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Editorial

Havva Alkan Bala (Co-Editor)

Entering the year 2025 with the energy of fresh and invigorating beginnings, the Journal of Design for Resilience in Architecture and Planning (DRArch) continues its trajectory of growth while steadfastly maintaining its commitment to quality and high standards. Through our research articles, esteemed contributors, and the inclusion of new reviewers from diverse disciplines, DRArch is embarking on a transformative new era.

We are proud to publish Volume 5, Issue 3, which opens with innovative ideas and commences with a study titled "Clay 3D Printing: Exploring the Interrelations of Materials and Techniques." In this article, Asena Kumsal Şen Bayram and Emel Cantürk Akyıldız aim to develop an algorithm for optimizing clay 3D printing. The algorithm's inputs are derived by synthesizing the findings of previous research with specific clay properties selected from various Anatolian regions, utilizing the design of experiment methodology. The design parameters include angle, profile, and height; printing parameters encompass compressor pressure, speed, and layer height; and material parameters are assessed through drop spike, tube pressure, and flow rate tests. After defining the inputs and their computational ranges, the algorithm was tested using various inputs and corresponding physical prints to evaluate its recommendation capability. The test prints indicated that the algorithm's suggestions for design, printing, and material parameters were suitable for the given inputs. While the current research does not yet serve as an expert recommendation tool, it establishes a foundational framework for further development.

The second article, titled "Importance of Indicators in Sustainable Urban Transformation: The Bağcılar (Istanbul) Sustainability Index Experience," explores sustainability criteria as a means to make the world a more livable place. Authored by Sezen Tarakçı and Gülşen Pelin Olcay, this study emphasizes the critical role of sustainable urban transformation practices within the framework of the Sustainable Development Goals. The authors discuss the methodologies and challenges encountered during the development of a Sustainability Index tailored for Istanbul's Bağcılar district.

Tuba Sarı, Nurhilal Burak, and Rümeysa Bayar, in their study "From Commerce to Art: Transformation of Intervention through the Interactions of Virtual and Urban Space in Karaköy," highlight a novel form of urban intervention through virtual spaces. This research examines how virtual environments can serve as a mode of intervention in urban spaces, focusing on the transformation of ordinary commercial sites into artistic urban spaces. The fieldwork, conducted along Tersane Avenue, Mumhane Avenue, and Ali Paşa Değirmeni Street in Karaköy, documents the evolution of these areas from commerce hubs to sites of collective artistic expression.

In a world where resources are increasingly scarce and global warming continues unabated, it is imperative for researchers to focus on energy efficiency, heating and cooling systems, and their relationship with the built environment. This issue includes several articles addressing these vital topics. Mustafa Özdemir and Ayça Gülten, in their article "Effect of Phase Change Materials on Building Heating and Cooling Loads Considering Different Wall Combinations," conducted energy analyses on a sample building. Their research explored 39 scenarios involving various combinations of materials (brick, concrete block, aerated concrete) and insulation materials, both with and without phase change materials (PCMs). Building heating and cooling loads were assessed for the coldest and hottest days of the year, as well as the total annual energy demand.

Ceren Aydan Nasır, in "Field Study on Determining the Impact of Design Decisions on Energy Efficiency at Settlement Scale," examines the impact of design decisions on energy efficiency in a multi-unit project in Sakarya's Serdivan district, utilizing Autodesk Forma for solar, microclimate, and comfort analyses supported by artificial intelligence. İlknur Zeren Çetin's article, "The Effects of Sinop Province's Relative Humidity Values on Bioclimatic Comfort and Urban and Landscape Planning," evaluates how monthly average humidity values influence planning strategies in different districts of Sinop.

Addressing global risks, Barış Barış and Menşure Kübra Müezzinoğlu, in "Diyarbakır Hasan Pasha Inn: A Thorough Evaluation of Risk Analysis and Accessibility Concerns," investigate the preservation of cultural heritage through improved accessibility and safety measures at the Hasan Pasha Inn in Diyarbakır. Similarly, Barış Ergen's article, "The Effects of COVID-19 on the Agglomeration of High-Tech Knowledge-Intensive Business Services in Ankara, Istanbul, and Izmir," analyzes the pandemic's impact on employment in high-tech sectors.

Esra Sivri İçöz and Ahmet Tuğrul Polat, in "Investigation of the Relationship Between Physical Activity and Park Utilization in Konya City (Karatay) Using the SOPARC Method," assess the physical activity levels of park users and provide design recommendations to encourage greater use of parks for recreational purposes.

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Another noteworthy contribution comes from Deniz Yıldız Uslu, Hafith Mohammed Sulayman Almansouri, Amragia H. Mostafa Elahsadi, and Mehmet Çetin. Their article, “Towards Sustainable Cities: Evaluating the Distribution and Functionality of Green Spaces in Atakum,” employs GIS analyses to assess disparities in green space accessibility in Atakum, Samsun, and offers strategic urban planning recommendations.

Zafer İslam Taşdemir and Aslıhan Öztürk, in “A Reading of 'Place Attachment' in Spatial Perception: The Case of KTU Department of Architecture,” explore the emotional, cognitive, and behavioral bonds between individuals and spaces, proposing strategies to improve "non-places."

Finally, Özge Zenter, in “Flexible Model Proposals for Post-Disaster Temporary Housing in Architectural Design,” presents student-designed solutions for disaster-response shelters, emphasizing flexibility, portability, and modularity in both education and practice.

As a multi-stakeholder independent organization, DRArch continues to foster academic innovation and collaboration. We extend our best wishes for a prosperous 2025, filled with advancements in science, technology, peace, and meaningful endeavors.

Best regards...

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

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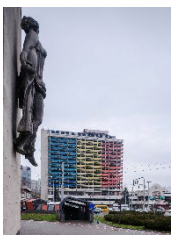

Cover photo: Image copyright ©Sena Özfiliz, Milano, (December 2024). The image on the left is detail "Chisinau ex-National Hotel and detail from exhibition center sculptures, Moldova”

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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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Research Article
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Clay 3D printing: Exploring the interrelations of materials and techniques

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Emel Cantürk Akyıldız[**]

Abstract

This research aims to design an algorithm for optimizing clay 3DP. The algorithm's inputs are defined by combining the results of previous research and specific clay information selected from different regions of Anatolia, utilizing the design of experiment methodology. The design parameters include angle, profile and height; printing parameters include compressor pressure, speed, and layer height; and material parameters are assessed through drop spike, tube pressure, and flow rate tests. Once the inputs and their computation ranges were defined, the algorithm was tested with various inputs and corresponding physical prints to evaluate its recommendation capability. The test prints demonstrated that the printing suggestions made by the algorithm for design, printing and material parameters were suitable for the given parameter inputs. With its current state, the research is not an expert tool for recommendation but a base of a more complex framework for further research.

Keywords: clay 3D printing, clay material, material-parameter interrelation

1. Introduction

Digital fabrication has consistently played a pivotal role in advancing bio-design explorations, where natural intelligence is integrated with embedded digital systems to create innovative and responsive structures. As Zimbarg (2021) highlights, this synergy between the biological and digital realms enables designers and researchers to push the boundaries of what can be achieved in architecture, product design, and ecological systems. At the forefront of these advancements is 3D printing (3DP), widely regarded as a revolutionary technology that can reshape the product development process and the entire manufacturing landscape. According to Gibson et al. (2015), 3DP's transformative impact stems from its ability to streamline production workflows, significantly reduce the material resources needed, and enable the creation of geometrically complex forms that traditional manufacturing methods would struggle to replicate if they could at all.

A key advantage of 3D printing in the context of bio-design is its adaptability. Pressure extrusion systems, in particular, are well-suited for these explorations as they allow for the customization of material matrices, opening up the possibility of working with unconventional materials, including those with irregular properties or textures (Crawford et al., 2022). This flexibility is especially valuable when designing with materials like clay, which poses unique challenges and opportunities for digital fabrication due to its variability and natural composition. Despite its vast potential, clay has not been as thoroughly explored in 3D printing compared to other materials, primarily due to the technical challenges associated with processing it. Issues such as feedstock preparation, sintering conditions, and mechanical weaknesses during and after printing present significant hurdles (Zocca et al., 2015). For example, achieving the correct water-to-clay ratio is critical, as an imbalance can lead to nozzle clogging or structural weaknesses in the printed object. Similarly, external factors like temperature fluctuations or compressor overheating can further exacerbate these challenges, leading to inconsistent print quality and diminishing the overall reliability and strength of the final product.

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Nevertheless, the versatility and sustainability of clay are attracting growing interest, especially in the realm of bio-composite integration within the built environment. One of clay's most compelling features is its hygroscopic nature, which allows it to absorb and release moisture—a property that becomes particularly advantageous when designing for environments that require natural regulation of humidity and temperature. As Dudukovic et al. (2021) point out, unglazed clay can function as a conduit for distributing moisture and nutrients throughout a structure, thanks to its capacity for liquid capillary flow. This characteristic opens up various possibilities for designers, architects, and engineers, ranging from load-bearing structural elements to more delicate applications like tiles, screens, and self-supporting 3D-printed products. Using clay in this way supports innovative design approaches and fosters the development of sustainable architectural solutions that are responsive to their environments (Ramirez-Figueroa & Beckett, 2020).

One of the most intriguing aspects of working with clay in digital fabrication is the material's inherent ability to introduce an experiential, tactile dimension into the design process. Unlike more uniform synthetic materials, clay's organic composition interacts with digital fabrication in unpredictable ways, meaning that designers often need to adjust and respond to the material as they work. This interaction creates a non-linear process, where a predictable, step-by-step design path is often impossible to follow. Instead, iterative testing and constant refinement are required to achieve the desired outcome (Crawford et al., 2022). Designing for clay 3DP, therefore, involves balancing the precision of digital tools with the unpredictability of the material itself. It's a process that requires continuous experimentation, adaptation, and hands-on involvement. This research sought to address key questions surrounding the refinement of this multi-layered process. Specifically, it explored how the workflow for clay 3D printing could be made more precise, how this environmentally friendly material could be made more accessible for designers, and whether a simple, intuitive tool could be developed to facilitate the process for a wider audience.

With these goals in mind, the paper aims to provide practical insights and recommendations for optimizing clay 3DP workflows. Through a combination of theoretical exploration and hands-on experimentation, the research outlines a methodology for improving the quality and consistency of printed clay objects. The iterative testing process employed in this study allowed for fine-tuning various parameters, including material consistency, extrusion pressure, and environmental conditions, all critical to ensuring a successful print. As a result of these experiments, an algorithm for clay 3DP settings has been proposed. This algorithm represents a significant step forward in the field, as it is designed to analyze input parameters—such as material properties, environmental factors, and user preferences—and generate an optimized set of printing values as output. By doing so, the algorithm simplifies the decision-making process for users, enabling them to achieve more reliable and accurate prints with minimal trial and error.

What sets this algorithm apart is its adaptive nature. It includes feedback mechanisms that allow it to learn from previous prints, adjusting its recommendations over time based on empirical data and user input. This continuous improvement ensures the algorithm remains relevant and practical, even as the user's needs evolve or new materials are introduced into the workflow. By incorporating this dynamic feedback loop, the algorithm enhances the immediate print quality and contributes to the long-term development of clay 3DP as a viable manufacturing technology. This could pave the way for a new generation of clay-based designs, from large-scale architectural components to intricate, personalized objects.

In conclusion, while there are still significant challenges to overcome in the realm of clay 3DP—such as improving the material's strength, addressing environmental sensitivities, and refining the precision of the printing process—the potential for innovation is immense. As more research is conducted and tools like the proposed algorithm become more sophisticated, clay will likely emerge as a key material in sustainable design and construction. By combining the timeless qualities of this natural material with cutting-edge digital fabrication techniques, designers and researchers can create a new paradigm for environmentally friendly, intelligent design solutions.

2. Literature Review

This research builds upon previous studies that have applied testing and optimization techniques to improve the performance of clay 3DP processes. Many of these studies have aimed to refine specific process parameters, such as material composition, extrusion speed, or layer height, to address the unique challenges posed by clay as a 3D printing material. For example, Revelo and Colorado (2018) conducted an in-depth analysis of the structural properties of 3D-printed objects made from kaolin clay. By evaluating compression strength, thermal stability, and density (particularly the water-to-clay ratio), they sought to optimize the production process to enhance the mechanical properties and print quality of the final products. Their research helped to highlight how sensitive clay's performance in 3DP is to material composition and print settings.

Similarly, Gürsoy (2018) approached the optimization process by systematically varying speed, layer height, and nozzle settings during the clay 3DP process. Using a consistent cylindrical 3D model, he explored how these parameters influenced print quality, revealing insights into how changes in each variable could affect the printed object's overall strength, resolution, and aesthetic. Guo et al. (2019) took a different approach by focusing on the internal mechanics of the 3DP process, conducting simulations to assess the impact of pressure distribution, shear rate, and velocity within the extruder. These simulations were aimed at identifying the optimal parameters for screw extrusion and direct writing, two techniques used for printing viscous materials such as clay. The study provided valuable data on how internal forces within the extruder could affect material flow and print quality.

Wang et al. (2020) advanced the study of clay 3DP by investigating how the extrusion process affects material behavior. They focused on several key factors—printability, geometrical accuracy, and mechanical performance—and examined how variables like filament profile, layer height, nozzle diameter, and movement speed influenced these outcomes. Their tests revealed essential relationships between these parameters, such as how altering the velocity ratio could affect the consistency of material flow and how the printing-path strategy could either enhance or detract from the final print's dimensional accuracy. Similarly, Cruz et al. (2020) examined the effect of extrusion parameters on the mechanical properties of printed clay geometries, with a particular focus on how changes in these parameters influenced curved and straight profiles with diverging angles. Their research provided insights into how geometric complexity could be managed in clay 3DP, paving the way for more intricate designs and functional architectural components.

Keep (2020a) contributed a practical dimension to the study of clay 3DP through a guide that outlined several hands-on testing methods. His work stands out for its detailed examination of parameters such as drop spike assessments, syringe pressure extrusion, tube pressure, and flow rate, offering practical solutions to common challenges in clay 3DP. His experiments covered various geometries and provided a real-world framework for understanding how specific parameter changes affect the outcome.

In addition to these studies, Farahbakhsh et al. (2022) explored three specific parameters—nozzle-to-substrate distance, delay time, and the distance between nodes and printing paths—to optimize the interlayer bonding strength in ceramic structures. Their work provided insights into how these parameters could be fine-tuned to improve the structural integrity of 3D-printed clay objects. Meanwhile, Lin et al. (2023) used advanced simulation software to model the stress state of the extruder during ceramic 3DP, focusing on key variables such as inlet pressure, moisture content, extruder length, and cone angle. They emphasized the importance of balancing printing speed to avoid defects like blockages or breakpoints, and their simulations helped to identify primary and secondary factors affecting print quality.

Asaf et al. (2023) approached clay 3DP from a materials science perspective, developing a method for transforming soils into a flowable mixture with post-deposition stability. Their experiments, which involved testing 12 different sand and clay mixtures, provided insights into how linear correlations between various properties could inform the optimization of the 3DP process.

