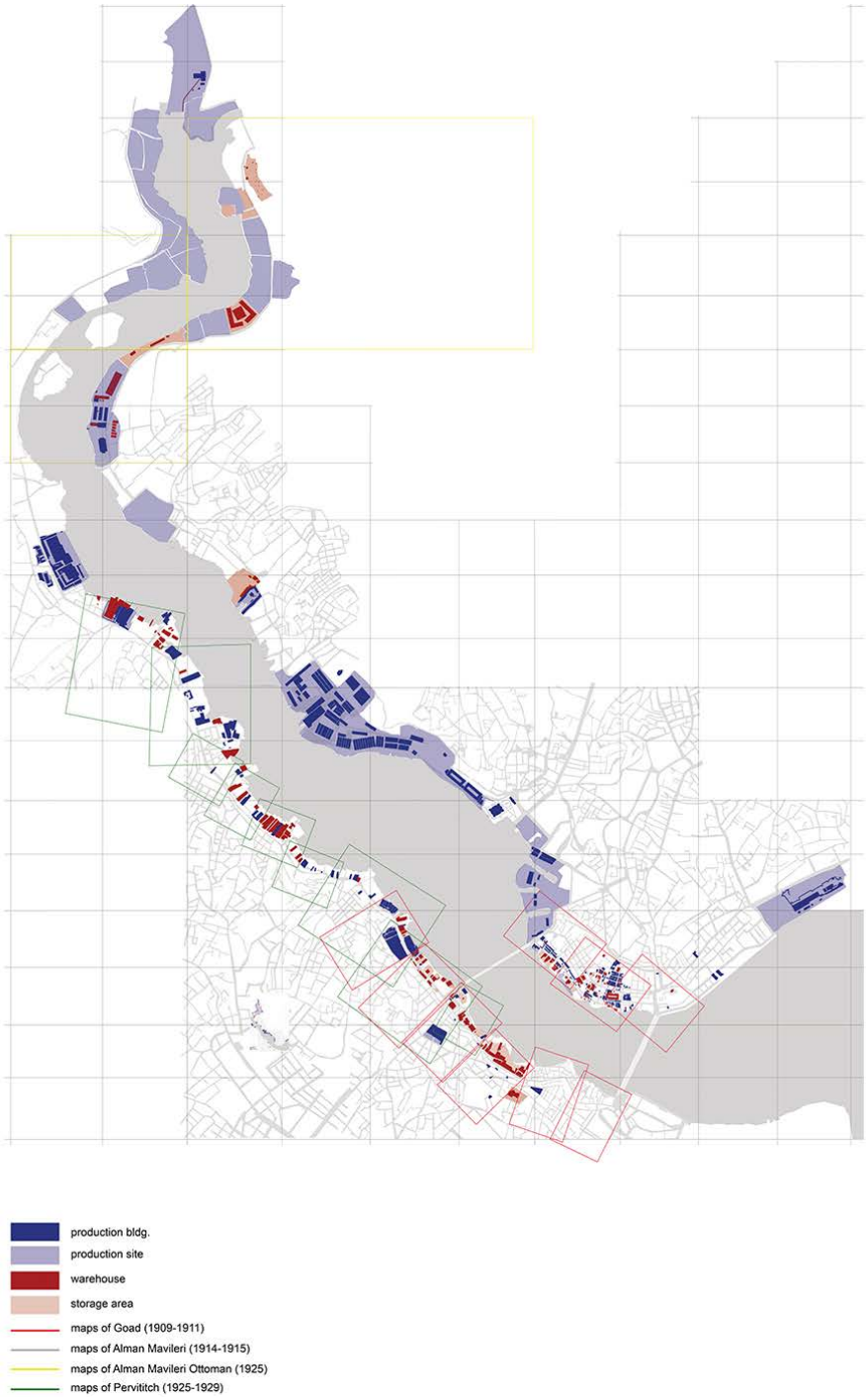

Figure 4 Map constructed to detail the urban fabric on the waterfront, the years from the 1900s to the 1920s

The Period of the Post-1970s

For the map of this period, the data were gathered from the documents published in the 1977 survey study in which the facilities were marked out per their manufacturing activities. Their address numbers were used to indicate their locations. However, determining the locations of these commercial and industrial establishments on the map presented some challenges. The cadastral maps did not include any records for address numbers, and some of the street names also changed over the years. Instead, the map published in the 1971 city guide of Istanbul was used as a base map to hypothetically locate the industrial buildings. Each industry outlined in the survey was assigned a colour, and each building was represented with a dot. This dot map serves as a record

of the final stage of industrial and business activities in the Haliç area just before deindustrialisation took place per the Haliç masterplan of 1985 (Figure 5).

Evaluation of the period of the post-1970s. The presence of a fine-grained urban fabric on the waterfront can be comprehended as the dots are a type of unit visualisation representing the actual locations of each facility and its relevant plot. Numerous small factories and warehouses that occupied a large proportion of the land on the waterfront area by the city walls were connected to the inner areas through the gates. The total area taken up by roads was very limited. This issue can be clearly seen in the studies of both maps constructed for the periods of the 1920s and the 1970s.

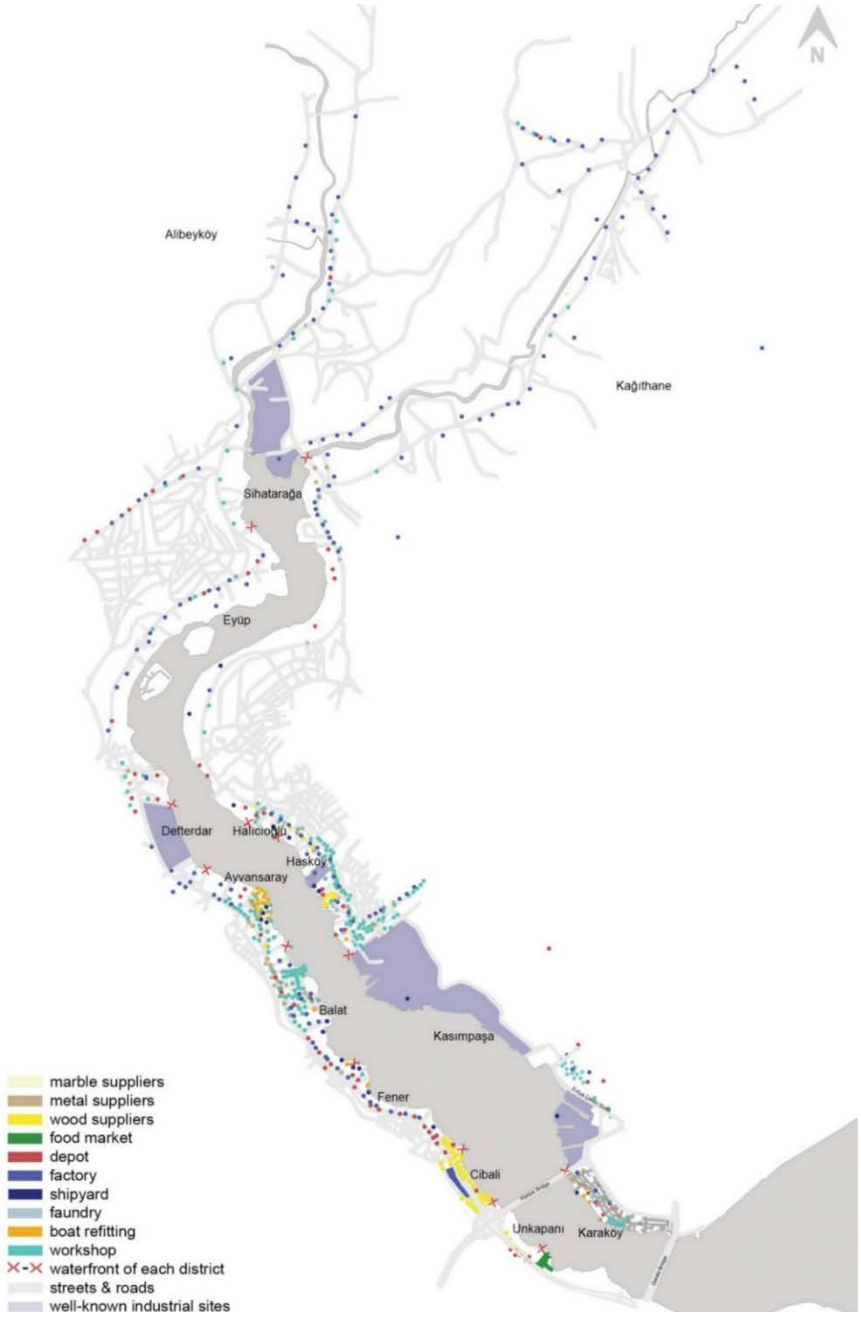

Figure 5 Commercial and industrial establishments in the Haliç area before the deindustrialisation

3.3.4. Identification of the Feature to be Tested in the Haliç Area

The waterfront area along the neighbourhoods of Unkapanı, Cibali, Fener, Balat, Ayvansaray, and Eyüp consisted of the three-character areas on the north-facing waterfront. Presently, this area is confronted with poor pedestrian facilities, as the newly established railway network does not

provide easy access to the walking and cycling areas on the waterfront. The period maps that were examined, illustrated that this area exhibited the characteristics of mixed-use and fine-grained urban fabric. This area was also vital for the well-being of the adjacent residential areas, where the characteristics of fine-grained urban fabric were most prominent. This situation described a pattern that could also be seen in other parts of the Haliç area.

As a result, the Haliç area needs to be revitalised, which can be achieved by establishing an urban fabric and integrating it with a high-quality streetscape environment to encourage people to engage in pedestrian-oriented activities. This can be achieved by understanding the cultural and heritage nature of the urban fabric and combining this with successful regeneration projects.

3.3.5. Pattern-matching logic

Methodologically, pattern-matching logic was applied in the third phase of this case study. This approach was first involved in exploring and then comparing the patterns evident in the primary data collected in the Haliç area with the expected pattern predicted by the theory of placemaking that embraces all the variables as shown in the conceptual model. In accordance with Yin (2014), if the empirically found patterns match the predicted ones, the findings can contribute to and strengthen the current situation in the study area.

3.3.6. Focusing on the semi-structured interviews in the third phase of the case study

The process of conducting semi-structured interviews marked the initial stage of the third phase of this research. As a first step, the pilot survey was carried out to gather some information that would aid in developing the interview questions as well as revising the contents, and the wording of the questionnaire survey prior to its implementation later on.

Consequently, the semi-structured interviews were decided to be carried out with some experts who were members of the design teams that participated in the ideas competition of 2020 and were awarded prizes. At the outset, a purposive sampling technique was selected, and five persons were interviewed from among the academic staff of Istanbul Technical University who participated in this competition. Later, these five respondents recommended two more academicians who participated in the same competition. Therefore, the semi-structured interviews were completed with seven academicians (Table 3).

Table 3 List of interviews

Respondents	Areas of Specialisation
Respondent 1	Landscape Architect
Respondent 2	Architect
Respondent 3	Landscape Architect
Respondent 4	Architect
Respondent 5	Landscape Architect
Respondent 6	Architect
Respondent 7	Planner

Each interview aimed to explore the viewpoints of the respondents, who worked on different projects, and the interviews consisted of three categories each with five questions. The first category focused on the respondents' personal opinions regarding the ideas competition and their chosen project sites. The second category involved a discussion on the responses of the pilot survey participants regarding the concepts of place. The last category was the discussion about the numerical issues presented in the relevant literature relating to the theory of placemaking.

3.3.6.1. Analysis of the Data Collected from the Interviews

The interviews were transcribed and entered into Nvivo; then the auto code wizard was used to generate the results. The most frequently occurring words were analysed, and the sub-themes that were identified as a result of auto-coding were sorted. The number of times an issue was raised (number of references) and the count of instances of the auto-coded themes within the interview data were used as indicators of the importance of these themes. These auto-coded themes were

then aggregated to form parent codes. Furthermore, the ongoing analysis of the interviews was completed by manually coding the data to some of the initial variables that were previously derived from the literature review (Figure 1 and Table 4).

Table 4 The coding structure including the first and second cycles of coding of data

AUTO CODED THEMES – THE HALIÇ AREA		
place attachment	6	21
place dependence	1	1
place identity	5	11
project sites (the Haliç area)	4	13
sense of place (*)	5	17
activities	5	17
urban fabric	6	80
mixed use	6	17
buildings	6	16
heritage buildings	5	8
low rise buildings	1	2
street life	1	1
streetscape - variety	3	3
public realm	6	55
areas	5	30
green areas	2	10
post-industrial regeneration site	1	1
public open spaces	5	14
urban plots	5	6
viability	2	3

(*) Carmona et al. (2003) stated the condition that conceptions of places vary. Montgomery (1998) specified that the three components that compose a sense of place that are the physical setting, activities and meaning can have proportionally different components in one place than those of another. When it comes to determining the conception of the sense of place in the Haliç area, it is possible to say activities have the greatest score.

As a result of the inclusion of these codes, as Bazeley and Jackson (2013) indicated, the matrix queries were constructed to obtain more reliable outcomes.

3.3.6.2. Cross-tabulation of the Data

The main research questions helped to refine this single-case study, one of which focused on the current state of the Haliç area. Therefore, it was decided to utilise the control variables to examine the state of the Haliç area where there are only green spaces currently, whether there was necessarily a need for the urban fabric.

Querying text is classified as one of the most common research methods (Bernard & Ryan, 1998). In Nvivo, matrix coding queries, which are a type of contingency tables used to compare two categorical variables, show patterns in the coded data with the coding interactions. It is widely accepted that placemaking activities deal with the creation of sense of place as well as the individuality of that place. Therefore, the sense of place and other concepts of place were compared with the first cycle coding of data to explore what the experts were thinking concerning the current situation in the Haliç area (Table 5).

Table 5 Matrix coding query results based on coding references (each row and column representing a different variable)

	A : place attachment	B : place dependence	C : place identity	D : sense of place
activities	0	1	0	18
urban fabric	0	0	3	16
heritage buildings	0	0	0	5
public realm	0	0	2	6
project sites	0	0	0	0
green areas	0	0	0	2

3.3.6.3. Final Themes and the Identification of the Overlaps in the Auto-coded Themes

Matrix coding queries were conducted to explore the relationships between the concepts of place and the auto-coded themes extracted via auto code wizard in NVivo. It was found that there were significant overlapping areas in the texts relating to the interviews. The codes and sub-codes were displayed as a matrix, and the relevant themes were linked together (Table 6). The final themes answered the relevant research questions concerning the current state of the Haliç area and the changes depicted in the heritage buildings in terms of sense of place.

Table 6 The list of the codes that were grouped together to create final themes

Themes (recurring in the data)	Codes and Sub-codes (existing and emergent codes)	Emergent Sub-codes
The grain of urban fabric	place identity /urban fabric place identity / public realm	 public realm
Activities	place dependence / activities sense of place / activities	 activities
Heritage buildings	sense of place / urban fabric sense of place / heritage buildings	heritage buildings low rise buildings
The post-industrial site	 sense of place/ public realm sense of place / green areas	areas green areas post-industrial regeneration site public realm

Theme one - The grain of urban fabric

The overlapping in place identity and urban fabric. In their design briefs, the teams stated that they tried to deal with the unsolved urban fabric issue to develop the place identity. Overall, the establishment of some promenades on the waterfront was thought to be the most sensible solution (Respondent 4).

> *'We recommended a promenade on the waterfront (…) These ideas can be seen in the proposals. The solutions seemed so comprehensive as the jury made comments which were similar to that (…) To deal with the unsolved urban fabric and try to establish the resilient urban fabric within the sustainable development in urban areas to support the public to have a place identity*' (Respondent 4).