Their work culminated in an in-situ cylinder printing test, further validating their method's effectiveness. Wang et al. (2024) focused on the optimization of process parameters for alumina ink in Direct Ink Writing (DIW) 3DP, investigating factors such as filling ratio, nozzle diameter, and layer thickness. Their research provided a deeper understanding of how these variables influence the printability and mechanical performance of alumina-based materials, which share similar challenges with clay 3DP. Finally, Yousaf et al. (2024) conducted a comprehensive study to optimize nozzle diameter, layer height, infill percentage, and printing speed for commercial clay. Their quantitative analysis, which compared measured dimensions to the intended design, helped to assess dimensional accuracy and buildability, offering valuable data on the structural integrity of 3D-printed clay objects.

3. Methods and Materials

This research is centered on designing an algorithm to optimise the 3D printing (3DP) of clay, a material with significant potential in digital fabrication but also presenting considerable challenges. The optimization process in this study is structured around the Design of Experiments (DOE) methodology. DOE is a systematic approach that involves the careful planning, execution, analysis, and interpretation of controlled tests. These tests are designed to evaluate the impact of various factors on a specific outcome, thereby facilitating the identification of optimal process parameters (Durakovic, 2017; Al Rashid et al., 2022; Al Rashid et al., 2024). In this context, the goal is to determine the best values for key parameters within the algorithm to enhance the overall quality, efficiency, and reliability of clay 3DP.

3.1. Parameter and Sub-parameter Definition

Drawing from the literature review studies, this research identifies three primary categories of parameters crucial for optimizing clay 3DP: design, printing properties and material behavior (Table 1). These categories form the basis of the research's focus on the ease-of-use analysis, one of the core objectives of the study. Within each category, specific subcategories are identified to streamline the optimization process.

Table 1 Selected Parameters and Their Subcategories for the Algorithm

Parameter type	Sub parameters
Design	Angle
	Profile type
	Height
Printing	Pressure
	Speed
	Layer height
Material	Drop spike
	Flow rate

For design parameters, the critical variables are the angle, profile type (in line with Cruz et al., 2020), and height (similar to Yousaf et al., 2024). Users are asked to define these parameters by providing an approximate angle value, selecting the profile type (straight or curved), and specifying the maximum height of the design. These design parameters directly affect the structural complexity and aesthetic outcomes of the printed object.

Printing parameters, on the other hand, include compressor pressure (similar to Revelo & Colorado, 2018; Lin et al., 2023), speed (as seen in Gürsoy, 2018; Wang et al., 2020), and layer height (referenced by Wang et al., 2020; Yousaf et al., 2024). These variables are essential for controlling the material flow and ensuring the accuracy of each printed layer. However, the capabilities of the clay printer used in this research impose certain limitations on these parameters, mainly due to the screw-controlled material flow system (Figure 1).

Delta LDM 3DP	
Printing area	Ø:300 mm h:400 mm
Nozzle size	1.5mm
Layer height	1 - 2mm
Extruder	Screw controlled
Tank size	Ø:100 mm – h:400 mm

Figure 1 The clay 3DP was used in this research

The reviewed articles emphasize the importance of chemical compositions and complex lab tests to analyze the properties of clays used in 3D printing. These studies often rely on data derived from intricate laboratory results, providing valuable insights into how different clay types respond to various printing processes. However, replicating such lab-based evaluations can be quite challenging for many users—particularly novice practitioners or those with limited access to advanced testing equipment. The expertise, time, and resources required to perform chemical analysis or advanced testing methods could act as significant barriers to entry, especially for individuals or small-scale operations looking to experiment with clay 3DP.

To address these challenges and ensure inclusivity, this research adopts more accessible and practical methods for evaluating material behavior. The aim is to enable a broader range of users, regardless of their technical background or available resources, to contribute meaningfully to optimizing clay 3DP. Therefore, more straightforward, approachable testing techniques are incorporated into the research scope, balancing precision and practicality while yielding reliable data for the algorithm's calculations. These methods make it easier for users to gather material behavior parameters without requiring extensive lab infrastructure.

The material behavior parameters selected for this study include drop spike test results, tube pressure measurements, and flow rate assessments (similar to Keep, 2020b). These tests are designed to be easy to conduct while providing sufficient information to inform the optimization algorithm.

Drop Spike Test: In this test, a standardized tool or weight is dropped from a fixed height onto the clay sample, and the indentation depth created by the impact is measured. This method helps assess the consistency and stiffness of the clay. The deeper the indentation, the softer and more pliable the clay is, indicating a higher water content or a less compacted material. Conversely, a shallower indentation would suggest a denser or drier clay sample. This simple test indicates the clay's workability, which is critical in ensuring smooth extrusion during 3D printing.

Tube Pressure and Flow Rate Test: A container is filled with each clay sample, and controlled pressure is applied to the material. The clay is then forced through an attached plastic tube, and the flow rate of the clay is measured as it exits the tube. This test simulates the extrusion process used in 3DP and helps evaluate how easily the clay can flow under pressure, which is crucial for determining its printability. If the flow rate is too slow, the material may clog the nozzle or lead to inconsistencies in the printed layers. If the flow rate is too fast, the clay may not retain its shape once extruded, leading to deformation in the final print. Users can gauge the optimal pressure and material consistency needed for successful 3D printing by measuring the flow rate.

These tests are selected not only for their simplicity but also for their ability to provide actionable data. Novice users can efficiently perform these evaluations with basic tools, yet the results offer valuable insights into the clay's behavior during printing. This approach ensures that the research remains accessible to a broad audience while offering a robust framework for optimizing clay 3DP workflows. By focusing on tests that can be conducted with minimal technical

expertise, the research encourages broader participation in the field, fostering innovation and experimentation across various levels of experience.

In addition, these approachable methods also help mitigate some of the inconsistencies that can arise when using natural materials like clay, which often vary in composition even within the same type. Using these simplified tests to assess material behavior on a case-by-case basis, users can adjust their printing parameters to suit the specific properties of the clay they are working with. This flexibility allows for more reliable results in real-world applications, ensuring that even novice users can achieve high-quality prints without conducting complex chemical analyses.

Ultimately, including these practical testing methods aligns with the overarching goals of this research—to democratize access to clay 3DP optimization tools and provide users of all skill levels with the resources they need to succeed. These methods not only simplify the process of gathering critical material behavior data but also help ensure that the resulting algorithm remains adaptable to a wide variety of use cases, from hobbyist projects to more advanced industrial applications.

3.2. Material Selection

The algorithm's computational capability is intricately tied to both the limitations of the machinery used and the type of clay employed during the 3D printing process. This relationship underscores the need for an in-depth understanding of the properties and behaviors of the materials involved. While previous studies (such as Keep, 2020b) have provided valuable material information that contributed to the development of this algorithm, further analysis was essential to tailor the tool to the specific types of clay utilized in this research. Consequently, in addition to leveraging existing data from the literature, the behaviors of three distinct clays sourced from Anatolia were analyzed to ensure the algorithm's effectiveness and applicability.

The clays chosen for this study were sourced from three different regions of Turkey, each characterized by unique climatic and geographical features. These variations in environmental conditions contribute to the distinct mineral compositions and physical properties of the clays, which can significantly influence their behavior in 3D printing processes. The selected clays include samples from Adana in the Mediterranean Region, Avanos in the Central Anatolia Region, and Menemen in the Aegean Region. Each region is known for its rich clay deposits, which are traditionally used in pottery and other ceramics, making them ideal candidates for exploration in modern clay 3DP.

A detailed comparison of their mineral compositions was conducted to understand these clays' differences comprehensively. This was achieved using XRF (X-ray fluorescence) analysis, a widely recognized and reliable method for determining the elemental makeup of various materials. XRF has long been used in material science and geology to analyze the chemical composition of soils, minerals, and other substances, offering a non-destructive way to identify key elements of the material. This technique identified each clay sample's specific mineral components, allowing for a more nuanced understanding of how these elements might impact the 3D printing process, such as their influence on extrusion behavior, drying time, or sintering properties (Abdulli, 2023).

The mineral compositions of the Adana, Avanos, and Menemen clays were analyzed and summarized in Table 2, providing a clear visual representation of the elemental differences between these samples. The XRF analysis revealed significant variation in the presence of certain minerals, such as silica, alumina, and iron oxide, which are known to affect the structural integrity and behavior of clays during printing. For instance, a higher silica content generally enhances the material's heat resistance and strength after firing, while variations in iron oxide can influence the clay's color and plasticity. These differences are crucial for determining how well a clay will perform in the 3DP process, from extrusion to final sintering.

The clay from Adana, located in Turkey’s Mediterranean region, is characterized by its relatively warm climate and fertile soil. The XRF analysis indicated that this clay has a balanced composition, with moderate levels of silica and alumina, making it versatile for various types of 3D printing

applications. However, its mineral composition suggests it may require specific adjustments to nozzle settings and extrusion pressure to achieve optimal flow during printing.

Avanos, situated in Central Anatolia, is renowned for its pottery tradition, with clay shaped by centuries of erosion from volcanic rocks in the region. The XRF analysis of Avanos clay revealed higher levels of iron oxide, which could affect the clay's plasticity and workability during 3D printing. This increased plasticity could be advantageous, making the material easier to shape but potentially more prone to deformation if not carefully controlled. The algorithm considers these unique properties, suggesting specific pressure settings and layer heights tailored to the Avanos clay.

The clay from Menemen, in the Aegean Region, displayed a higher silica content, which enhances its durability and heat resistance. This property makes Menemen clay an excellent candidate for more structurally demanding 3D printed applications, such as load-bearing components or architectural elements. However, the increased silica content may also lead to a stiffer material, requiring careful extrusion speed and nozzle diameter adjustments to ensure a smooth printing process without clogging or inconsistencies.

By integrating the results of the XRF analysis into the algorithm, the tool can make more accurate predictions and recommendations for each type of clay, adjusting parameters like extrusion speed, layer height, and nozzle diameter accordingly. This approach optimises the clay's performance during printing and ensures that the final printed objects meet the desired structural and aesthetic standards.

The regional variations in clay composition underscore the complexity of working with natural materials in digital fabrication. Unlike synthetic materials, which can be engineered for uniformity, natural clays exhibit significant variability even within the same type or geographical area. This variability necessitates a flexible and adaptive approach to 3D printing, where the printing parameters must be adjusted based on the specific properties of each batch of clay. The algorithm developed in this research incorporates these considerations, offering a more tailored solution that considers the nuances of working with diverse clays from different regions.

Table 2 XPF Analysis of Adana, Avanos and Menemen Clays (Gathered from Abdulli, 2023)

	Fe2O3	CaO	SiO2	K2O	Cl	CuO	TiO2	SO3	MnO	Al2O3
Adana	13.83	24.5	31.31	2.01	0	0.07	0.98	0.65	0.17	8.35
Avanos	15.18	9.03	42.42	5.09	0	0.07	1.48	0	0.17	17.23
Menemen	16.89	4.52	44.96	5.11	0	0.07	1.58	0	0.08	19.46

The XRF analysis of the selected clays from Adana, Avanos, and Menemen provides a solid foundation for the algorithm's ability to optimize clay 3DP workflows. By understanding the elemental compositions of these clays, the algorithm can make informed recommendations, ensuring that each type of clay is used to its fullest potential. This tailored approach not only enhances the precision and quality of the printed objects but also expands the versatility and usability of the algorithm across different types of clay and 3DP applications.

When the table is examined, the high SiO2 and Al2O3 content commonly detected in all materials indicates the materials' high fire resistance and structural integrity capacity. The CaO content, detected predominantly in Adana clay, can improve the hardening and adhesion properties of the material but may also cause deformations and cracks. The Fe2O3 content, observed in similar proportions in all materials, plays a significant role in the colouring of the material. The presence of other components such as K2O, TiO2, MnO, and SO3 has minimal impact on the physical and chemical properties of the materials. For example, K2O can affect the fusion temperature in ceramics, while TiO2 can provide pigmentation properties. The deficient levels of CuO and Cl indicate that these elements will not significantly affect the overall properties of the materials (Abdulli, 2024).

As previously mentioned, since the research aimed to create an algorithm that everyone can easily use, simple test results that do not require access to laboratory results, as discussed above,

were used as inputs. The drop spike and flow rate test results conducted on samples were believed to have the appropriate consistency for the machine's usage, supporting the materials' laboratory results (Table 3).

Table 3 Drop Spike and Flow Rate Tests of Selected Clay Types

	Spike depth(cm)	Tube flow (cm/10sec)	Pressure (bar)
Adana	2.5	2	8
Avanos	3	4	8
Menemen	3	6	8

3.3. Algorithm Framework

By adapting and transforming the detailed examination of Cruz et al. (2020), printing trials with straight and curved sections at 30, 45, and 60 degrees were conducted for each clay to gather the information used in the algorithm's suggestion calculations. Due to the necessity of obtaining height data where the prints progress smoothly from the trials, the prints were observed, and printing was stopped at the height where issues occurred. The print speed and flow rate were kept at 100% during the trials, while the layer height was set to 1mm for all prints. The results showed that hard materials reached lower heights in straight sections (Figure 2). The data obtained from the tests are supported by studies from the literature where the same data could be obtained, allowing for the development of the algorithm's computational technique and the creation of a recommendation process.

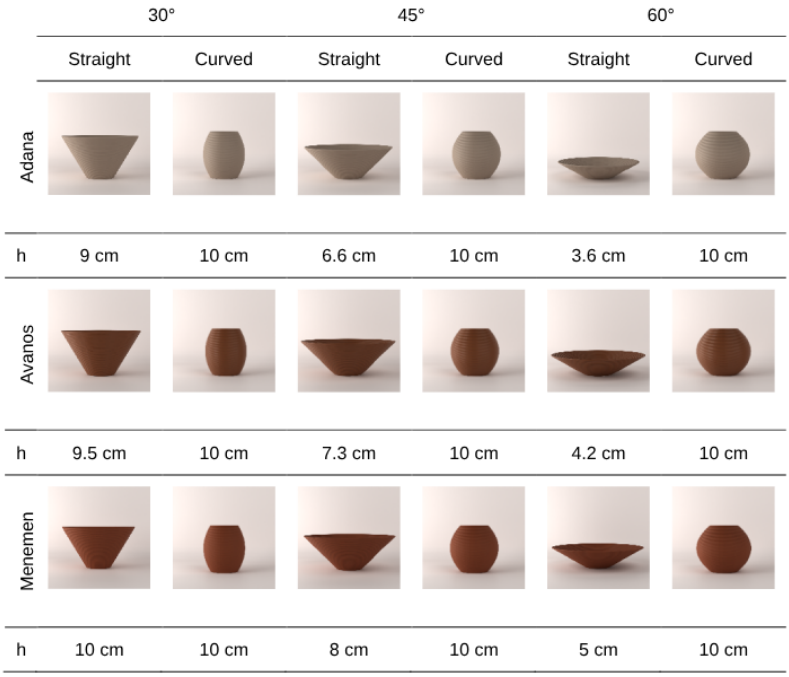

Figure 2 Clay-printed examples with changing section, angle and height values

The primary objective of this research is to develop an algorithm capable of providing recommendations for missing inputs based on the given design specifications, printing configurations, and material properties. By inputting data from at least two of these three parameter groups, recommendations for the third parameter are developed using the Python tool in Rhino 3D's Grasshopper interface. Grasshopper is the graphic interface to design algorithms. The Phyton tool of that interface allows users to embed their code for operations directly for desired calculations. Although the researchers of this paper are architects without coding knowledge, today, with the improvements in artificial intelligence (AI) tools, it is easy to have Phyton codes with the help of AI tools. Therefore, ChatGPT, an advanced AI-powered conversational assistant developed by OpenAI, was asked to write a Phyton code for Grasshopper that can turn defined

inputs through pre-defined rule sets. The gathered code was then re-designed with the pre-defined parameters to make the desired suggestions for the final algorithm (Figure 3).

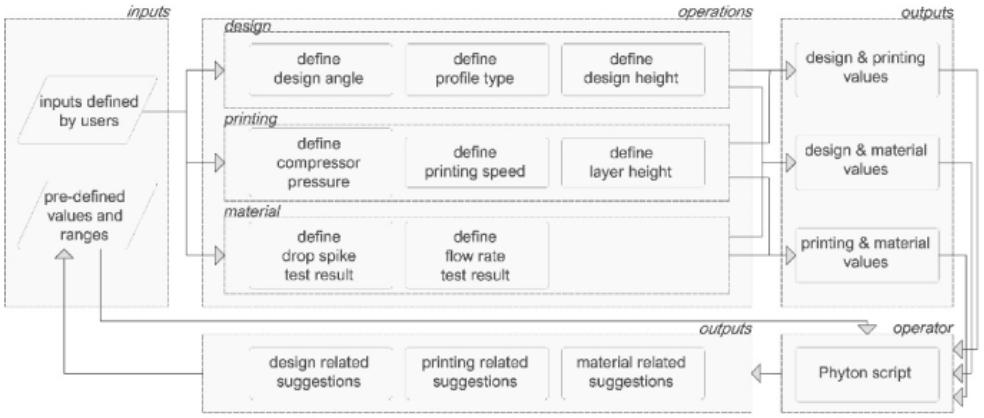

Figure 3 Algorithm flowchart

4. Results and Findings

The algorithm underwent meticulous and comprehensive testing across three applications involving different input values and clay types. This rigorous approach was designed to ensure the algorithm's effectiveness in generating precise recommendations within suitable ranges, fostering confidence in its reliability and practicality.

4.1. Test 1: Printing Parameter Suggestions

The design and material inputs were entered in the first test to gather recommendations for printing parameters. The angle parameter was set at 50 degrees—situated between previously tested ranges of 30–45 and 60 degrees—to assess the algorithm's decision-making in a new range. A height of 10 cm and a curved profile type were selected to create a standard testing condition. The material properties were defined to mimic Menemen clay, with a drop spike value of 3 and a flow rate of 6, ensuring alignment with its printing requirements.

The algorithm output pressure values of <8, a speed of 100, and a layer height of <1, which were well-suited for Menemen clay. A prototype was printed using these parameters to validate the algorithm's predictions, confirming the accuracy of the results (Figure 4).

4.2. Test 2: Design Parameter Suggestions

Material and printing inputs were provided in the second test to obtain design parameter suggestions. For material testing, none of the selected clays had a flow rate 1, allowing the test to evaluate the algorithm's behavior under low flow rate conditions. Printing parameters were kept consistent with the previous test (pressure: 8, speed: 100, layer height: 1) to analyze the algorithm's ability to adapt its design recommendations.

The algorithm suggested a design angle between 30–45 degrees, a straight profile type, and a height of <4 cm. These outputs closely aligned with the properties of Adana clay. A prototype was printed using this clay type, further validating the algorithm's reliability (Figure 4).

4.3. Test 3: Material Parameter Suggestions

The third test assessed the algorithm's capability to suggest material parameters based on specific design and printing inputs. With prior trials using angles of 30–45 and 60 degrees, the angle was again set at 50 degrees to observe the algorithm's recommendations at higher values. Recognizing the challenges of printing at steeper angles with straight profiles, the height was limited to 4 cm. Printing parameters included a low-pressure input of 6, chosen to test the algorithm's ability to suggest materials akin to Avanos clay, which performs well under low-pressure conditions.

As anticipated, the algorithm proposed drop spike values >3 and flow rates >6, consistent with the properties of Avanos clay. A prototype printed using these outputs confirmed the accuracy and suitability of the algorithm's recommendations (Figure 4).

The results of these test prints unequivocally demonstrated the algorithm's reliability across all tested scenarios. Its ability to provide accurate suggestions for design, printing, and material parameters underscores its versatility and adaptability to various clay types and conditions. Including different clay types during testing was particularly noteworthy, showcasing the algorithm's potential to optimize the 3D clay printing process. By offering precise, reliable, and practical guidance, the algorithm supports achieving desired outcomes across a wide range of specified parameters, further validating its application for diverse material variations.

		Test 1		Test 2		Test 3	
		inputs	outputs	inputs	outputs	inputs	outputs
Design	Angle	50			30-45	65	
	Profile type	curved		straight		straight	
	Height	10			<4	4	
Printing	Pressure		<8	8		6	
	Speed		100	100		100	
	Layer height		<1	1		1	
Mat.	Drop spike	3		2			>3
	Flow rate	6		1			>6
Printed results							

Figure 4 Test results of the algorithm with various input types

5. Discussion

Based on the comprehensive trials conducted under various parameters, it is clear that the optimization algorithm designed to provide 3D printing (3DP) recommendations for clay-based materials has successfully achieved its primary objective. Although promising, the results of these tests also revealed several technical challenges that need to be addressed for future improvements. One of the most significant challenges is the limitation posed by the algorithm's reliance on the computational module. This module depends heavily on data drawn from existing literature and results obtained from real-time testing. While this data provides a solid foundation, it does restrict the algorithm's flexibility and scalability. The performance and accuracy of the algorithm are bound by the availability and quality of the data, which may only sometimes be sufficient for more complex or diverse printing scenarios.

Moreover, a critical obstacle encountered during the testing phase is the inherent variability in the properties of clay, even when working with the same type of material. Clay, a naturally sourced material, is subject to inconsistencies in composition, moisture content, and texture, all of which can lead to fluctuations in print quality. These variances make it difficult to maintain uniformity across prints, as subtle differences in the material's behavior can result in inconsistent outputs. Therefore, addressing this issue of material uniformity is essential for enhancing the reliability and predictability of the 3D printing process.

Another limitation identified is related to the clay printer used throughout the research. Although this particular printer has been sufficient for the early stages of experimentation, it needs more versatility to handle a broader range of clay types optimally. Fortunately, ongoing research is being conducted with a more advanced clay printer, capable of printing with a wider array of materials and offering improved precision. This opens the door to more complex and nuanced studies and emphasizes the importance of equipment quality in achieving consistent results. While

this study provides valuable insights, it is apparent that more sophisticated hardware will be necessary to fully realize the algorithm's potential.

Environmental factors also posed significant challenges during the experimentation process. The sensitivity of the 3D printing equipment to external conditions, such as fluctuations in temperature and humidity, proved to be a substantial barrier to reproducibility. Variations in these environmental factors led to inconsistent print outcomes, particularly in terms of layer adhesion and material curing times. While the physical conditions of the laboratory were controlled to some extent, the unpredictable nature of sunlight exposure, temperature shifts, and humidity changes had a noticeable impact on print quality. Though manageable in a controlled single study, these environmental influences must be minimized for more rigorous and long-term testing. To ensure the algorithm's accuracy, future experiments should be conducted in environments where temperature and humidity can be strictly regulated to prevent interference with printing.

Another aspect that emerged during the testing was the algorithm's computational demands. The algorithm's required data processing complexity means that real-time feedback is often delayed, hindering practical, real-world applications. For this tool to be effective in professional 3D printing settings, the algorithm's processing speed must be optimized for instantaneous adjustments and recommendations. Any significant lag in feedback could disrupt the flow of the printing process, leading to errors that may not be immediately correctable. Therefore, optimizing the algorithm for real-time use is one of the most pressing challenges.

The next phase of this research will involve a deeper dive into fine-tuning the algorithm's parameters. This will include extensive testing with various clay types, encompassing different compositions, textures, and moisture contents, to further refine the algorithm's predictive accuracy. By experimenting with a broader range of printing conditions, the research team aims to develop a more robust model capable of handling clay materials' diverse and unpredictable nature. This exploration will provide a more comprehensive understanding of how various factors influence print quality and how the algorithm can adapt to different scenarios.

Aside from technical refinement, another crucial step in this research will be the collection of user feedback. We are committed to engaging with diverse users, from professionals to hobbyists, to identify any practical issues that might arise when the algorithm is used in real-world applications. This feedback will be invaluable in making user-centered improvements, ensuring that the tool remains intuitive and responsive to the needs of its audience.

To complement these advancements, developing a comprehensive user manual and training program will be essential. This will include creating detailed documentation that outlines every aspect of the algorithm's operation, from its initial setup to more advanced troubleshooting tips. Interactive tutorials, incorporating video demonstrations and step-by-step guides, will also be developed to assist users in navigating the software effectively. By providing clear and accessible instructions, the research team hopes to make the algorithm widely adoptable, even for individuals with limited technical expertise.

In terms of future improvements, there are several promising avenues for enhancing the algorithm's functionality. Expanding the database of clay types and material properties database would allow the algorithm to generate even more precise recommendations tailored to a broader array of materials. Additionally, integrating machine learning techniques could enable the algorithm to learn from each print, continuously improving its performance by analyzing past results and adjusting its recommendations accordingly. This adaptive capability would make the tool not only more accurate but also more efficient over time. Moreover, incorporating a user-friendly interface with real-time visualization and feedback features would make the algorithm more accessible to a broader range of users, ensuring that experts and beginners can take full advantage of its capabilities.

In conclusion, while this study has demonstrated the potential of the optimization algorithm for clay 3D printing, there remains significant room for development. Addressing the challenges of

material variability, environmental sensitivity, computational demands, and user engagement will be critical in ensuring the algorithm's long-term success and applicability across various industries. By continuing to refine the tool and expand its capabilities, this research has the potential to revolutionize the field of 3D printing with clay, paving the way for more reliable, efficient, and user-friendly solutions.

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Resume

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Importance of indicators in sustainable urban transformation: The Bagcılar (Istanbul) sustainability index experience

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Abstract

Sustainable urban transformation practices play a critical role in implementing the economic, environmental, and social dimensions of sustainable development in cities. Sustainability indices are important parameters for achieving sustainable development goals. The use of these indices supports the making of strategic decisions for the future of cities, such as in urban transformation practices. Indicators and data are defined as vital tools for evaluating the success of sustainability policies and monitoring the economic, environmental, and social performance of cities. Establishing more comprehensive and accessible data collection systems at the local level and effectively sharing this data is crucial for developing policies based on these indices. This study highlights the significance of sustainable urban transformation practices within the framework of the Sustainable Development Goals (SDGs), emphasizing the methodologies and challenges encountered during the development of a Sustainability Index tailored to the Bağcılar district in Istanbul. The findings indicate that localized data collection and indicator adaptation are essential for achieving measurable and actionable sustainability targets, despite significant limitations in data accessibility. Bağcılar offers an important area of study in terms of sustainability with its dynamics such as rapid population growth, dense construction and socio-economic differences. Planning urban transformation projects within the framework of sustainability principles is a strategic necessity for Istanbul and similar metropolitan cities. By establishing a system that tracks regular, reliable, and internationally standardized data, it will be possible to create measurable, reportable, and comparable targets for sustainable urban transformation practices. However, in developing countries like Turkey, deficiencies in data collection and analysis processes make it difficult to achieve sustainability goals. This study suggests that improving data collection processes and increasing transparency are fundamental steps to ensuring sustainable urban transformation.

Keywords: Bagcılar, data, indicators, sustainable development goals, urban transformation

1. Introduction

The generally accepted definition of sustainable development is development that "meets the needs of the present without compromising the ability of future generations to meet their own needs." Sustainable development has three main pillars: economic, environmental, and social (Hemphill et al., 2004; Williams & Dair, 2007; Yıkmaz, 2011; Zheng et al., 2014; Tuğaç, 2018; Gavaldà et al., 2023).

Sustainability is a system in which the balance of economic competitiveness, improved environmental performance and social integration is observed. In this context, defining the responsible actors to achieve the determined goals and supporting this process with continuous control and monitoring is of great importance in terms of implementing sustainability. The private sector, national, regional and local actors, and civil society organizations are important actors in the process (Ulubaş Hamurcu & Aysan Buldurur, 2017). One of the organizations that conducts the most comprehensive studies on sustainable development is the United Nations (UN). The UN has set forth the Sustainable Development Goals (SDGs) targeted to be achieved by 2030 under 17

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headings. These goals aim to end poverty, protect the environment, take precautions against the climate crisis, share prosperity fairly and achieve peace (UN, 2019).

Nowadays, urban transformation has become an important element of urban policy in many countries and is closely related to sustainable development (Ulubaş Hamurcu & Aysan Buldurur, 2017; Cappai et al., 2019). Urban transformation, particularly in industrial zones, presents complex challenges that intersect economic, social, and environmental dimensions (Kazmierczak et al., 2007; Zheng et al., 2014; Cappai et al., 2019). Industrial sites can be transformed into functions such as housing, services, tourism, commerce, and knowledge and creativity-based production areas. Sustainability provides an appropriate framework for the transformation of these areas. The transformation of these sites varies depending on the conditions of the country such as legal regulations, and social and economic structures. The urban transformation process involves various planning issues and different stakeholders, and the relationship between them complicates the process. In order to achieve effective and efficient sustainable urban transformation practices, it is first necessary to understand the mechanism behind this process (Zheng et al., 2016). In recent years, many academic studies have frequently emphasized that the transformation of industrial sites should be addressed within the framework of sustainability principles (Hemphill et al., 2004; Hemphill et al., 2004; Zheng et al., 2016; Cappai et al., 2019; Williams & Dair, 2007; Spina et al., 2017). However, fragmented and market-driven redevelopment processes often undermine these objectives, as seen in various industrial case studies (Hemphill et al., 2004; Williams & Dair, 2007).

The concept of sustainable development offers a comprehensive structure with its economic, social and environmental dimensions. Therefore, the effects of changes occurring in these dimensions are quite complex and multifaceted. In addition, the fact that sustainable development has a dynamic and constantly evolving structure makes it even more difficult to understand and evaluate the subject (Yıkmaz, 2011). Therefore, in order to measure progress towards sustainable development, it is necessary to quantify the phenomena that represent this progress (Dizdaroğlu, 2017; Verma & Raghubanshi, 2018). This quantification is done through indicators. Indicators are statistical data or measurements that reflect changes in a particular situation. These indicators are selected to provide information about the functioning of a particular system or purpose and serve to support decision-making and management processes (Hiremath et al., 2013; Dizdaroğlu, 2017; Ay, 2017; Gavaldà et al., 2023). Indicators in sustainable development provide the necessary information to measure environmental, economic and social progress (Yıkmaz, 2011; Verma & Raghubanshi, 2018) (Verma & Raghubanshi, 2018). Thanks to this information, decision makers and the public can understand the status, weaknesses and strengths on the way to achieving sustainability goals. (Verma & Raghubanshi, 2018). Thanks to indicator-based sustainability assessment, it is possible to find the best policy measures for sustainable development by providing feedback (Dizdaroğlu, 2017).