The teams aimed to develop the place identity; however, establishing some urban fabric on the waterfront of the Halic area was not considered an option. However, as required, the teams had to consider that this area needed to be turned into a green space and should provide easy access to the waterfront (Respondent 4).

> '*However, the thing you already mentioned above was the urban fabric of the Haliç area and being able to establish an area where people have place identity'* (Respondent 4).

The overlapping in place identity and public realm. The respondents agreed that because of the predefined project sites of the competition, the proposals had to have their own merits and should be evaluated in terms of these areas' characteristics (Respondent 5).

> '*If the Haliç area is considered only as a waterfront area, this leads the participants to lose their place, identity which also leads us to the concept of non-place (…) it is not fair to define it only as a waterfront area and it would be a mistake to establish public spaces as parks and other green spaces without having any purpose'* (Respondent 5).

The Haliç area does not seem to have a public realm that can support the public to spend some time in this area. When considering this area as a whole, there is an enormous area of green spaces; however, when considering the quality and the distribution, it is insufficient (Respondent 3).

> *'It is a waterfront area that is mostly demolished and does not consist of any facilities for people to socialise*' (Respondent 3).

> *'When considering this area as a whole, there is an enormous area of green spaces; however, when considering the quality and the distribution, it can be clearly said that there are not enough' (Respondent 3).*

Theme two – Activities

The overlapping in place dependence and activities. There are two viewpoints regarding the Haliç area, one of which is seeing the area as an ongoing regeneration activity to be designed as green spaces in the end to establish place dependence that was an attachment based on function (Respondent 2 and Respondent 4).

> *'The daily activities may take more time than usual, such as cycling and jogging, therefore, the time spent on the waterfront can depend on the activities to be focused on'* (Respondent 2).

> *'… if we try to establish some daily recreational activities for that place then we can achieve the place dependence'* (Respondent 4).

The other one is that this area needed to be designed as a place consisting of various daily activities. Some stated that competitors should have focused on the quality of space rather than quantity, as more efficient usage with fewer green areas could be achieved (Respondent 1). It can be said that public spaces and green spaces are being defined by buildings and urban fabric (Respondent 4).

> *'What we need is quality of space rather than quantity as more efficient usage with less green areas can be achieved'* (Respondent 1).

> *'We were not so into designing some outdoor sitting areas whereas we wanted to design something that was more suitable for the daily activities in the city'* (Respondent 4).

The overlapping in sense of place and activities. The respondents confirmed that establishing various recreational activities can lead to place dependence that has functional relationships with a specific place and has a relationship with place attachment that is partly connected to sense of place (Respondent 5).

> *'When we consider the heritage buildings together with some other historic buildings, such as the fountains, they act as landmarks in the landscape and the area around them can be designed to have some recreational activities that have an edge with the urban fabric in the neighbourhoods*' (Respondent 5).

Theme three - Heritage buildings

The overlapping in sense of place and urban fabric. Place identity and sense of place can support the surviving heritage buildings. Some respondents stated that although the waterfront of the Haliç area was designated for green spaces where the regeneration activities were still ongoing, the establishment of some urban fabric could well be considered (Respondent 1).

> *'(…) In other words, I can create a strip of land with a significant presence of vegetation to include some culture-led activities together with small businesses, that is a point of view. There should be some post-industrial heritage buildings that would create some area of interest within the urban fabric*' (Respondent 1).

Nevertheless, the outcomes of repurposing surviving heritage buildings were referenced as one of the best solutions (Respondent 2 and Respondent 5).

> *'It would be a better idea to refurbish or repurpose the surviving heritage buildings in order to achieve viability and vitality'* (Respondent 2).

> *'We also thought about this and focused on the repurposed heritage buildings'* (Respondent 5).

The overlapping in sense of place and heritage buildings. Following the relevant literature, repurposing heritage buildings plays an essential role in creating the place identity in the urban fabric, and strengthening it if there are any previously repurposed ones. Repurposing helps set up quality public spaces that value community and enhance the city's cultural heritage as well as provide some sort of entertainment activities to give a unique competitive edge. Moreover, place dependence and place identity are classified as two important notions that refer to how people are attached to a particular place; therefore, these heritage buildings also help to establish a strong sense of place via placemaking activities (Respondent 3).

> *'Place identity can be felt better with the historical heritage buildings that offer much better visual perspective in the Haliç area'* (Respondent 3).

Design-led regeneration activities mostly deal with the application of placemaking that is 'sense of place'. The respondents believed preserving the heritage buildings should offer viability and vitality. This could only be achieved if these buildings are easily accessible (Respondent 3).

> *'The heritage buildings that are preserved can offer vitality and viability; however, they should provide some access to the public'* (Respondent 3).

Theme four - The post-industrial site

The overlapping in sense of place and public realm. It was understood that this area was a post-industrial site and quality public spaces were needed to encourage the public to spend more time in this area (Respondent 2).

> *'… the Haliç area was considered as a district for manufacturing industries and commercial activities in the past. however, today it consists of numerous industrial heritage buildings as well as some green areas and networks of connections'* (Respondent 2).

As specified by the respondents, most design teams proposed certain recreational activities in the green areas, which made it difficult to establish place dependence and could lead to a weak sense of place. They agreed that it is the public realm that should give the Haliç area a strong sense of place (Respondent 1).

The overlapping in sense of place and green areas. The findings revealed that when participating in a design competition involving green space, the teams naturally aimed for achieving quality green areas (Respondent 1).

3.3.6.4. The Second Cycle of Coding

The second cycle of coding was manually conducted to focus on the concepts that could be coded to the variables of the theory of placemaking detailed in the conceptual model (Figure 1).

Firstly, the content as expected to be seen in the data that would have corresponded to the aspects of place dependence and place attachment were coded at them directly. The coding references and the number of files involved clearly indicated that place attachment was influential in the study area which was also pointed out by some of the respondents as follows.

> *'It takes a very long time to establish a place attachment with the Haliç area by the people who just visit this area sometimes (…) The concept of place attachment should be considered by focusing on the locals and people who live around here'* (Respondent 6).

> *'(…) Therefore, the people who participated in this survey should have some form of place attachment'* (Respondent 5).

Secondly, the relevant content was coded at the dependent variable streetscape, then with the auto-coded themes that were public realm and those lower down in the hierarchy such as areas, green areas, and public open spaces were established in a hierarchical order respectively. Consequently, at this stage; in the second cycle of coding, it was clearly seen that public realm was

one the emergent sub-codes due to the number of its coding references and respondents' files involved.

Finally, a hierarchy of codes was emerged as some content was coded to the dependent variable mixed use to which all code references were aggregated this time. This code hierarchy was regarded as the proof that indicated the importance of the urban fabric on the waterfront.

3.4. Reviewing the Themes and the Outcomes of Coding

The themes extracted from the interview data corresponded to the three components of sense of place described by Montgomery (1998) as the results of peoples' interaction with the physical space, the activities in that place, and lastly the ability to give identity to the place.

The theme that is the grain of urban fabric is the main issue in the Haliç area. Although all agreed that the quality of space should be offered rather than quantified as the more efficient usage with less green areas can be achieved, the respondents were still undecided whether to focus on the main stream approach that placemaking affords, which is to establish a sense of place in a fine grained urban fabric, or alternatively provide enough activities in green areas enhanced by repurposed heritage buildings, accepting the fact that this area is a post-industrial site. Therefore, informing the public about its sense of place would be a better solution.

The activities theme clearly establishes the fact that activities are needed to enhance the sense of place, which in return strengthens the relationships between facilities, mixed use, streetscape, and street life in places where permeability is enabled by short urban blocks in the urban fabric. The current state of the Haliç area is seen as a place that has no facilities for people to socialise. The urban fabric that consists of historical buildings is unsolvable; therefore, the respondents focused on the repurposed ones. While some of the respondents put forward the need to identify some activities that were suitable for daily routines, others agreed that activities together with small businesses can sufficiently provide what was needed for the area. On the whole, as the respondents were not given the option to offer creating some urban fabric on the waterfront, they conformed instead to the different acceptability criteria per the ideas competition requirements.