1.1. Aim and Objectives

1.1.1. Aim

This study aims to reveal that sustainable urban transformation practices are of critical importance for sustainable development and the necessity of using sustainability indexes in decision-making processes regarding these practices.

1.1.2. Objectives

This study aims to emphasize the critical importance of sustainable urban transformation practices in terms of sustainable development goals through the experiences gained in the process of establishing the sustainability index in Bağcılar district, one of the more densely populated urban areas of Istanbul. Bağcılar offers an important area of study in terms of sustainability with its dynamics such as rapid population growth, dense construction and socio-economic differences. In line with this purpose, the objectives of the study are as follows:

a. To emphasize the critical importance of sustainable urban transformation practices in terms of sustainable development.
b. To propose the establishment of more comprehensive and accessible data collection systems at the local level.
c. To demonstrate the significance of achieving these goals based on the experiences gained during the process of establishing a sustainability index in Bağcılar, one of Istanbul's densely populated urban areas.

1.2. Research Questions

a. What data is required for the sustainability index?
b. How and where can this data be collected?
c. Do local and central governments produce comprehensive and accurate data? If so, is it shared and accessible?

2. Literature Review

2.1. Sustainable Urban Transformation and the Role of Indicators

The importance of sustainability assessment in urban transformation practices has been recognized by many researchers (Hemphill et al., 2004; Zheng et al., 2014; Huang et al., 2015; Zheng et al., 2016; Ulubaş Hamurcu & Aysan Buldurur, 2017; Ayık et al., 2021). Indicators play a critical role in revealing in which areas a city performs better than others and how it will be evaluated according to certain targets (Hemphill et al., 2004) (Hiremath et al., 2013). Sustainability assessment based on indicators is increasingly recognized as an important tool in the planning process. Indicators have the potential to provide a basis for informing planning actions and assessing the sustainability of planning outcomes (Hemphill et al., 2004; Zheng et al., 2014; Dizdaroğlu, 2017).

In the literature on sustainability indicators, a distinction is often made between the terms data, indicator, and index. These terms form a conceptual hierarchy (or pyramid) of indicators (Figure 1). While data represents the key components of an indicator, multiple indicators form an indicator set or composite index. An indicator is an “operational representation of an attribute” of a system, while an index is a more complex composite variable in which multiple indicators are combined using various normalization and weighting methods (Huang et al., 2015).

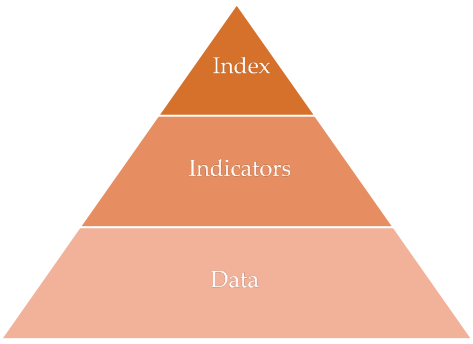

Figure 1 Pyramid of sustainability indicators (Huang et al., 2015)

While the importance of indicators for both sustainable development and sustainable urban transformation practices is emphasized in the literature, another important issue is the data at the bottom of the sustainability pyramid in Figure 1. Although all these stages and their importance are agreed upon in the literature, the importance of obtaining data in calculating sustainability indices is not emphasized enough. The availability of data is an important issue when creating indicators (Michael et al., 2014). It is observed that developing countries face various difficulties in measuring sustainable development. Among these difficulties, problems such as lack of institutional infrastructure and policy coherence, insufficient knowledge and experience regarding the environment, and limited statistical data stand out (Yıkmaz, 2011). For example, in Africa and Asia, where 90% of urban growth is expected to occur by 2050, insufficient urban data is a significant

problem in many cities (Klopp & Petretta, 2017). In some cases, even if data exists, it is inaccessible and unprocessable. It is emphasized that the proliferation of new technologies and big data is important to solve the problem of data deficiency and insufficient data collection capacities (United Nations, 2013). In recent years, big data and the effective management of this data, which have frequently come to the fore in the context of smart cities, have emerged as one of the most critical elements in urbanization processes as a result of research. The complex network structure of the city poses a significant challenge in the processes of storing, processing and managing big data. However, it is envisaged that these challenges can be overcome more effectively by supporting them with advanced technologies such as advanced remote sensing techniques. In addition to facilitating big data management, these technological solutions can also make significant contributions to making cities more sustainable, efficient and livable (Klopp & Petretta, 2017; Ayık et al., 2021). However, on the other hand, although big data and the smart cities movement offer the potential to produce new data, who collects these data, how they are used, and how these processes affect social participation and accountability are issues that need to be considered (Klopp & Petretta, 2017). Therefore, indicators should make the sustainable development of the city more visible and transparent, support comparison, evaluation and forecasting, help create and harmonize data banks, provide relevant information for decision-making processes, and increase public participation (Hiremath et al., 2013). It is envisaged that cities of the future will be able to achieve their sustainability goals more comprehensively and effectively thanks to advanced big data management (Ayık et al., 2021). These advanced data management approaches will enable cities to respond faster and more accurately to environmental, social and economic sustainability parameters, thus enabling sustainable urban transformation practices.

It is not enough to just sign international agreements to combat climate change. In order to make the calculations required by these agreements, the necessary data must be published in an open and transparent manner. Having this data accessible in both developed and developing countries will increase the effectiveness of sustainability efforts. Therefore, the importance of data collection should be emphasized when creating sustainability indices and the necessary steps should be taken in this regard. However, especially in developing countries such as Turkey, the difficulties of data collection pose a major problem in the production and implementation of sustainability policies. The purpose of this article is to emphasize the importance of obtaining data first in order to calculate sustainability indices.

The United Nations Sustainable Development Goals (SDGs) contain roadmaps for countries worldwide to achieve their sustainability goals, and the collection, reporting and analysis of data in line with these goals is of great importance. Turkey has also adopted these SDGs and publishes its data at the national level through institutions such as TÜİK. However, there are major deficiencies and difficulties in collecting and analyzing data at the local level, on a provincial, district or neighborhood basis.

In large metropolises like Istanbul, not only structural transformation decisions but also functional transformation decisions can have major impacts in terms of sustainability. However, the lack of data required to analyze the impacts of these transformations on sustainability poses a major obstacle. When field studies are required to access data, the data collection process becomes quite laborious and complicated, as the data is located in different units of different institutions. This situation makes it difficult to analyze any region with economic, environmental and social indicators and to make strategic decisions about the future of the city. Moreover, instead of such scientific analyses, the transformation of cities in line with the investment preferences of capital groups jeopardizes the achievement of sustainability goals. In the current period, when we are faced with global crises such as climate change, not being informed about the limited resources of cities is an important problem in the context of planning and managing cities. The inability to analyze the social structure makes this situation more complicated.

Nations (UN) is an international organization founded in 1945 and currently consists of 193 Member States. The document titled "Transforming Our World: 2030 Agenda for Sustainable

Development" was signed by UN member countries, including Turkey, and entered into force in January 2016. The Sustainable Development Goals (SDGs), which focus on solving problems related to three main global issues (economic development, social justice and environmental protection) for 15 years covering the period 2016-2030, are a roadmap covering common goals and targets. The Sustainable Development Goals consist of 17 main headings such as combating climate change, ensuring gender equality, spreading quality education, responsible production and consumption all over the world. 169 goals were determined to achieve these goals, and then global indicators were selected to monitor the level of progress towards these goals and targets (UN, 2019).

When the 169 goals in question are examined, it is seen that the realization of 105 of them can be possible with the inclusion of local governments in the process. Local governments are key actors in sustainable development because they are close to the people and have a grasp of all the problems and solutions of the region. Indeed, the fact that the 11th SDG is directly related to "livable and sustainable cities and communities" is a sign of the importance of local governments. Local governments have two basic roles in this process: the first is the overlap of the local development policies of cities with global goals; the second is the contribution that local governments will make to these goals through their actions (Marmara Municipalities Union, 2022).

2.2. Sustainable Urban Transformation Approach in Turkey

The United Nations (UN) is an international organization founded in 1945 and currently consists of 193 Member States. The document titled "Transforming Our World: 2030 Agenda for Sustainable Development" was signed by UN member countries, including Turkey, and entered into force in January 2016. The Sustainable Development Goals (SDGs), which focus on solving problems related to three main global issues (economic development, social justice and environmental protection) for 15 years covering the period 2016-2030, are a roadmap covering common goals and targets. The Sustainable Development Goals consist of 17 main headings such as combating climate change, ensuring gender equality, spreading quality education, responsible production and consumption all over the world. 169 goals were determined to achieve these goals, and then global indicators were selected to monitor the level of progress towards these goals and targets (UN, 2019).

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Since 2016, various self-assessment reports have been planned to be prepared in order to monitor the targets and indicators. Turkey submitted its first Voluntary National Assessment Report (VNR) in 2016 and included a roadmap containing the steps planned to implement the SDGs. The 2nd VNR Report presented in 2019 focuses on progress in the SDGs. In addition to the VNR reports at the national level, many new steps have been taken for the implementation of the Sustainable Development Goals (SDGs) and the evaluation of indicators, especially as of 2022. The most important of these is that the "National Sustainable Development Coordination Board" was established within the Strategy and Budget Presidency by being published in the Official Gazette dated 19.07.2022 and numbered 31897. In addition, as of 24.12.2022, the "Sustainable Development Indicators Web Portal" was put into service by TUİK in order to publish sustainable development indicators more effectively.

At the same time, the Twelfth Development Plan emphasized the main objective as "Creating smart, safe, sustainable cities and settlements that are resilient to climate change and disasters, have qualified settlement areas compatible with historical and cultural heritage, provide accessible urban services for everyone, have high quality of life, and are based on green and digital

technologies" (Presidency of the Republic of Turkey, Strategy and Budget, 2024, p.206). The urban transformation projects aimed to create settlement areas that are suitable for the needs of the social structure and sustainable urbanization characteristics and are resilient to disasters. It was also stated that the information system infrastructure that will enable the relevant stakeholders to monitor project data related to urban transformation applications on a national scale will be developed (Presidency of the Republic of Turkey, Strategy and Budget, 2024, p.205-206).

In Turkey, urban transformation projects have come to the fore as one of the tools to create disaster-resistant settlement areas, especially with the effects of the Marmara and Düzce Earthquakes (Kuyucu & Ünsal, 2010; Penpecioglu, 2013; Genç, 2014). The importance of disaster-resistant cities has been revealed once again with the Kahramanmaraş Central Earthquakes of February 6, 2023. As emphasized in the Twelfth Development Plan, in the reports prepared at the national level, urban transformation applications in our country are seen as an important tool for both disaster-resistant cities and sustainable urbanization.

However, under the influence of neoliberal policies, urban policies have been adopted since the 2000s to make Istanbul a "global city". Accordingly, when the urban transformation practices and relevant legislation are examined, it is seen that the common point of urban transformation projects is that they are disconnected from planning, do not take into account the social, economic and environmental dimensions of the city, and only include fragmented physical arrangements (Balaban, 2012; Karaman, 2013; Penpecioglu, 2013; Şen & Öktem Ünsal, 2014; Sakızlıoğlu, 2014; Kuyucu, 2018; Topala et al., 2019; Tarakçı & Türk, 2020). Rising land prices in rapidly growing cities, the demand for new functions and high-density construction for industrial areas that have lost their functions or have been moved out of the city, and the emergence of more dense construction demands for residential settlements built with or without a permit have accelerated urban transformation practices (Kocabaş, 2005). Especially with the Law No. 6306 on the Transformation of Areas at Disaster Risk, which entered into force in 2012, urban transformation has become an important policy that directs urban development. In particular, many large-scale, mixed-use, prestige projects based on redevelopment are being carried out by the private sector in Istanbul, and industrial areas are the ones most subject to transformation within the scope of the law due to their large plots of land (Tarakçı & Olcay, 2022). The socio-spatial structure and functional-sectoral dynamics of urban areas are also changing with these projects (Özcan, 2016).

It is clear that urban transformation practices carried out with this approach cannot be a solution to the expectation of sustainable development. Urban transformation practices in our country have the potential to be a tool for the creation of sustainable settlement areas. However, importance should be given to urban transformation practices being utilized within a balanced and holistic system structure that gives equal importance to the three components of sustainability. Decisions taken at the national level and the principles and policies developed in line with these decisions will play a critical role in solving the problems encountered. However, in order to ensure the effectiveness of these policies and principles, they must be measurable, therefore controllable and evaluable. Despite this, concrete indicators for measuring the performance of urban transformation policies and principles have not yet been defined, and a comprehensive study has not been initiated in this area (Ulubaş Hamurcu & Aysan Buldurur, 2017). It is seen that the Sustainable Development goals, targets and indicators put forward by the UN, adopted by institutions in Turkey and included in official documents, provide an important framework and data set that can be used in sustainable urban transformation studies (Olcay & Tarakçı, 2021).

3. Methods and Materials

This study adopts a mixed-method approach, integrating both qualitative and quantitative data to assess the sustainability dimensions of urban transformation in Bağcılar. A comprehensive review of existing studies on sustainable urban transformation, sustainability indices, and the application of these frameworks in urban areas was conducted. The review also focused on the Sustainable Development Goals (SDGs) and their relevance to urban transformation in Istanbul.

Bağcılar was selected as a case study because, while manufacturing areas have been rapidly transformed into functions such as luxury housing, offices, and hotels in recent years, the manufacturing sector still continues to exist.

The transformation of manufacturing areas such as Bağcılar, where manufacturing activities continue, within the framework of the sustainability principle, is important in terms of the correct use of the city's resources. Therefore, between August 1, 2022, and August 1, 2024, we conducted a research project titled “Sustainable Development and Transformation Model of Manufacturing Industry Zones in Cities: The Case of Bağcılar District, Istanbul.” Within the scope of this project, we aimed to examine the transformation of manufacturing areas into functions such as luxury residential, office, and hotel functions in Mahmutbey, 15 Temmuz, and Bağlar neighborhoods, which cover an area of approximately 662 hectares and are located in the Basın Ekspres Axis, where manufacturing has developed and transformed intensively in the district, within the scope of sustainability (Figure 2). This article evaluates the preparation process of the index created using sustainability indicators.

A detailed literature review was conducted to determine the sustainability index indicators. After this research, the sustainability indicators of the UN were selected. Then, the Delphi method was employed to localize and refine the sustainability indicators, and the indicators were weighted with the Analytical Hierarchy Process (AHP). The indicators were weighted by experts consisting of urban planners, academics, sector representatives and NGO representatives through structured forms. In addition, in-depth interviews were conducted with the Istanbul Chamber of Industry (ISO), the Istanbul Chamber of Commerce (ITO) and various companies in order to understand the quality and quantity of the companies in the region. In-depth analyses of the current situation were conducted to prepare the sustainability index. Then, data on the indicators were collected. For this purpose, first of all, face-to-face interviews were conducted with various public institutions and organizations such as the municipality, the Provincial Directorate of Environment and Urbanization, ISO, ITO, TUİK, and data related to the research topic were collected. Data that could not be obtained through these interviews were obtained by conducting surveys with structured forms with the companies in the region.