The heritage buildings theme clearly describes a similar pattern as above in terms of sense of place, according to the respondents. The Haliç area consists of some former industrial buildings that were repurposed. Moreover, this area does not have any facilities for people to socialise. Some recreational activities that are suitable for daily routine, such as restaurants and cafes, should be established here as well as designing walking paths that have connections with the inner areas to the waterfront.

The post-industrial site theme describes the current situation in most of waterfront areas as former industrial sites. The respondents mostly agreed on the fact that the ideas competition was aimed to achieve quality green areas and public open spaces in the Haliç area, where, instead, it led to a weak sense of place as a result of difficulties in even establishing place dependence. In successful regeneration schemes, this issue has been overcome by respecting the grain of urban fabric and focusing on fine urban grain.

4. Conclusion

This research paper details a part of a single-case study, that questioned the current state of the Haliç area as a waterfront regeneration scheme and examines specific aspects of the urban fabric with the help of the control variables.

It was aimed to use the results of the qualitative analyses of the semi-structured interviews. In this regard, the interview data were inductively and deductively analysed, and the themes were linked to the data. The coding intersections helped to identify the themes in the coded data, especially the effect of the place-based concepts, in order to explore and identify how current situations are influenced by the regeneration activities in the Haliç area.

The competition teams tried to strengthen the place identity by dealing with the unsolved urban fabric issue. When there is no urban fabric, there is less place identity, which also has a downside effect on the physical setting, activities, heritage buildings, and the post-industrial site, which are the overarching themes that create sense of place.

The pattern of the findings can be outlined as follows:

Based on the interview data, it can be clearly stated that the historical and cultural nature of the urban fabric in the Haliç area needs to be understood. Consequently, the regeneration activities in this area to make the waterfront more viable will be more effective, and the regeneration activities will be more effective.

Therefore, the observed results reflecting the experts' view matched the expected result as predicted above.

The results of the semi-structured interviews can be aimed to design a questionary survey that could obtain the opinions of the inhabitants and visitors in the Haliç area to test the theory of placemaking and come up with recommendations for the application of placemaking activities on the waterfront.

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Resume

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Fractal and geography: Fractal scanning in three different urban areas of Elazığ

Emrah Şıkoğlu*

Abstract

The study of systems' ability to self-organize, internal structural balance, and space partitioning is the focus of a larger body of theories produced by mathematicians in the second half of the twenty-first century, which includes fractal theory and analysis. These theories focus on how the distribution of forms and urban functions within an urban agglomeration, the sequencing of the settlement system, the choice of a specific style of localization, or the evolution of urban sprawl is influenced by a region with inhomogeneous characteristics. The study's objective is to quantify how urban macro-forms reflect urban space. It is aimed to use fractal analysis, one of the methods that examine the structure of urban areas, as a measurement technique and to increase the recognition of this method in the community. When performing fractal analysis, the study area is generally evaluated holistically. Determining the place of the parts that make up this whole within the analysis is another aim of the study. The most basic method used in the study is the Fractal Analysis method. In order to make a relevant evaluation, Fractalyse 3.0 program was used. Two bases were created for the urban spots to be used in the program. While one of these bases is the parcels of Elazığ city center, the other one is buildings. In order to measure the parts of the whole mentioned as one of the aims of the study, three different regions of the city were identified, and fractal analyzes were carried out separately for those regions. The study field covers all the central 42 neighborhoods where Elazığ city develops. According to the results obtained from the analysis, the Fractal dimension value of the city was 1.62. This value is a very interesting result as it is considered a transition criterion for cities to be fringed and compact. Accordingly, Elazığ city is a fringed city in the process of becoming compact. In the analysis of three different sections containing the parts that make up the whole, the fractal value of Doğukent neighborhood, located in the easternmost part of Elazığ city, was calculated as 1.70. This area, which has a compact structure, presents a positive response against the urban sprawl. The sample taken from the central part of the city, called the Center, showed a high value of 1.89 in fractal dimension. The fractal dimension value of the sample selected from the south of the city showed a high fringed result of 1.32.

Keywords: Elazığ, fractal, fractal dimension, fractal geography

1. Introduction

First, in 1975, Mandelbrot coined the word “fractal” by transforming the word "fractus", derived from the verb "frangere" meaning to break (Köprülü & Topçu 2023, p. 952), to describe the shapes, sizes and geometry he produced, which is also compatible with the sound of the English words fracture and fraction and is used as noun and adjective in English and French today (Trippet 1994; Gleick 1997; Kaya 2003, p. 41). Many studies have been done on generating fractal geometry. In this regard, the works of mathematicians Julia, Fatou, Hubbad, Barnsley and Mandelbrot are of paramount importance (Kaya 2003, p. 48).

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A rough, jagged universe model that is neither spherical nor flat can be seen in the geometric structure of many natural elements, including the shapes of clouds, mountains, and river basins. This is the geometry of objects with indentations, protrusions, breaks, bends, tangles, and knots (Figure 1). In Richardson's 1961 article, Mandelbort attempted to use geographic objects to illustrate this geometry. In actuality, Mandelbort (1967) used the length of the British shoreline as his initial illustration. In his subsequent work "Fractal Geometry of Nature" (Mandelbort, 1977), he expanded on this topic.

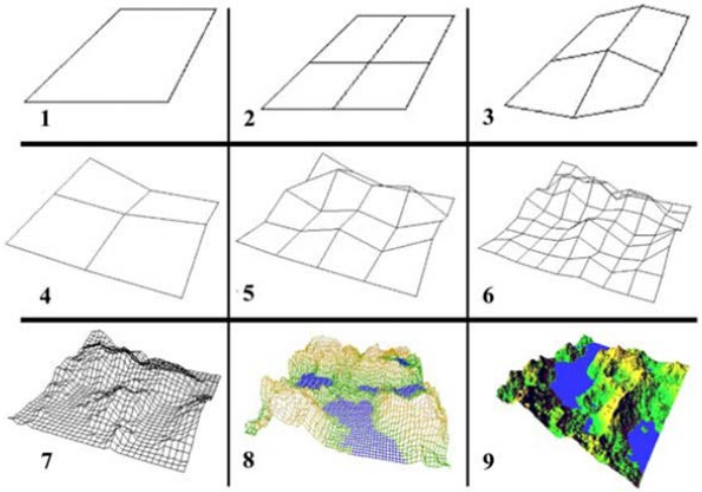

Figure 1 An example of a fractal structure created in a virtual environment (Bourke, P.)

Lovejoy (1982) has made studies indicating that cloud formation areas and their environments are fractal in almost all of his works. Based on these early examples, other meteorologists also used multifractal methods to understand the organization of temperature and pressure fields (Dauphiné 2012, p. 3).

In the discipline of hydrogeology, French geographers provided additional fractal instances. Delahaye provided the first and Martin provided the second examples in 2002 and 2004, respectively. The research on river system mapping by RE Horton and AN Strahler, both published in 1945 and promoting the use of the Fractal system, serve as the foundation for these efforts, though. By employing this technique, Delahaye and Martin were able to create a power law between river length and basin area.

Fractal later began to be used in the field of Geomorphology. In fact, Canada quickly became interested in the fractal paradigm in this regard. Especially in the first quarter of the 90s, some works, albeit rare, were produced. Although the Fractal method was used in a study on corals in the field of biogeography in the 1980s, geographers did not continue this subject.

In the field of geography, the area where the Fractal method is most applied is urban studies. Fractal analysis, a mathematical method, was developed completely independent of urban morphology. Scientists studying urban geography are interested in interdisciplinary studies due to the nature of their work. During their interest, they discovered that this method, which explains mathematical methods, is actually similar to the shapes of urban areas (Mcadams, 2007, p. 153).

In geographical research that aims to comprehend the structural uniqueness of the city, fractal theory has a significant impact on urban management and planning. Numerous urban geographers have been working on this topic ever since fractal theory was established in the early 1970s (Mendelbrot, 1967). The spatial and temporal dynamics of the process of urban growth and land use change are also successfully revealed by it (Erdoğan, 2015, p. 33).

Urban areas generally grow with a non-homogeneous distribution. It undergoes various evolutions as it grows. Built-up areas and empty areas intertwine and thus cities have different density areas. For all these reasons, fractal analysis of urban texture finds a much closer

correspondence with spatial realities (Cirnu, 2014, p. 67). France was also the pioneer of using fractal in urban areas. This movement was started by Frankhauser in France in 1994 and continued by his students. These trained geographers contributed to the creation of many algorithms that were later integrated into the Fractalyse program, one of the system's software. A number of urban geographers outside France have created a list of population densities and other variables using digital terrain modelling. The fractal dimension allowed them to describe the spatial irregularity of cartographic phenomena. For example, Wong and colleagues analyzed social segregation in American cities in 1999 using a Fractal approach. But unfortunately, geographers did not pay much attention to the issue in the following periods. Fractal method has also been used in studies on urban transportation networks. Chapelon (1996), Françosis (1997) and Genre-Gradpierre (1999) have conducted many studies on this theme. These studies were greatly appreciated by British researchers (Dauphiné 2012). Apart from the subjects mentioned above, the Fractal method has also been used on issues such as population, traffic flow, internet traffic and migration flow.

Studies on the fractal dimension in our country started in the 1990s. The first applications of this method, which is generally used frequently by engineering faculties, were given mostly by Computer and Electrical and Electronics Engineering. In the 2000s, works on the subject were published by the Architecture, Urban and Regional Planning departments. The first representatives of studies on urbanization were Yüzer (2001) and Kaya (2003) with their City and Regional Planning studies. No study on the Fractal method has been done by geographers until this study.

2. Fractal Dimension Calculation Methods

Although the fractal dimension is widely adopted today, it is still seen as an abstract concept to make this less of an abstract concept, the fractal dimension is generally considered to be the degree to which it fills spatial gaps. A curve with D very close to 1.0 (such as 1.1) behaves much like an ordinary one-dimensional line, but a curve with D very close to 2.0 (such as 1.9) has a very convoluted shape, much like a two-dimensional surface. Unfortunately, this space-filling perspective often creates the incorrect impression that fractal dimension is another measure for density. Essentially, density is a Euclidean concept, while fractal dimension is fractal-based (Jiang & Yin, 2013, p. 532).

Fractal dimension is defined as a ratio of the change in detail to the change in scale (Mandelbrot 1982). This is not a simple ratio, but the ratio of logarithms, such as D = log(N)/log(r), where r is the measuring scale (or simply change in scale) and N is the number of the scale needed to cover the whole fractal pattern or set (or equivalently change in detail). The slope of the distribution line in the Richardson plot (logarithm) is equal to the fractal dimension D. The simple ratio is not used because the change in scale r and the change in detail N are disproportional (Jiang & Yin, 2013, p. 533).

The meaning and properties of the dimension have been a matter of curiosity since ancient times, especially in mathematics. After Mandelbort developed the fractal dimension, many concepts describing the dimension have been developed in connection with it. Some of these are as follows:

i. Hausdorff dimension
ii. Self-similarity dimension
iii. Box-Counting dimension
iv. Topological dimension
v. Fractal dimension
vi. Euclidean dimension
vii. Compass dimension (Divider or Ruler dimension; compass dimension)
viii. Single-way Dimension
ix. Lyapunov Dimension
x. Information Dimension

All of the above dimension types are special forms of the "Fractal Dimension" (Kaya, 2003, p. 52).

Additionally, there are many methods used to measure the fractal dimension, and these methods have advantages and disadvantages against each other. We can list the calculation methods as follows:

Fractal dimension can be calculated in 7 different ways:

1. Grid
2. Radius mass
3. Dilation
4. Correlation
5. Gaussian convolution
6. Box-counting
7. Network (Erdoğan, 2015, p. 43)

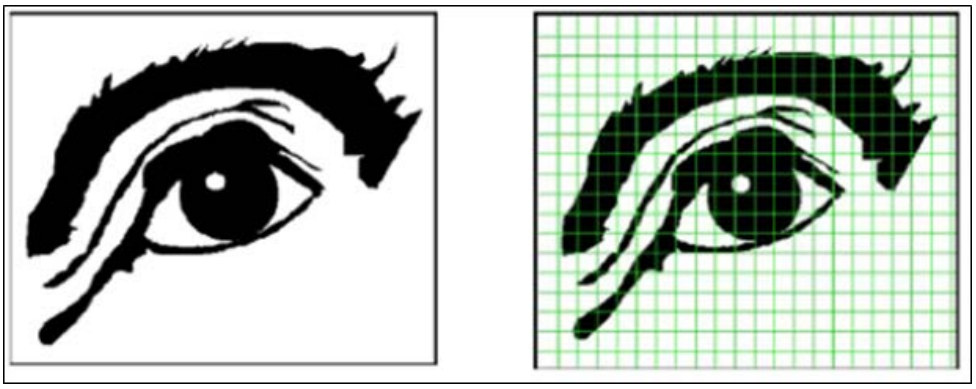

Figure 2 Situation of an Image Used for Analysis in Boxes (Kaya 2003, p. 83)

The most frequently used calculation method is the box counting method. The box counting method is conceptually related to the self-similarity dimension. Although this method often gives the same numbers as the self-similarity dimension, this is not always the case. Generally, examples that can be studied with different compass length settings, such as coastlines, or structures that have very special properties that can be characterized, such as self-similarity, are shown as examples. Box counting dimension offers a systematic measurement method that can be applied to every structure on the plane and easily adapted to every structure in the space, without looking for self-similarity (Kaya 2003, p. 58).

This technique, meaning box counting or Cobblestone (here cobblestone is used because it resembles a three-dimensional square box), is the most used method for fractal measurement. The basis of this dominance lies in the fact that it can be easily calculated automatically by machine. The program can be implemented regardless of the presence or absence of self-similarity. Objects can also be placed within higher dimensional space. For example, if objects are considered in three-dimensional space, the boxes are not in the plane but are three-dimensional cubes with height, width and depth (Kaya 2003, p. 60). The box counting method's closest accuracy depends on the resolution of the measured area. The data used in this method is first divided into the required number of boxes and the areas remaining in the box are evaluated with the result obtained as a result of a series of calculations (Figure 2).

3. Objectives and Methodology

The aim of the study is based on measuring the reflection of urban macroforms on urban space. More clearly, it is to measure the development form of cities, which constitute one of the elements of urban morphology, with a different method. It is aimed to use Fractal analysis, one of the

methods that examine the structure of urban areas, as a measurement technique and to increase the recognition of this method in the geography community. In addition, while fractal analysis analyzes an area as a whole, determining the place of the parts that make up this whole within the analysis constitutes the other purpose of the study.

The most basic method in the study is the Fractal Analysis method. Fractalyse 3.0 program was used in order to make an evaluation. Fractal analysis is used today by some scientific fields, especially to calculate the morphological features of cities. The Fractalyse program was developed to analyze urban textures more easily. This program has the capacity to count entire cities at different scales and produce different types of analysis based on the distribution of the city. This program has been developed in 2001, within the ThèMa laboratory of the Franche Compté University, being constantly improved up to its current 3.0 version.

In each of the counting stages, the number of pixels belonging to urban spots contained in the structured environment is taken into account. Each time, the size of the defined perimeter is also modified. In this sense, the two main elements are the elements number (black pixels marked by the print of the built area) – N – and the size of the defined perimeter or of the referential element (ε). A series of points are obtained with the absciss ε and the ordinate N, doubled by the relation $N = \varepsilon D$ or $N = \varepsilon\text{-}D$, with D being the fractal dimension. D falls between the values 2 and 0. The value of this dimension characterizes the level of concentration of the constructed mass in a certain area of the urban fabric. A value close to 2 corresponds to a homogeneous structure, without a pronounced hierarchy, while a value close to 0 corresponds to a strong hierarchy in terms of elements, with mass concentrations on particular points and isolated concentrations from the other elements made possible through void spaces (Cirnu, 2014, pp. 67-8).