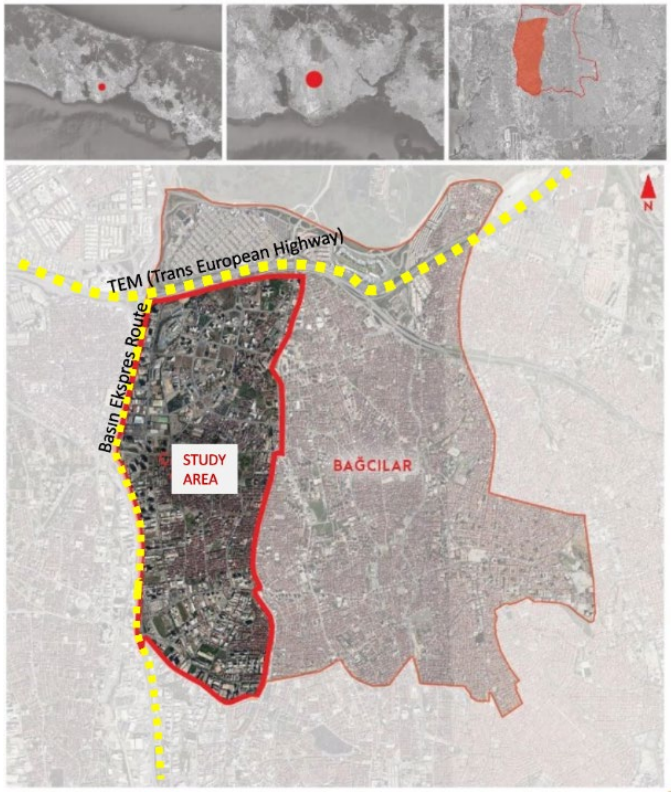

Figure 2 Location of Bagcılar district and the study area

4. Results and Findings

4.1. Transformation of Industrial Areas and Sustainability in Bagcılar

While Bağcılar district had been a village with vineyards and gardens until the 1950s, it started to become a shanty town in the 1960s and entered a rapid urbanization process (Bağcılar Municipality, 2008). The development of the region, which initially consisted of low-density villages, accelerated from the 1970s onwards. In the 1980s, the opening of the Bosporus Bridge connecting the Asian and European continents, the opening of the TEM and E-5 Highways and the Basın Ekspres Axis connecting these roads, and the provision of important transportation opportunities, led to the settlement of industrial companies in the region. After the 1980s, parallel to the opening of the economy to the outside world and the development of export-oriented industry in Turkey, industrialization accelerated in Bağcılar and production for export began. With the increase in production and job opportunities in the region, Bağcılar district became one of the regions that received the largest share of the rural-urban migration in Turkey in the 1980s. While the population of Bağcılar was 9,688 in the 1970 census, there was an extraordinary increase of approximately 5500 percent between 1970 and 2000. This high population growth has continued to the present day, and Bağcılar has become one of the most densely populated districts of Istanbul (Olcay & Tarakçı, Sustainability Index as a Tool in the Transformation of Manufacturing Areas, 2021). Today, Bağcılar district, one of the most important trade and industrial centers of Istanbul, contains small and large workshops, commercial establishments, factories and trade centers. In Bağcılar, which hosts a significant portion of the weaving, textile and clothing industry enterprises and employment in Istanbul, especially Bağlar, 15 Temmuz, Mahmutbey and Güneşli neighborhoods stand out (Olcay & Tarakçı, Sustainability Index as a Tool in the Transformation of Manufacturing Areas, 2021). As a result of the rapid migration experienced in the region along with rapidly increasing industrialization, shanty settlements have also increased.

In the 2000s, Bağcılar became a region faced with environmental pollution, and population and building density problems brought by industry. On the other hand, the neoliberal policies that the state followed in parallel with the globalization processes in the world and supported the real estate sector were reflected in the region. Accordingly, industry began to be decentralized from parts of Bağcılar with planed decisions. The existing industrial areas in Mahmutbey, 15 Temmuz and Bağlar Neighborhoods located in the west of the district were determined as Prestige Service Areas and Central Business Districts. Prestige service areas were planned as areas where international companies and media management functions, accommodation facilities, residence housing structures, business centers, offices, bureaus, shopping malls, etc. would be located (Bağcılar Municipality, 2008). Central Business Districts were planned to be divided into two and a part of them was planned to continue production in smoke-free, waste-free industrial areas that did not pollute the environment. In this way, the plans in question enable both the continuity of industrial areas in the region and their transformation into the real estate sector. Instead of providing a vision for the region, the plans allowed development to be left to market conditions and paved the way for investors to make the most profitable investment. The large plots of industrial areas attracted the attention of the real estate sector and were transformed into prestige service areas, residence housing structures, business centers, offices, bureaus and shopping centers (Sarp et al., 2019; Olcay & Nurtekin , 2020). Prestige structures are being built in place of industrial areas, especially in the Basın Ekspres Axis (Sarp et al., 2019). The increase in land values after 2010 and the attraction of large industrial parcels by investors increased transformative pressure on the axis (Olcay & Tarakçı, 2021; Tarakçı & Olcay, 2022). However, in this process, the effects of the economic, environmental and social transformation of the region on the city were ignored. This situation clearly shows that the demands of investors are prioritized in the transformation process and the factors that are critical for sustainable development are neglected. However, the development and transformation of manufacturing areas such as Bağcılar, where production activities continue within the framework of the sustainability principle, is extremely important in terms of the correct use of the city's resources. Therefore, it is important to create a sustainability index based on economic,

environmental and social indicators to examine this functional change in the region within the framework of sustainability principles. In this context, three neighborhoods (Mahmutbey, 15 Temmuz and Bağlar Neighborhoods) covering an area of approximately 662 hectares parallel to the Basın Ekspres Axis in Bağcılar district, where both manufacturing continues and urban transformation is intense, were determined as the study area.

4.2. Selection of Indicators and Data Collection Framework for Sustainability Analysis

In this study, firstly, field work was conducted between October and December 2022 and function analyses were conducted to reveal the spatial distribution of different sectors in the region. Then, data on industrial companies operating in the region were obtained from the Istanbul Chamber of Industry, and plans and company information on areas transformed into real estate sectors such as offices, luxury housing, hotels, and residences in the manufacturing sector were obtained from the Bağcılar Municipality. In order to examine the dynamics of the development of manufacturing in the region and its transformation into a service sector, face-to-face interviews were conducted with companies using semi-structured forms between January and June 2023. The companies to be interviewed were determined within a sample framework created by considering sub-sectors and workforce size. Interview questions were asked about the qualifications of the companies, location selection, reasons for coming to and staying in the region. Similarly, company qualifications, location selection, and function selection issues were examined in the interviews with real estate companies. Based on these field analyses and in-depth interviews, a SWOT analysis was conducted to reveal the strengths and weaknesses of the region, thus comprehensively analyzing the development and transformation dynamics of the region.

In order to understand the extent to which the development of a region is sustainable, it is important to prepare an index that consists of a wide range of variables and brings together performances in different dimensions (Dizdaroğlu, 2017; Klopp & Petretta, 2017; Ayık et al., 2021). In order to examine the sustainability of the region in terms of industrial and real estate sectors, it was first established which indicators would be used to make these evaluations. Since the importance of determining the indicators is frequently emphasized in the literature (Hemphill et al., 2004; Williams & Dair, 2007; Hiremath et al., 2013; Huang et al., 2015; Zheng et al., 2016; Dizdaroğlu, 2017; Verma & Raghubanshi, 2018; Cappai et al., 2019; Ayık et al., 2021; Gavaldà et al., 2023), this process was considered as one of the main stages of the study. In general, the development and selection of indicators is a long and complex process. In the literature, it is emphasized that local , economic, social and environmental characteristics of the city are important in determining the indicators, and that indicators suitable for the intended purpose should be determined (Hemphill et al., 2004; Zheng et al., 2016). One of the organizations that has conducted the most comprehensive studies on sustainable development is the United Nations (UN). The SDGs and indicators prepared by the UN, accepted universally, referred to in Turkey's national documents and whose data are collected by TUİK, provide the most up-to-date and comprehensive indicator set. It is seen that the indicators adopted by institutions in Turkey and included in official documents provide an important framework and data set that can be used in sustainable urban transformation studies.

In the study, SDGs 7-8-9-11-12-13 were selected from 17 SDGs, and the indicators that were appropriate for the study scale and subject were selected.

- Goal 7 - Ensure access to affordable, reliable, sustainable and modern energy for all.
- Goal 8 - Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.
- Goal 9 - Build resilient infrastructures, support inclusive and sustainable industrialization, and strengthen innovation.
- Goal 11- Make cities and settlements inclusive, safe, resilient and sustainable.
- Goal 12- Ensuring sustainable consumption and production patterns.

- Goal 13- Take urgent measures to combat climate change and its effects.

There are a total of 61 goals and 82 indicators under these objectives. However, since this study aims to create a sustainability index for the evaluation of the transformation and development of manufacturing areas, 17 goals and 23 indicators were used. These 23 indicators were localized according to the characteristics of the study area and the boundaries of the study. In this localization process, an evaluation was made by taking into account the data obtained from the field study. As frequently emphasized in the literature, the necessity of localizing the indicators stood out as one of the most important steps of this stage, considering that the study was carried out at the neighborhood scale. In the process of making the indicators local-specific, the opinions of various experts (academics, industrialists, investors, municipal representatives and professional chambers) were consulted using the Delphi Technique. In addition, another important issue emphasized in the literature, the weighting of the indicators, was carried out by the relevant experts. In this context, 17 different experts, including urban planners working in the private sector, universities and local governments, experts in various non-governmental organizations and experts in the manufacturing sector, participated in the evaluation process to represent different stakeholders. In this process, the Analytical Hierarchy Process (AHP) method was used. AHP is one of the multi-criteria decision-making methods. With AHP, decision makers have the opportunity to model complex problems in a hierarchical structure that shows the relationship between the main goal of the problem, criteria, sub-criteria and alternatives (Samut, 2014).

After the economic, environmental and social indicators were decided and weighted, the necessary data for the indicators were requested from the relevant institutions in order to calculate the index. However, significant difficulties were experienced in this process. Although there was data for each indicator at the national level due to the fact that TÜİK shares its data with the UN and calculates the provincial level data using the sampling method, it was not possible to obtain this data at the Bağcılar district or neighborhood level, although there was data at the Turkey scale. The district level data was collected in a scattered manner in various institutions, and various interviews were held in advance to determine which data should be obtained from which institution or organization. The fact that the data is located in various units of different institutions makes this process even more difficult. For example: (a) Municipality Environment Directorate and Technical Affairs Directorate for solid waste amount, (b) İSKİ for wastewater drainage, (c) Istanbul Chamber of Industry and Istanbul Chamber of Commerce for company information, (d) Provincial Directorate of the Ministry of Environment, Urbanization and Climate Change for recycled waste (e) Social Security Institution for employee numbers (f) Different unions for employee rights (g) Information should be obtained directly from companies for economic data and production capacities. However, since many data are raw, unprocessed or scattered, it was decided to obtain data from companies through surveys.

4.3. Findings and Challenges in Creating the Sustainability Index for Bagcılar

There are approximately 1000 industrial companies in a total of 426 parcels in the study area, and 16 parcels have been converted from industrial areas to offices, luxury housing, residences and hotels (Figure 3). Within the framework of the sample created according to manufacturing sub-sectors and workforce sizes, surveys were conducted with companies of various sizes and from different sectors, and data on the indicators were obtained. The confidence interval of the survey in question is 95% and the margin of error is 10%. In this context, approximately 400 companies in the region were contacted with responses from 94 companies, and the experiences gained in this process revealed how the concept of sustainability is perceived in Turkey. To calculate the sustainability index of the region, data were collected under three main categories: economic, environmental, and social indicators. These data were categorized in alignment with the respective indicators. Economic data were gathered through questions regarding firms' export activities, employee qualifications, production capacities, revenues, and R&D activities. Environmental data were collected by asking questions about sustainable production methods, energy consumption,

and waste generation. Social data included information on employees' vocational and technical education, gender distribution, unionization rates, and workplace accidents.

In addition, questions related to the location preferences of the manufacturing and service sectors and their expectations from urban transformation were asked to analyze the dynamics of the region's development and transformation. While questions concerning employees' educational status and wages were answered with ease, responses to questions on workplace accidents and unionization were not obtained. Firms were found to have relatively accurate information about their production capacities and revenues; however, it was observed that environmental data were not systematically recorded. The collected data were raw and scattered, and the data maintained by local and central governments on these issues were also determined to be in a raw format, lacking the quality required for detailed analysis. The absence or fragmentation of data indicates a lack of necessary attention and sensitivity toward sustainability. Only companies that export and are obliged to prepare sustainability reports are quite open to this concept and have contributed to the urban sustainability index study by sharing their data. 68% of the companies interviewed export and 11% have sustainability reports. Since these companies also use sustainability data in their own reports, they have collected their data regularly and systematically. On the other hand, non-exporting companies were more reserved about the concept of sustainability and initially responded negatively to interviews on this issue. Since the companies that accepted the interview did not have sufficient information on sustainability, it took time for them to compile their data and answer the questions.

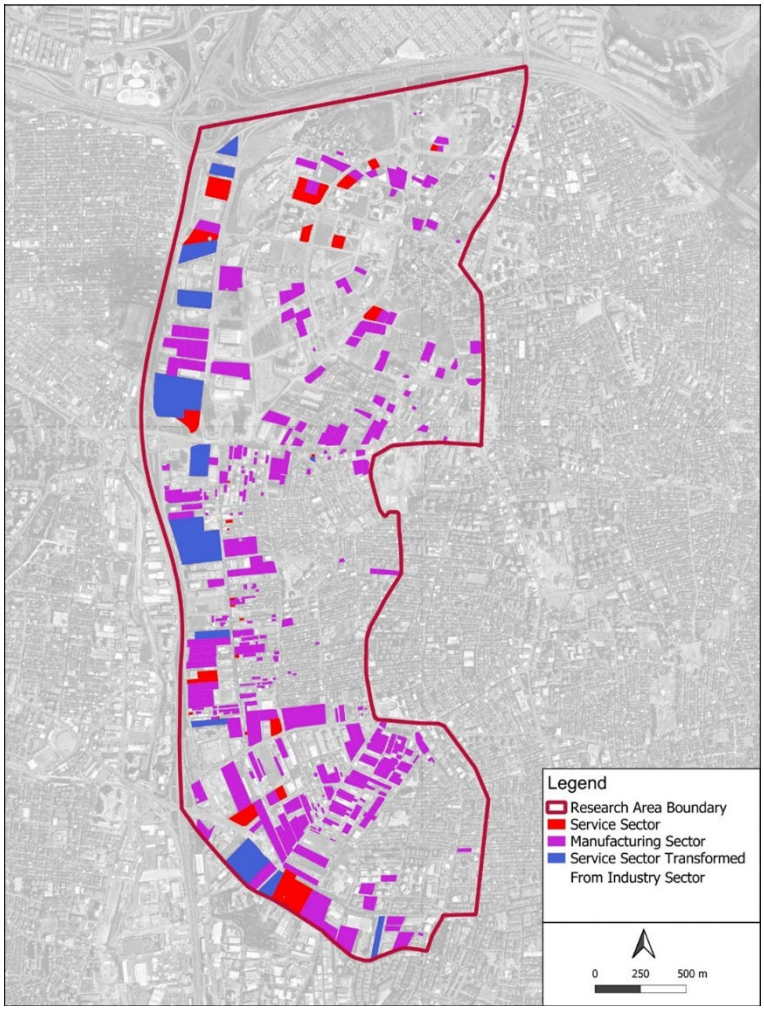

Figure 3 Analysis of manufacturing and service sector in the study area (Source: Field study)

In the interviews conducted with real estate companies, it was determined that the understanding of sustainability was limited. The approaches of these companies to sustainability

were generally limited to revising the total construction areas in order to fulfill requirements such as the use of grey water in green areas or green roofs arising from the Istanbul Zoning Regulation. These findings show that the real estate sector has not yet adopted the concept of sustainability comprehensively and that more comprehensive strategies are needed.