Two basic bases were created for the urban spots produced to be used in the program. While one of these bases is the parcels of Elazığ city center, the other one is buildings. The main purpose of including both parameters in the system is to better observe the change of the fractal dimension. In other words, these selections are intended to show the difference between the fractal dimension in the area where the parcels are located and the fractal dimension in the measurements of the buildings.

After the comparative fractal dimension analysis in parcel and building measurements, measurements were continued with only the building spread areas of the city. In order to measure the parts of the whole mentioned as one of the aims of the study, three different regions of the city were identified and fractal analyzes were carried out separately for those regions. A common dimension was chosen for these analyses, and sections from three different areas of the city were obtained with this dimension. Sections were taken from the planned area in the east of the city, from the densely populated area in the central part of the city, and finally from the sparse and scattered textured area in the south of the city (Figure 3).

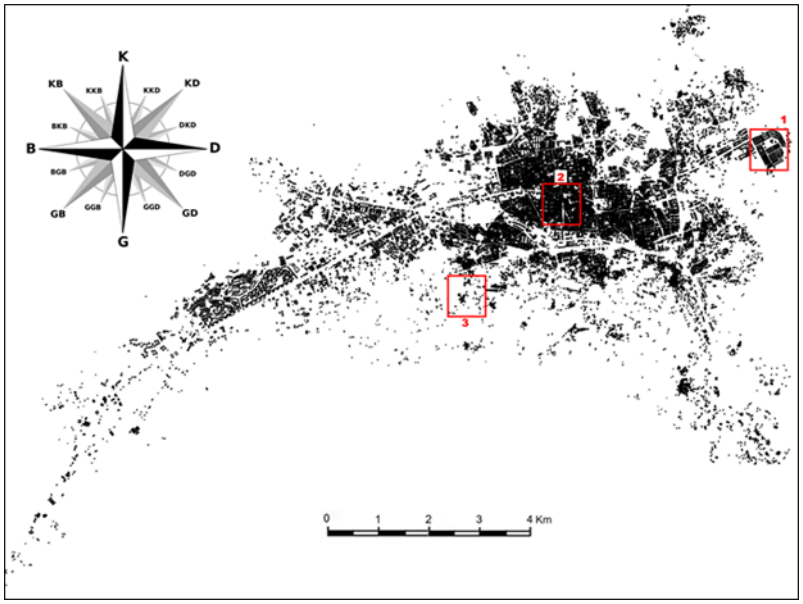

Figure 3 Sampling Areas Selected for Fractal Dimension Analysis

Measuring the fractal dimension is used in many independent scientific fields, from health to architecture, geography and mathematics. Accordingly, software such as Fractalyse, İmagej, HarFA have been developed just to measure the fractal dimension, as well as tools have been developed to measure the fractal dimension for well-known GIS programs such as ArcGIS. Of the programs mentioned above, Fractalyse 3.0 was preferred in the study as it can analyze both raster and vector data. To prepare the bases for the program, islands and buildings were first recorded in separate layers. Then, for raster analysis, the work area was saved in .tif format using MapInfo Pro, and for vector analysis, it was saved as files with .shp extension. The created files were measured using the Fractalyse 3.0 program to measure the fractal dimension of the working area.

4. Study Area

Elazığ is located in the Upper Euphrates section of the Eastern Anatolia Region. The city is neighbors with Kovancılar and Palu in the east, Maden Sivrice in the south, and Baskil and Keban districts in the west. On a provincial basis, it neighbors Tunceli in the north, Bingöl in the east, Diyarbakır in the southeast, and Malatya in the west and southwest. Elazığ is also surrounded by Keban Dam Lake from the North and Karakaya Dam Lake from the West and South (Figure 4).

This region, which is entirely located within the Southeastern Taurus Mountains fold belt, has mountains extending in the southwest-northeast direction and occasionally forming regular rows, and co-oriented plains located between these mountains. In the north of this mountainous mass, Uluova, one of the important plains of Eastern Anatolia, with an altitude varying between 900-1000 meters, and 1020 m, where today's Elazığ city is located. Elazığ Plain is located at a high altitude. To the north of Uluova, there is the Harput mountainous mass extending in the southwest - northeast direction (Ünal, 1989, pp. 31-32; Tonbul & Karadoğan, 1999). The study area is limited to the city center that spreads over the Elazığ plain.

The historical development of the city of Elazığ dates back to the migration from Harput to Elazığ between 1800 and 1900. The first settlements of the city are Çarşı District and Sarayatik District. İcadiye, Mustafapaşa, Akpınar Neighborhoods were added to these between 1833-1876, and Rızaiye and İzzetpaşa Neighborhoods were added between 1876-1923. With the establishment of the Republic, the post-war problems in the country negatively affected urbanization and the city of Elazığ was limited to 7 neighborhoods. Between 1927 and 1935, Rüstempaşa and Nailbey Neighborhoods were added to the city.