This entire process has revealed that the Sustainable Development Goals (SDGs) have not yet been sufficiently internalized by both public institutions and the private sector. SDGs are generally addressed at the national level, which prevents the implementation of the goals at the local level. However, as is frequently emphasized in the literature, priority should be given to local level implementations in order for SDGs to be truly implemented. The lack of decision-making processes centered on economic, social and environmental indicators, themselves based on sustainable development in the development and transformation of cities, creates a major gap in the current situation.

The importance of this issue needs to be understood and adopted, especially and primarily by local governments. Although some municipalities have published Voluntary Local Assessment (VLR) reports, this number is quite insufficient. According to the report published by the Marmara Municipalities Union (MBB), only 1% of the municipalities in the Marmara region have published a VLR report and approximately 2% have published a Sustainability Report (Marmara Municipalities Union, 2022). This situation shows that there is a significant deficiency in the internalization of the sustainability issue at the local level and the adoption of the SDGs.

The transformation of cities is a multidimensional and public issue that cannot be left to the decisions of investors alone. While the climate crisis is on the agenda all over the world and many countries are seeking solutions to it, it is of vital importance for critical issues such as urban transformation to be planned in a metropolitan city like Istanbul on the axis of sustainability. Although the focus has been on the rapid demolition and reconstruction of housing due to earthquake risk, this process covers not only housing but also rapidly transforming industrial areas in terms of both implementation and legislation. For this reason, comprehensive policies regarding urban transformation need to be developed. Therefore, this situation is of great importance for the economic, environmental and social future of cities.

In this context, the development of sustainable urban transformation policies is a multidimensional process that requires local governments and all relevant stakeholders to act in cooperation. Addressing sustainability not only as an environmental concept, but also in its economic and social dimensions, will play a critical role in achieving cities' long-term development goals. Therefore, the effective implementation of sustainability principles in urban transformation is a strategic necessity not only for Istanbul but for all cities in Turkey.

5. Conclusion

It is not feasible to evaluate multidimensional concepts like sustainability using a single variable or within a single dimension. To assess the sustainability of a region’s development effectively, it is essential to construct an index that integrates a broad spectrum of variables, reflecting performance across multiple dimensions. One of the most comprehensive frameworks for sustainable development has been established by the United Nations (UN) through the Sustainable Development Goals (SDGs). These goals serve as roadmaps for countries worldwide, guiding them toward achieving sustainability targets. Central to this process is the systematic collection, reporting, and analysis of data. The SDG indicators, goals, and targets offer a robust framework and data set that can significantly inform sustainable urban transformation efforts.

Turkey has adopted the SDGs and regularly publishes related data at the national level through institutions such as TÜİK, while also creating national coordination mechanisms, such as the National Sustainable Development Coordination Board. However, while sustainable development is addressed comprehensively at the national level, there is a significant lack of research and implementation at local levels. Collecting and analyzing data at the provincial, district, or

neighborhood level remains a significant challenge, impeding the formulation of strategic, evidence-based policies.

Urban transformation, particularly in metropolitan cities like Istanbul, is a critical public issue that extends beyond the decisions of private investors. As the climate crisis becomes an increasingly pressing global emergency, cities worldwide are devising strategies to mitigate its impacts. In this context, planning urban transformation projects with sustainability principles is not merely desirable but imperative. In Istanbul, strategic decisions such as relocating industrial zones or converting them into residential areas have profound implications for sustainability. However, the absence of comprehensive, accurate, and accessible data hampers the ability to assess the impacts of such transformations.

The findings of this study highlight key challenges in sustainability awareness across sectors. While large export-oriented manufacturing firms demonstrate relatively higher levels of sustainability awareness, this awareness is markedly lower in service-oriented sectors, such as residential, hotel, and office developments. This discrepancy complicates efforts to analyze regions using economic, environmental, and social indicators and obstructs the development of strategic policies for urban transformation. In a period marked by global crises, such as climate change, the lack of critical information regarding the adequacy of cities' economic and environmental resources is a serious concern. Furthermore, the inability to evaluate the social structure exacerbates these challenges.

Addressing these issues requires urgent policy interventions at the legislative and implementation levels. Developing comprehensive and accessible data collection systems at the local level is a fundamental step. Such systems should facilitate effective data sharing and ensure that sustainability indicators are measurable and traceable at the local scale. This approach will enable more informed, strategic decision-making for the future of cities.

This study underscores the vital importance of sustainable urban transformation practices, with a particular focus on industrial zones. The findings emphasize the necessity of localized sustainability indices, robust data collection systems, and stakeholder collaboration. Future research should prioritize developing standardized frameworks for sustainability assessments at the local level, ensuring alignment with broader sustainability goals and facilitating effective urban transformation.

Planning urban transformation projects in line with sustainability principles is a strategic necessity for Istanbul and similar metropolitan cities. This approach will support the creation of economically, environmentally, and socially resilient cities capable of achieving their long-term development objectives. Establishing systems that ensure the collection of regular, reliable, and internationally standardized data will enable the formulation of measurable, reportable, and comparable sustainability targets. Such advancements will not only enhance cities' adaptability to global challenges but also pave the way for a more sustainable urban future.

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Resume

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From commerce to art: Transformation of intervention through the interactions of virtual and urban space in Karaköy

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Abstract

Having been subject to various spatial interferences amid rapid urbanization, Karaköy is one of Istanbul's central neighbourhoods whose identity has significantly transformed in the last years. This paper focuses on Karaköy's streets which were once the centre of trade, have now been replaced by artistic collective constructs. The study aims to document this transformation, considering various physical and social aspects of urban space, while highlighting a new form of "urban intervention" through virtual spaces. It questions how virtual environments can be considered as a mode of intervention in urban space and delves into the transitions from ordinary commerce places to artistic urban spaces. Validating user-space interaction, the technological interference of social networks with physical space creates virtual centres of attraction, improving the popularity of places. The field research focuses on the environs of Tersane Avenue, Mumhane Avenue and Ali Paşa Değirmeni Street in Karaköy, attending to spaces where commerce once took place –now replaced by artistic collective constructs and articulations. Captured virtual-spatial interventions are operationalized in three stages: First, functional transformations are analysed at the street-scale. This is followed by analyzing images and quantitative data extracted from social network databases. Finally, the up-to-date spatial analyses are constructed, and the intersections of virtual and urban spaces are evaluated. Findings show that the user experience and pleasure-based design elements bear the interaction between virtual and urban space, additionally, the virtual-spatial intervention encompasses the transformation of urban space beyond conventional practices aimed at structural and functional change.

Keywords: Karaköy, social network, transformation, urban intervention, virtual space

1. Introduction

In 2009, global smartphone shipments stood at 173.5 million, surging to 1.17 billion in 2023, as per Statista (2023a) Turkey witnessed a significant uptick in smartphone and location-aware app usage starting in 2010. Statista's data (2023b) indicates that the user base for social media has surpassed 4.7 billion and is on the upswing as the proliferation of social networking apps continues. Following to this trend social media applications allow users to widely share – in addition to their thoughts, activities, and photos – the locations they frequent with the 'check-in' feature (Li & Chen, 2009). Place notifications prevalently contribute to people's knowledge and experience about new places with immediate effect, removing the need to displace. Social networks thus play a role in certain places becoming more popular and attractive. Rapid developments in information technology induce conceptual changes regarding time and space. Public spaces where individuals physically come together and spend time are digitally reconfigured through social networks, becoming intangible and invisible entities in cyberspace. Here, the discussion about the ways social media is related to the design of the space comes into prominence (Abdel-Aziz et al., 2016). The seizure of physical space by digital networks blurs the boundaries between the real and the virtual space (Thompson, 2008). In social media networks, virtual spaces denote visual icons of physical

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space (Kellerman, 2016). However, such representations are made of perspectives emanating from imaginary worlds possessing fantastic objects (Appadurai, 1996). These social and collective spaces are illusionary, in that they provide mentally consumable images appealing to individuals' perception. Introduced by social networks such as Facebook, Twitter, Instagram, Tik-Tok, and Swarm, these virtual spaces easily enable accessible communication and faster organization, thanks to their collective action structure: Engendering a sense of familiarity among users (Humphreys, 2010), this structure is conducive to quickly breed confidence in the information that is circulated.

Individuals' relationship with place entails a sense of attachment (Waxman, 2006). Nowadays, the sense of place attachment implicates visual and perceptual priorities. The curiosity and sense of ownership in the virtual environment reconfigure visual perception that plays a crucial role in enlarging the user base. Drucker and Gumpert (2012) state that virtual networks generate a source of interaction dissociated from space. As "[m]odern life is lived in the interstice between physical and media space", they designate this interstice as an intervention between the physical and the virtual. Meanwhile, in addressing the relationship between human and environment, Rapoport (2016) emphasises the ways the semantic dimension of image, which concerns cognition and perception, shape individuals' understanding and behaviour in relation to their environment. The spaces where the physical and digital worlds converge and boundaries blur are called 'hybrid spaces.' These are where mobility and social practices intersect. Users who access the virtual environment with their mobile devices are open to new experiences and can be seen as nomadic figures, constantly moving and creating their own paths of experience De Souza e Silva (2006).

Recent research shows that image-based social media like Instagram influences urban experiences and perceptions. Its design impacts user interactions (Hochman & Manovich, 2013), while user-generated geo-tagged content provides valuable insights for urban planning (Ciuccarelli et al., 2014). Additionally, Instagram builds community connections and changes how urban spaces are explored (Gatti & Procentese, 2021), emphasising social media's role in urban perception. This study foregrounds the transformation of urban intervention forms and actors in the process, depending on the structural and functional articulation of the intervention. The research's hypothesis states that visibility and 'me media' posts constitute the most significant actors of this transformation. Me-media is a noun in the Collins English Dictionary (2024), defined as online services where users can publish their own content, such as blog posts, photos, personal profiles, etc. Additionally, it is to prompt a specific user to participate or to invite their engagement in a conversation. In determining the effects of social networks on spatial transformation, the observation of virtual spaces – which is created by social networks as recent instruments of spatial intervention in Karaköy – and their projections in the field becomes valuable. Although conventional urban interventions such as renewal, rehabilitation, protection, revitalisation, arrangement, cleaning, development, and renewal by filling in the gaps are still widely used, the last decade has proven that the virtual environment has also had an impact on urban spaces as a new form of public space. Gathering, sharing and being visible in a virtual environment through an urban environment has been a mutual effect Van Dijck and Poell (2015). Posting, hashtags, geotagging and creating a me-world on social media triggered and created multi-functional, out of common and attractive urban spaces as a new mode of urban intervention.

Today, smart cities are increasingly characterised by widespread computing and data-driven governance (Kitchin, 2014). Batty (2020) notes that real-time data and smart technologies are reshaping urban functions like transportation and utilities, improving the management of urban systems. However, Kitchin (2014) points out concerns about big data and smart urbanism, including privacy risks and technocratic governance. Schechtner (2017) emphasises the challenges in implementing smart city technologies and the need to bridge the gap between municipalities and tech developers.

The influence of information and communication technologies (ICTs) on urban environments manifests in nuanced changes in spatial, temporal, and material processes, rather than a binary distinction between virtual and physical spaces Crang et al. (2007). However, these emerging

technologies present opportunities for enhanced citizen participation in urban planning by means of participatory and visualization tools. Virtual platforms like Second Life can function as experimental arenas for assessing urban designs and constructing narratives Foth et al. (2009). The paper aims to document the transformation from being the centre of trade and financial circulation to artistic collective constructs, considering various physical and social aspects of urban space, while highlighting a new form of "urban intervention" through virtual spaces. Therefore, this study questions how virtual environments can be considered as a mode of intervention in urban space and continuously delves into the transitions from ordinary commerce places to artistic urban spaces that mainly serve social media through time. The main concern of this study is about the multi-functional, dynamic, and varying fabric of the area, which hinges on various forms of interventions at different scales including redevelopment, reconstruction and parcel-based renewal aiming for functional change. Thereupon it focuses on the transformation of urban intervention forms in Karaköy refers to the ability of current urban intervention forms in escaping physical and circumferential limitations. As having preserved its original multi-layered structure, Karaköy, as the study area, is continuously subject to rapid structural and functional transformations. In this virtual-spatial context characterised with people and information flows directed by social communication networks, this study demonstrates the emergence of a new image of 'Karaköy' arranged by cognitive and cultural signs.

The methodology indicates location-based social media applications as the last actors of these interventions and analyses data gathered from the field research conducted in Karaköy documenting land-use change as well as data from virtual spaces created by social media networks.

With reference to the variables and invisible actors pertaining to the transformation, it discusses not only on the physical dimension of the intervention, but also on its perceptivity in the virtual environment. In examining the transition from commerce to art in Karaköy, the study also examines urban layers, physical urban interventions and the change in the functional and social structure belonging to different periods. The interventions in the Karaköy are analysed along two different axes, namely Tersane Avenue and Mumhane Avenue, where commercial and artistic functions are concentrated parallel to the coast. The findings highlighted that Karaköy was launched and developed as a regular commercial place throughout history and faced several urban interventions. However, social media has become a considerably effective urban intervention mode to transform from commerce to art. Priorly dilapidated and occupied informally by inedible industry, a part of the field has been transformed into a local coffee area solely by the power of shared virtual posts.

2. Methodology

The transformation of urban intervention in Karaköy is observed under three headings: functional analyses of the transformation from commerce to art, the density analyses of the multi-functional articulation led by social media, and spatial analyses. Firstly, all the interventions that took place in the history of Karaköy are analysed on maps and then compared to the neighbourhood's form in 2018. Historical land use data from old maps were meticulously compared with current conditions using a detailed comparative analysis. This comparison elucidates the functional transformations that the Karaköy area has undergone from the past to the present.

Next, virtual interventions are identified in connection with place notifications in 2018 on social media. For the social media analysis, we began by focusing on the Instagram, the most widely used platform for photo sharing and social interaction. We scanned the hashtags of all the locations in the Karaköy area specified in Table 2 and Table 3, and examined the number of posts associated with each location. Additionally, we delved into the number of shares for the same locations on Foursquare and Swarm applications, which allow users to comment, rate, and check in to indicate their presence at a particular location. The chosen venues are all located within the confines of the study area. These venues were analyzed based on the sequence of their check-ins and the use of hashtags. Based on the data obtained by examining the opening years of the venues, it is evident that all venues were established after 2011, following the declaration of Istanbul as the capital of

cultural heritage in 2010. Therefore, the analysis commences from 2011, with a focus on comparing the years 2018 and 2023.

Finally, the third section describes the ways virtual interventions intersect with spatial interventions based on the reflections from the field research conducted in 2023. Table 1 documents the process whereby data are collected and analysed concerning the transformation of urban interventions in Karaköy, including the examination of old maps and the relevant literature. The intervention forms are then evaluated based respectively on physical, functional, and social transformations. The study makes use of G. D'Ostoya map (1858), Marie de Launay map (1864), Huber maps (1887), Charles E. Goad (1905) insurance maps, Suat Nirven (1948) maps to trace physical urban interactions in Karaköy from the 19th and 20th century. The field research involves on site mapping relating to the functional and physical structure in addition to the determination and analyses of various quantitative data with regards to the use of space transitioning from commerce to art Páez and Scott (2004). Virtual interventions pertaining to places entail the virtual and spatial interactions numerically computed based on place notifications in most-frequently used applications. Taking the form of common prompts such as 'I am/was here', place notifications denote not only an 'urban' engagement of individuals with space but also a 'virtual' one Quesnot and Roche (2015).

Table 1 Methodology and Data of the Research (Source: Authors, 2024)

Period of Analysis	Used Methodology	Used Data	Source of Data
Urban Interventions in 2018	Function-analysis (De Groot, 2006).	G. D'Ostoya (1858)	Map Collections, Atatürk Library, 2023
		Launay map (1864)	Map Collections, Atatürk Library, 2023
		Huber map (1887)	Map Collections, Atatürk Library, 2023
		Charles E. Goad (1905)	Salt Research, 2023
	On-site analysis by the authors	Map of Karaköy (2018)	Open Street Map, 2018
Density Analyses of Virtual Interventions in 2018	Social Media Analysis Martí et al. (2019).	SWARM	Authors applications and account
		Instagram	
		Foursquare	
	Digital Ethnography (Murthy, 2008; Prior & Miller, 2012).	Numbers of Cafés/Art spaces & years they opened.	Conducted by the Authors
Virtual & Spatial Interventions in 2023 through Spatial Analyses	Function-analysis (De Groot, 2006).	Site Analysis	
	On-site analysis by the authors	Photography	

The current spatial analysis focuses on the relationship between virtual and spatial interventions and the visual and design outputs of urban spaces in the context of the virtualization of space through spatial field research conducted by the authors. The first phase of the research includes the identification of structural and functional changes that characterise urban interventions on base maps from 2018. While functions involve cafes, hotels as well as institutions of art, worship and trade, ruined buildings are also found in the field. The base maps are then compared with the historic maps to show how the functions have transformed in the long term as a result of the interventions. By producing function diagrams of current uses in the digital platform and comparing them with historical maps, it is possible to compare the functional changes in the survey area based on the dates of the maps.

Once the functional changes have been identified on maps, the second phase overlaps the quantitative inputs from digital platforms with the social interaction spaces. For this step, the digital ethnography method is used which is a research method that uses digital technologies to study

human behaviour and culture in online and digital spaces. Digital ethnography is a qualitative research method that applies traditional ethnographic approaches to investigate online cultures and communities Borkovich (2022). It allows researchers to portray real-life cultures through digital storytelling, providing immersive experiences of other cultures Underberg and Zorn (2013). Digital ethnography includes various styles, such as social media ethnography, contextual digital ethnography, meta-digital ethnography, and cross-media ethnography, depending on the type of data collected and fieldwork conducted Paoli and D'Auria (2021). Researchers utilize mobile, multi-sited, or "un-sited" research methods, crossing spatial and temporal boundaries online to study diverse social-cultural groups in synchronous and asynchronous settings Borkovich (2022). This method yields profound insights into understanding the "how and why" of online behaviours and their impact on opinions, habits, and worldviews.

Conducting an urban analysis using digital ethnography involves using digital tools to collect and analyse data about urban spaces and their inhabitants. It involves applying ethnographic methods to the study of digital cultures, which includes social media, online communities, virtual environments, and other forms of digital media (Murthy, 2008; Prior & Miller, 2012). This phase comprises the density analyses of multi-functional articulation in Karaköy based on data and information collected from Swarm; the most popular location-based application (over 10 billion place notifications in the last four years) released by Foursquare. The number of 'check-ins' for all cafes is calculated in direct proportion to the years in which these stores were launched. Through a digital ethnographic analysis, we can uncover the intricate interconnectedness of the virtual environment shaped by the community engaging with the Karaköy area. By scrutinizing hashtags and check-in data, we are able to discern how the area garners momentum in both the virtual and physical realms, with fluctuations in intensity over time. This approach also sheds light on the correlation between the inaugural years of physical spaces and the pace at which they establish a presence in the virtual environment.This analysis underscores the profound influence of social media on the metamorphosis of urban spaces. As individuals share their experiences online, they contribute to the evolving identity of a neighborhood, impacting both its popularity and physical development. The interplay between social media and urban space creates a feedback loop, where virtual representations drive physical changes, further stimulating online activity. This dynamic exemplifies how social media can expedite the transformation of urban areas, sometimes leading to rapid gentrification or reshaping the character of neighborhoods, as exemplified in Karaköy.

At the third stage of addressing the functional and spatial transformation of the Karaköy neighbourhood, several methods are employed in the field research, including photographing and site analysis (De Groot, 2006). This last stage of the research incorporates the study and assessment of visual materials as well as of spatial design originating from the most up-to-date virtual-spatial interventions of 2023, which displays a particular reflection of the digital environment on urban space.

3. Study Area

Known as Galata until the 1960s, the neighbourhood of Karaköy (Figure 1) refers to the port area within the Beyoğlu district of Istanbul (Türker, 2000). Following the Suriçi region, Galata had been considered as one of the city's central settlements, besides Eyüp and Üsküdar, until the 19th century (Banoğlu, 2007; Deleon, 2003; Freely & Freely, 2016). Given its trade port function established by the Genoese, the Galata region was protected against possible attacks thanks to the surrounding walls, the traces of which can still be seen today. The port area of Galata is located at the opposite of the historical peninsula that shores the Golden Horn. These two parts of the city have long harboured diverse structures and settlements (Akın, 1998), where Galata Tower, with its feudal appearance, constitutes the highest triangulation point.

Figure 1 The field research area (Source: Authors, 2023)

The streets that form the quay axis, in addition to those running perpendicular to the Karaköy Square and Galata Tower, are distinctive of this region sloping up to the north. Inhabited by people from various cultures and nations, especially from Europe, Galata exhibited a more cosmopolitan, modern, and dynamic image compared to Suriçi, Üsküdar and Eyüp in the Ottoman Era. Located at the intersection of the Ottoman and Western worlds, it was encompassed spaces pertaining to various lines of work, as practiced by sailors, traders, craftsmen, ship carpenters, caulkers, etc. (Çelebi, 1969; İnciciyan, 1977). While warehouses, small-scale depots and other commercial structures were located ashore, dwellings occupied the north and top parts of the region. Following the conquest of Constantinople in 1453 by the Ottomans, the trade rights, and the overall presence of the Genoese – who had contributed to instil a Mediterranean fabric in the area via the port and settlements – persisted for some period. As the Genoese started to retreat from the region, diverse populations came to settle here, marking a certain transformation. Today, Karaköy serves as a significant hub for both domestic and international passenger travel. Karaköy and the ancient peninsula are connected by the Galata Bridge, which also has a station for Karaköy and a tram line that runs between Baclar and Kabataş.

4. Results and Findings

4.1. The Analysis of Functional Transformation in Karaköy

The field research is composed of three interlinked stages: Firstly, based on the historical maps transformation and interventions of urban space and functions. Afterwards, in the physical analyses carried out in 2018, the transformation caused by urban interventions at the borders of Azapkapı and Kemankeş Karamustafa neighbourhood is observed in terms of the functional change at the level of buildings. Accordingly, the functional transformations at the Tersane Avenue and Mumhane Avenue – which are connected to Karaköy Square via axes parallel to the shore, extending along the east-west direction east-west direction – are analysed. To begin with historical analysis, building typologies and urban frontiers that had been constituted in relation to vital needs stand out in the seaport harbouring vernacular structure forms characteristic of the Middle Ages. This plan from the early 14th century demonstrates a grid design materialised by sets built at different elevations (Figure 2, a).

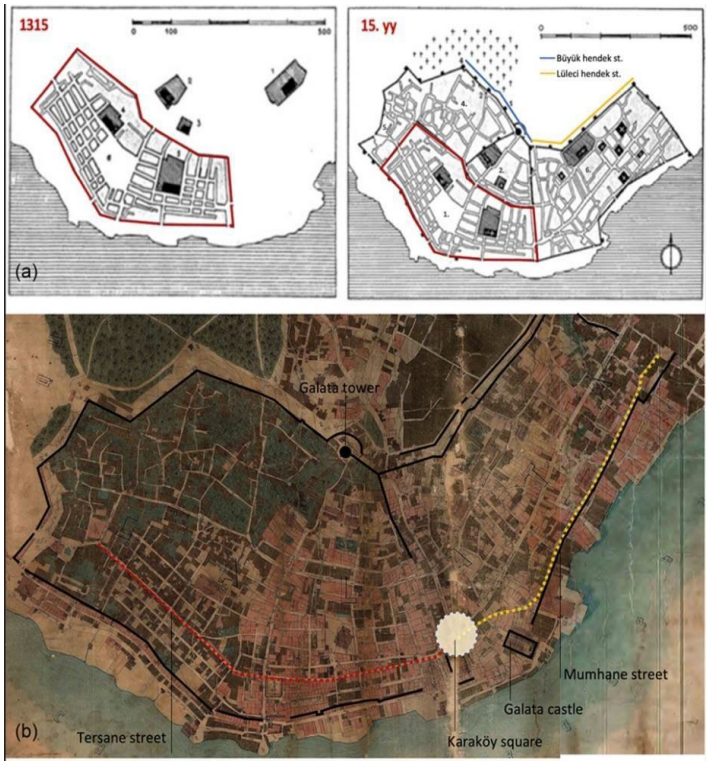

Figure 2 (a) Galata Tower and rampart borders in the Pera region of 14th and 15th century (Source: Sauvaget, 1934) (b) Tersane Avenue, Mumhane Avenue ve Karaköy Square in G. D'Ostoya map 1858 (Source: Atatürk Kitaplığı Harita Arşivi, 2023a)

During this period, the Genoese extended the borders of the Galata region along the ramparts and moats to the environs of Azapkapı-Şişhane-Galata Tower-Tophane (Akın, 1998). The urban design that arranges religious buildings and housing zones around the squares and within city walls can be still traced, as Büyük Hendek Avenue and Lüleci Hendek Avenue represent old axes once functioned as moats. Attached tower blocks as housing units that used to be located along these axes back then are now replaced by commercial arcades, small retailer shops (antique, pendant, electricity etc.), food and beverage shops (e.g., fast-food) and artistic coffee shops.

A large part of the Galata walls neglected since the 16th century was demolished in the 19th century (Hasluck, 1905). Following the foundation of Ebniye-i Hâssa Müdürlüğü (Directorship of Royal Buildings) in the 1830s, Karaköy was subject to a large-scale transformation in line with modernist efforts, where financial and commercial building stock grew. Contending that the entire commercial activity of Istanbul took place in here, Edmondo de Amicis (1878) writes that on both sides of the region existed narrow and mazy roads where taverns, merchant offices, workplaces and old houses were situated.

The urban interventions in the 19th century comprised intensive modernist transformations led by the 6th Municipal Circle. The physical changes related to these urban interventions of entail the extensive demolition of city walls, road width expansion, creation of new building blocks, the expansion of Karaköy Square and the renewal of Galata Bridge (Orçun Kafesçioğlu, 2016). G. D'Ostoya map, prepared between 1858-1860, shows that the port had yet to be built (Figure 2, b). This map illustrates Kemankeş Avenue and – although not yet existing – Mumhane Avenue, first street parallel to Bosporus. The latter is circumscribed from the south by Galata Tower and city walls (Küçük & Mazlum, 2017). Tersane and Mumhane Avenues that are situated within Galata walls and connected to Karaköy Square in the east and west directions, appear as the two main axes defining the area on D'Ostoya's map. The walls and castle of Galata are still read as an urban historical trace. Kemeraltı Street and the Galata Bridge as the arteries that increase pedestrian and vehicle accessibility to the services of the area did not exist yet on D'Ostoya map compared to Huber's late 19th-century map.

In this map and study on the city walls, Marie de Launey, engineer of the 6th Municipal Circle, heralds the transformation of the area with the demolition of the walls: the provision of the accessibility of vehicles, the removal of blind alleys, the preparation of driveway projects and the increase in the commercial activity between the port region in Galata and upper neighbourhoods. Within the framework of the renewal of Mumhane Avenue, the municipality had the sheds located on both sides of the road removed, enabling its expansion. In F. Huber Map (1887), the abundance of roads, squares and buildings point out to spaces cleared following the removal of the city walls and the reclamation of the reclamation the Karaköy Quay (Orçun Kafesçioğlu, 2016). While commercial buildings are organically situated along the wall line, in Mumhane Avenue, the settlements comprising commercial and housing units display a grid design (Figure 3, a).

Meanwhile, Goad's Map in figure 3 (b) (1905) indicates the region acquiring a new fabric with the quay construction. The land reclamation produced a straight shoreline and provided space for commercial buildings and customhouse. Defining Karaköy shoreline, Rıhtım Avenue, Kemankeş Avenue, Mumhane Avenue and Galata now called Necati Bey Avenue preserve their status of the main link shaft between Karaköy and Tophane region on the Suat Nirven Map (1948) (Figure 3, b). Besides the building blocks by the coast appearing as the first major change in the area, new building space is also indicated obtained by the land reclamation. The wards supplemented following the gradual obsoletion of Galata Tower's walls eloign Mumhane Avenue and the line of walls from the sea.