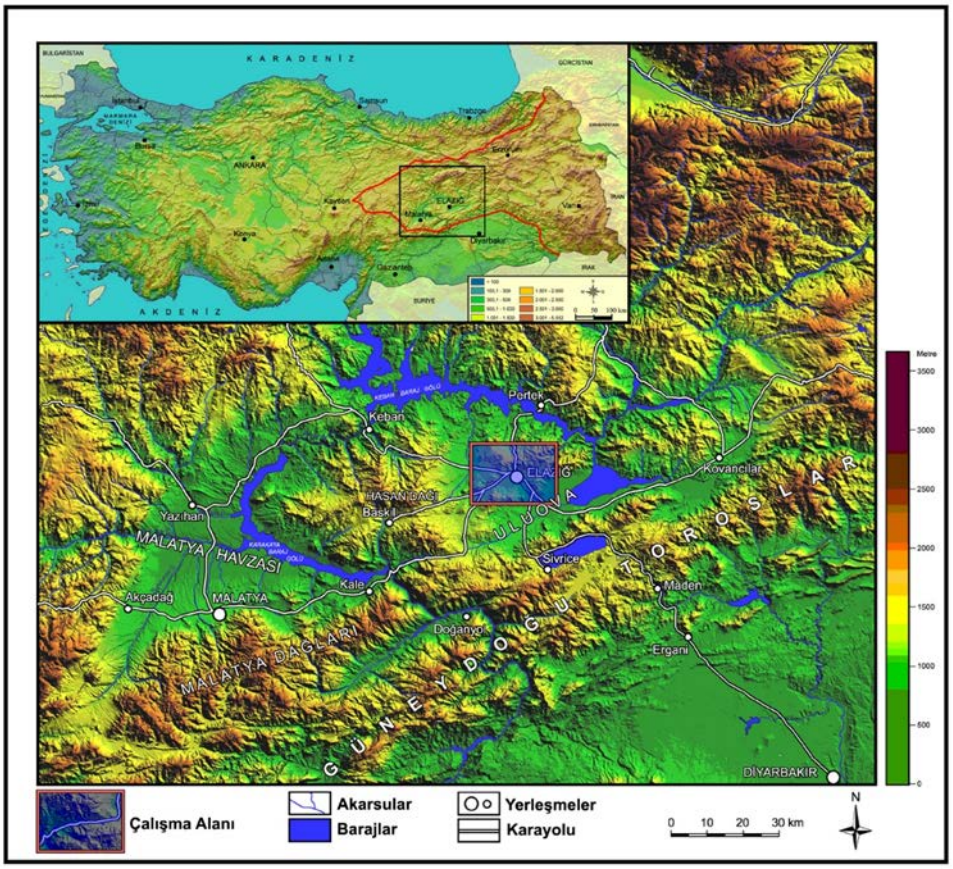

Figure 4 Location of the Working Area

Gazi Street was added in 1940, roughly dividing the city into two in east-west direction. Again, after the 1940s, developments in the western parts of Rızaiye, İzzetpaşa, Nailbey and Akpınar Neighborhoods located in the north of the city accelerated (Karakaş, 2001). Development progressed slowly until 1950, compared to later periods that started to gain momentum with the help of transportation and public investments, and the acceleration of internal migration after 1990 with the completion of the Keban Dam in 1974 helped the development to continue rapidly (Karakaş, 1999). Its development until 1950 was towards the railway located to the south of the current Gazi street. The railway prevented the city from advancing southwards, and Sürsürü and Kesrik, Yenimahalle and Kültür Mahallesi were added later. In 1968, Elazığ was included among the priority provinces in development and the opening of the Academy in 1967, with the creation of a slum prevention zone in Zafran and areas such as Abdullahpaşa on the "Malatya road (1800 Evler)" (in case the city could not handle the population that came and will come before the dam and the possibility of slums (Atay, 1991; Çotur, 1990), the city started to develop towards the west. For these reasons, Fevzi Çakmak and Yıldızbağları developed in the north of Yenimahalle and İzzetpaşa District in the northern part of the city, and the development of the city was directed towards the west with the 1800 Houses created for the future residents of Keban and the University District formed due to the academy. As a result, Aksaray, Üniversitesi, Fevzi Çakmak neighborhoods were developed in 1967 and Yıldızbağları neighborhoods were developed in 1968. After the 1970s, the establishment of a small industrial site caused the nearby villages of Çatalçeşme (Morning), Gümüşkavak (Hırhırik), Ulukent (Hüseynik) to grow and become populated, as well as the fact that Salıbaba Neighborhood, which is connected to Çatalçeşme village located to the east of the industry, was preferred by those working in the industry and those coming from outside. This led to it being turned into a neighborhood since 1974. Since 1991, Doğukent District has emerged in the area between Ulukent and Çatalçeşme Districts (Karakaş, 1999). After the 2000s, four different neighborhoods were added to the city: Ataşehir, Hicret, Hilalkent and Çaydaçıra District. After the 2020 Elazığ earthquake, with the transformation of the areas where TOKİs were established in various areas of the city into neighborhoods, Elazığ became a city consisting of 42 neighborhoods

with a population of 387,072 (TUIK 2022). The study area border covers all the central 42 neighborhoods where the city is developing.

5. Findings

When the urban stain of the residential area of Elazığ city divided into parcels is analyzed, a possible fractal dimension of 1.86 appears as high as 1.86. In other words, it tells us that the city is highly compact. However, this value leads us to a misleading conclusion. Because choosing islands in the city stain in the analysis is contrary to the logic of measuring urban structure in Fractal theory. Because in this system, a result is obtained as if the entire residential area of the city is used (Figure 5).

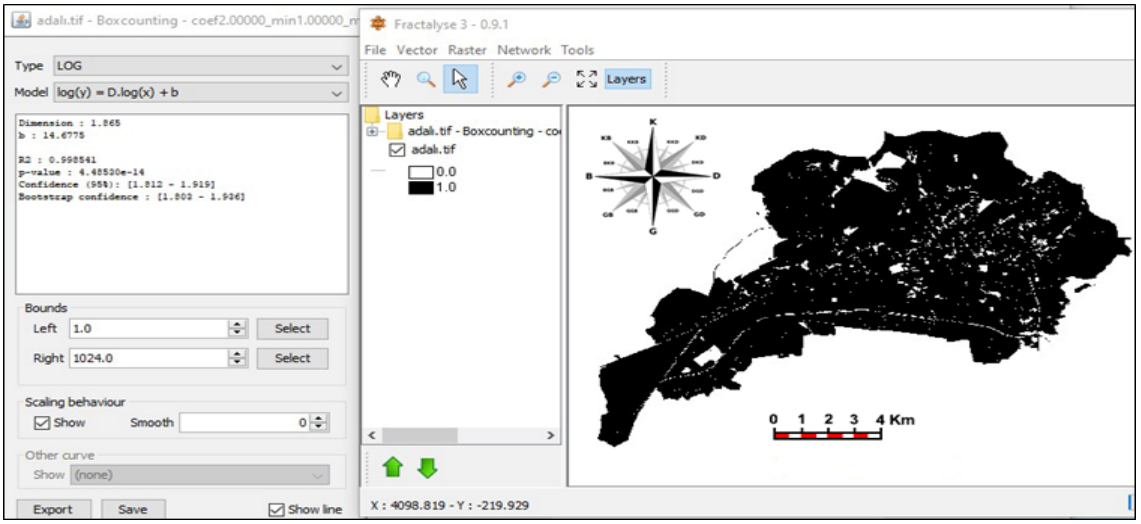

Figure 5 Urban Spot and Fractal Analysis (Raster) of Elazığ Residential Area at

When we apply the same measurement to the urban spot, where only the buildings of the city are spread, the result is quite different compared to the previous analysis. According to the new result obtained, the Fractal dimension value of the city is 1.62. This value is a very interesting result as the value of 1.60 is considered a criterion for cities being fringed and compact. Accordingly, Elazığ city is a fringed city in the process of becoming compact. In other words, a tendency for buildings within the city to come closer to each other has been observed (Figure 6).

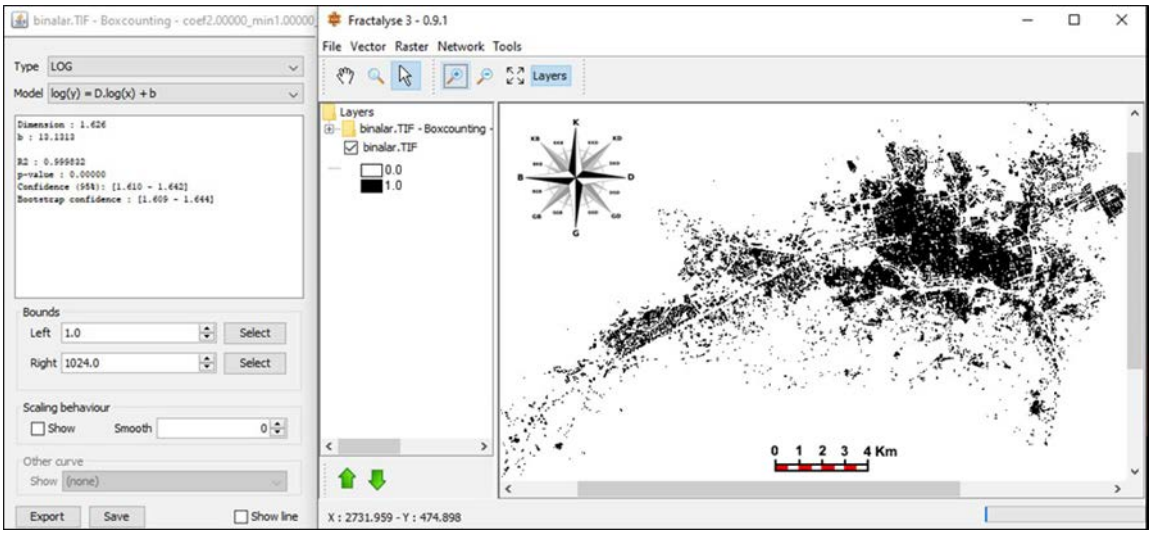

Figure 6 Urban Spot and Fractal Analysis (Raster) of Elazığ Residential Area at

A different result was obtained when the study area was analyzed vectorially. The result of fractal dimension analysis in vector data was 1.59. This value is very close to 1.60. However, what is understood from this analysis is that Elazığ is a city that still maintains its fringed structure on the way to compactness (Figure 7).

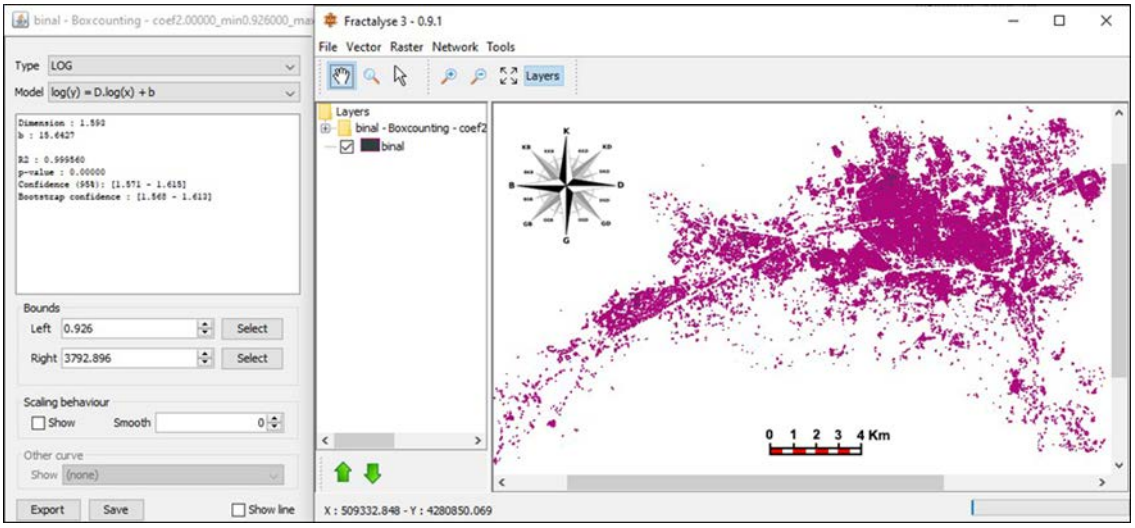

Figure 7 Urban Spot and Fractal Analysis of Elazığ Residential Area at Building

Urban morphology: Chapters are a section that provides understanding of the formation and transformation processes of settlements, their spatial characters, advanced developments and various comprehensive analyzes involving settlements (Kubat & Topçu, 2009, p. 336). One of the methods used when analyzing urban morphology is Space Sequence Analysis. In this method, both global and local analyzes can be performed. Thus, it is possible to explain both holistic and partial analysis. In this context, one of the questions that comes to mind is what is the Fractal dimension behavior of the parts that make up the whole? In order to answer this, it is necessary to resort to the analysis of three different selected spaces (Figure 3).

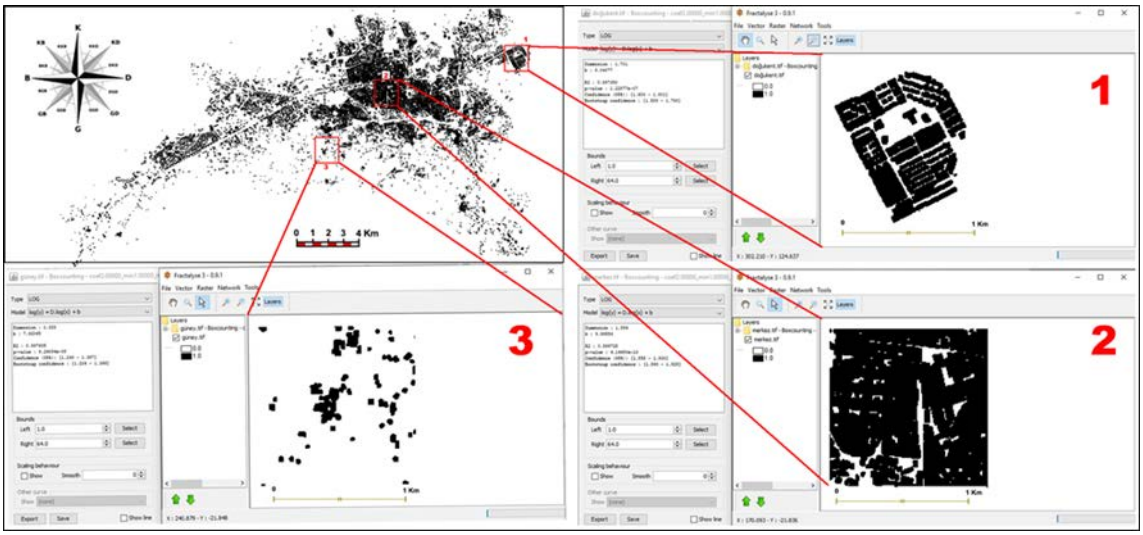

Figure 8 Fractal Analysis Results of Sample Selected Places. 1 Doğukent Sampling Area, 2. Central Sampling Area, 3. South Sampling Area Sampling Area, 2. Central Sampling Area, 3. South Sampling Area Scale (Vector)Building Scale Island Scale

In the easternmost part of Elazığ city, there is Doğukent District, which was built in a planned manner in the 1990s. In this place, which was developed in a "D" shaped pattern, residences and green areas were planned and built in advance. As a result of the fractal dimension analysis, the fractal value of the area was calculated as 1.70. This area, which has a compact structure, presents a positive situation against the urban sprawl. The sample taken from the central part of the city, called the Center, showed a high value of 1.89 in fractal dimension. The fact that the lands in the urban area are very valuable in terms of area has led to the construction of almost every part of this region. Dense construction, on the other hand, of course exhibits a compact structure with a high value. The newly developing northern, western and especially southern parts of the city display a sparse texture compared to an urban space. This sparse and scattered texture has of course

created the areas where the fringing is most intense. As a matter of fact, the fractal dimension value of the sample selected from the south of the city showed a high fringed result of 1.32 (Figure 8).

6. Conclusion

Urban morphology consists of holistic subjects that examine the process of the physical texture of cities coming together, the qualities of the patterns within the texture, and the observation of temporal changes. One of the important methods that makes sense of the morphological features of cities and produces products on a scientific scale is the fractal dimension. There are many ways to calculate fractal dimension. The most common of these is the box counting method. Many software have been developed in this context. While some of these software are developed only for fractals, some are in the form of tools within programs. The preferred program for this study was Fractalyse 3.0, which can analyze both vector and raster data.

While raster data counts only point urban spots, vector data also includes points, lines and polygons. Vector and raster data have advantages and disadvantages against each other. For example, vector data allows network analysis because it can analyze polygons and lines, while raster data allows correlation analysis. Higher resolution of vector data can provide more accurate results in fractal measurements. Based on the information obtained from the study, it was concluded that the measurement difference was not very high. Raster and vector data can preferably be used in analyses.

In fractal analysis, city spots should be created not on islands-parcels but on buildings that show the real expansion area of the city and the way it uses the space. In this context, it is possible to say that the city of Elazığ is at a point between being fringed and compact, based on both vector and raster analyzes performed on city spots obtained from buildings. While the old neighborhoods of the city contribute positively to its compactness, the newly developed neighborhoods around the city increase the city's sprawl coefficient. The evolution of the city over time will determine its own destiny.

Of course, the data obtained from holistic analyzes are meaningful on their own. However, analyzing the parts that make up the whole gives information about how the city should actually grow as it grows. For example, in the fragment analysis, the center and Doğukent emerged as compact spaces. But is the city formally like Doğukent? Or is it like in the center? We need to consider that it should be compact. So, does having a very high fractal dimension always have a positive outcome for cities? The answer to the question must be sought. In fact, further studies can be carried out to reveal the optimum numerical value of compactness. For example, when viewed morphologically, Doğukent District in the study area presents a harmonious structure for the urban form, both with its green area and its alignment. Since the fractal dimension value of this area is 1.70, it can be said that this value is the optimum fractal dimension value for the study area.

While measuring the fractal dimension in the future, it is thought that performing part analyzes as well as holistic analyzes will make a positive contribution to the system in order to get a more detailed idea about the study areas.

In line with the information obtained from previously produced publications during the study, it was concluded that fractal analyzes are not just simple fractal measurements. Multi-fractal analyzes can also be performed in which the physical, human and economic characteristics of cities are overlapped with their fractal dimensions. In line with this information, we can say that geographers in our country should show interest in studies using both fractal and multi-fractal methods.

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Resume

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