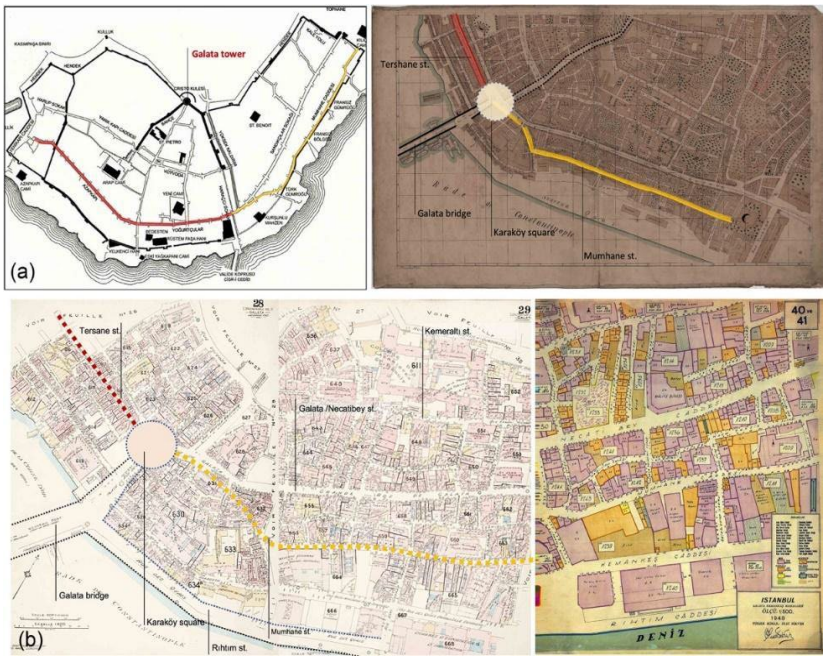

Figure 3 (a) The map of Galata walls (left) (Launay, 1864), F. Huber map, 1887 (right) (Source: Atatürk Kitaplığı Harita Arşivi, 2023b) and (b) C. E. Goad's insurance map, scaled 1/600, dated 1887 (left), S. Nirven map dated 1948 (right) (Source: Salt Research, 2023)

In line with Menderes' development plans in the 1950s, Kemeraltı Avenue was extended following the demolition of many historical buildings in Karaköy and Tophane squares, becoming one of the main arterial roads connecting Azapkapı, Tophane and the costs of Bosporus. The daily vehicle traffic taking place currently shows that the Avenue still preserves its main transit road status. As a result of this transformation, Galata Avenue (now Necatibey Avenue) has become an axe of second degree. While the density of the traffic still persists, it maintains its commercial trade function at the small scale. Consequently, Karaköy still sustains its trade port function and its central transit status. Galataport, the urban transformation project completed in 2018, indicates the continuity of the morphological and structural changes in the region. "Gentrification" constitutes a part of the interventions, considering the increase in the number of hotels, coffee shops, design

studios and art galleries etc., which indicate the persistence of transformation in the physical and well as social structure of the region.

Second phase of analysis focused on the 2018 urban functional analysis. It is determined that there are 9 art spaces, 29 coffee shops, 6 hotels and 47 spaces sustaining their commercial activity on Mumhane Avenue and, parallel to it, in Ali Paşa Değirmeni Street. There exist 39 dilapidated buildings and 27 of them have been subject to renewal interventions. But for this study, crucial moments regarding the transformation of the past commercial activities in Tersane and Mumhane Avenues are investigated (Figure 4). The site analysis reveals that small-scale commercial functions on the ground floors have been replaced with consumption-oriented spaces like cafes, restaurants, and art spaces since 2011. Besides art spaces, many consumption-oriented spaces are redesigned by artistic works like graffiti, paintings, and other cultural images. The transformative effect of art has been observed through virtual and spatial interventions in Karaköy.

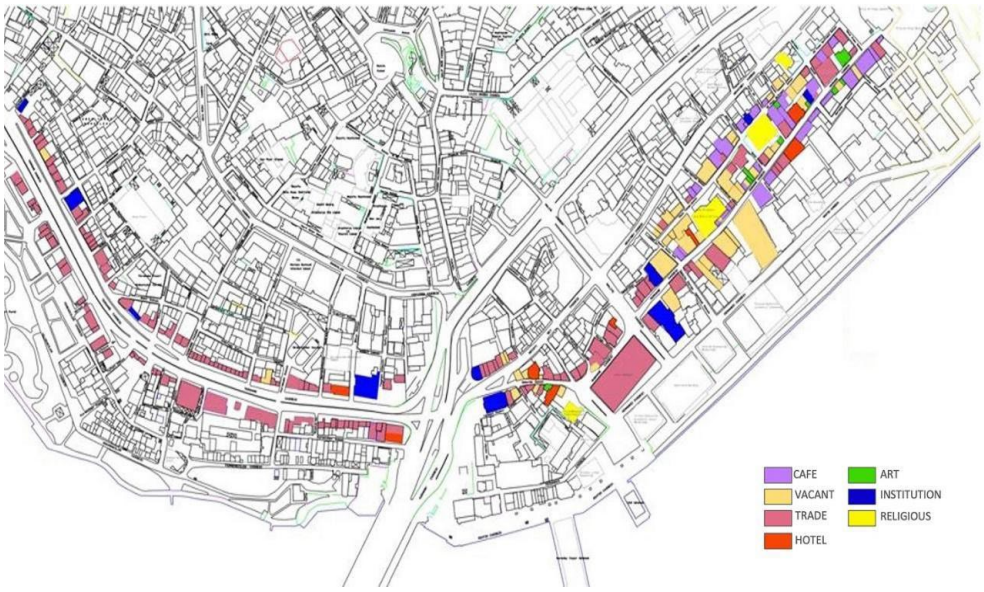

Figure 4 Functional analysis of Tersane Avenue and Mumhane Avenue (Source: Authors, 2018)

The transformation taking place in Karaköy along the axe of Tersane Avenue refers to a consecutive diachronic urban articulation. The intensity of the current commerce-oriented configuration in Karaköy is directly related to the neighbourhood's history. In the Ottoman era, the installation of Haliç Shipyard launched the development of structures related to shipbuilding in time. Housing units of workers used to be located at the section behind the shipyard (now, Kasımpaşa). As the shipyard region grew in time, buildings relating to this line of work started to settle from Hasköy to Karaköy Square. The commercial function concentrated along the shoreline is manifested by an ensemble of hardware stores coexisting side by side. While it appears new projects and initiatives have been intended for this region in the last years, the character of the region has rather been dominated by small-scale commercial properties and retail shops selling construction materials. On the other hand, the functional change brought by Haliç Port Project (Tersane Istanbul), which entails the renewal of the shipyard building, has caused serious debates in terms of the intervention's dimension and characteristics. In fact, the region populated by hardware stores has been under the threat of a similar intervention, due to the presence of stakeholders who are willing to see a similar transformation here. The functional analyses of the area in Tersane Avenue, which is close to Karaköy Square, show that the region mostly accommodates commercial buildings. However, despite being in the same neighbourhood and on the same axe with Mumhane Avenue, the transformations connected to social media cannot be observed in Tersane Avenue. This is because of functional as well as physical reasons: The buildings facing the road in Tersane Avenue altogether indicate a street hierarchy that renders shops more accessible to pedestrians. Although the avenue continues to serve as a commercial centre today, heavy vehicle and public transport traffic take precedence over sociability and public spaceness.

Urban interventions denote transformations and forms of structure that serve different purposes, including multiple variables and actors. They concern the transformation of unauthorised building areas, inadequate housing settlements and areas with other uses affected by natural disasters, dilapidated business centres, unhealthy and non–urban areas, historical spaces and conservation areas (Çağla & İnam, 2008).

Savage and Warde's framework for categorizing the phases of urban gentrification focuses on the visual changes in a specific area resulting from the influx of a new demographic group and the accompanying shifts in cultural norms. They argue that the gentrification process culminates in significant alterations to the area's economic dynamics. In their discussion of Zukin's analysis of the New York project, the authors emphasize the influence of cultural factors on the structure of residential environments (Savage & Warde, 1993). Sassen (1991) argues that gentrification, marked by the emergence of boutiques and art galleries, is not a new phenomenon but rather a result of people's growing purchasing power and desire for a different lifestyle. This transformation encompasses not just food, but cuisine; not only clothing, but designer labels; and not just decor, but authentic art objects. Castells (2000) further adds that in the new spatial logic of the information city, the concept of "places" is being displaced by the concept of "flows." As urban forms and processes become more globalized, consumption patterns, lifestyles, and forms are affected within the context of changing space-time relations. The case of Karaköy exemplifies a process involving targeted interventions at the individual level to rejuvenate declining commercial centers that have lost their original function, ultimately leading to gentrification. The forms of gentrification are primarily driven by changing consumer preferences and demand. This process, which is defined as ‘back to the city movement’ by Smith (1979), is shaped by the role of producers as well as the role of consumers.

Gentrification is both an economic process and a catalyst for social and cultural changes. It alters local culture and community identity through changing consumption habits. In Karaköy, the closure of small businesses has led to the rise of new art and commercial spaces, transforming the area's identity. This process transforms space into a commodity, fundamentally reshaping its commercial value and meaning (Lees et al., 2010). Mumhane Avenue and Ali Paşa Değirmeni street illustrate this, as it can be seen at an upper scale, also considering the process of the physical transformation in the area since the 2000s. While there is no sharp differentiation in terms of land-use at macro scale, functional differentiations are striking at the building level. Since 2011, shops that sell marine supplies, electronic appliances etc., representing small-scale commercial functions, have been replaced by coffee shops, where art and glamour act as fast-moving consumption. In addition, with the flourishing of art studios in the neighbourhood, Karaköy has turned into an utterly different place, as its old identity has slipped away. Another important finding from the field research conducted in Mumhane Avenue and Ali Paşa Değirmeni Street indicates the 27 dilapidated buildings that are going to be hotels. Despite designating large blocks as a result of parcels being accorporated, some of these buildings are not grouped at a specific point, but rather are scattered through the region.

4.2. The Analysis of Multi-Functional Articulation in Karaköy Based on Social Network

The second phase of the research concerns the analyses of multifunctional spatial articulation in Karaköy based on the data collected from social media networks. In the light of detailed studies and specific site analysis conducted in the field, different periods of transformation pertaining to buildings subject to functional change are reconsidered. As a result, particular inputs – other than conventional development planning, zoning, public works etc. – are found to trigger transformation in the region. For instance, the transformation in Mumhane Avenue conveys that social media users have a certain discretion for intervention. In this way, the form of urban interventions gets detached from the purview of concrete and formal decisions and becomes more affiliated with a collective social construct that instrumentalizes social interaction networks.

This step of the study contains the analysis of data collected from location-based social networks in 2018. Herein, Swarm, the application released by Foursquare with its place notifications exceeding 10 billion in four years, becomes the primary source of the study, providing the numbers of place notifications/'check-ins' associated with all the coffee shops located on the axes selected in Karaköy. These data are then evaluated in correspondence with the years these shops started to operate. Considering the number of place check-ins, it is argued that the popularity effect in social media contributes to the functional transformation and to the location choice of coffee shops in Karaköy (Ersoy et al., 2020; Lin et al., 2016). From 2010 to 2018 the number of commercial spaces (i.e., coffee shops and art studios) launched per year, every year the number of venues were doubled compared to the previous year (Authors, 2018). The check-in numbers in Karaköy based on the hashtags "karabatakkarakoy", "filbooks", "unterkarakoy" refers to 1.078, 3.310 and 1.524 number of signposts respectively, also reflect the relationship these places establish with the consumer by means of the 'art' they offer and identify their virtual impact radius (Instagram, 2018).

There are three coffee shops and a small parlour that produces and sells handicrafts, the latter being the first shop with the same function, which started business in the region in 2011. Prior to that, marine supply stores were instead located in their place. Meanwhile, 38 buildings appeared in 2018, all associated with art production and accommodating coffee shops. On the other hand, the check-in numbers these places received on Swarm seem lower, compared to the 7 stores opened before 2015 having the highest check-in numbers, as seen in Table 2. The comparison of store check-in numbers with opening years depicts that a variation exists in terms of check-in numbers among stores opened in the same year, but it is also found that relatively recent stores can elevate their 'check-ins' in the following years (Table 2). An overall linear increase in the number of check-in numbers of the stores is also observed, based on data collected from location-based social media networks. This implies that the popularity generated on social media has an impact on the location choice for stores, contributing to the functional transformation in Karaköy. The check-in numbers the stores receive are directly dependent on the 'art' they offer to the customer that has an impact in creating a gravity and thus in increasing their impact radius.

Table 2 The Number of Place Notifications of Coffee Shops and Art Spaces in Karaköy

THE NUMBER OF PLACE NOTIFICATIONS OF COFFEE SHOPS		
Place Name	**Number of Place Notification**	**Opening Year**
Karabatak	145,722	2011
Unter Karaköy	82,501	2012
Tükkan	79,037	2013
Ops	67,417	2012
Chez Moi	54,876	2015
Filbooks	44,234	2015
Mums	37,200	2014
Karaköy Çorba Evi	23.314	2011
Naif Cafe	18,175	2012
Galaporto Cafe	14,962	2015
Han Karaköy	14,573	2013
Starbucks Reserve	14,167	2017
Grigio	13,612	2017
Station	11,211	2017
Brew Cafe	6796	2013
Tahin	5466	2016
The Sia	3,738	2017
Levanten	2746	2018
İZ Kafe	1764	2016
Kemankeş	1706	2016
Pango Waffle	1677	2018
Berlin Line	766	2018
Lunapark	732	2016
Dreikopf Coffe	611	2018
İnfinity Lounge	283	2018

Kinoa Karaköy	169	2018
Deep Karaköy	156	2018
Korsanın Yeri	29	2018
PLACE NOTIFICATIONS PERTAINING TO ART SPACES		
Place Name	**Number of Place Notification**	**Opening Year**
Nice to Have	305	2018
Atölye 11	159	2011
BOU Art Design	78	2015
Pitane	35	2014
Sanat Karaköy	34	2018
Sanatorium	24	2012
Atelier Lal	7	2015

Coffee shops found in the area turn out to be places where art products are exhibited and sold, surpassing its original function. Although they contain diverse – also high valued – products such as jewellery, furniture and paintings, the check-in numbers of art/design spaces are much lower than those of coffee shops, as seen in Table 2. These quantitative data should not infer that the related places are simply not interesting, because the sale and marketing of such products is detached from the café ambience. The design of art places and coffee shops plays a role in the time spent (Broadway et al., 2018; Waxman, 2006; Waxman, 2022).

Based on the findings of spatial analysis, in Karaköy, sensorial experience-based consumption is used as a marketing strategy to influence consumers' five senses. This experience is dominating with the coffee shops, these- art and design-oriented places rather retain their singularity, diverging from the social and collective features of the former. The place notification numbers of these places, in addition to their impact radius on social networks, are lower than other consumption places, since they do not provide experiential activities, which would enable individuals and people to spend more time there and to form social environments Urban interventions have been operating indirectly via virtual spaces, albeit with strong effect. Attached with tags and 'hashtags', the circulation of photos and videos on social media platforms are instrumental in transporting urban space to the virtual dimension in a very quick and organised fashion. As venues are associated with instant experiences (e.g., eating and drinking in a certain place) with the help of such categorization, they gain a powerful ability in directing individuals and increasing their attraction. Physical spaces are thus redefined in the virtual environment by means of images, having cognitive implications for users (Zimmerman et al., 2022). Investors gravitate towards this ability in engendering popularity, which eventually informs their choice of location. In this way, they become actors of urban transformation as seen in Karaköy.

After Istanbul joining the UNESCO network of creative cities in 2010 indicates an intervention to the space at the global scale, contributing to exchange and consumption based spatial and experiential articulations. In the light of this, the study evaluates coffee shops in a context that foregrounds their identities other than their conventional commercial feature, as it detects an intention to create a divergence from the conventional café idea via the service offered. This effort directs these places to prioritise the spread of their familiarity on social media. Therefore, it proves the phenomenon of 'transformation of intervention' in the region through ever-changing actors-social media networks that enable collective organisation in virtual spaces. This approach, aiming to create a virtual supply and meeting demand, becomes a mandatory method for all the other 'consumable art' venues in the region. Photos, 'check-ins', 'hashtags', comments, and notifications pertaining to these places blend with the street, moving outside of the venues. Colours, plants, pictures, different furniture, and designs appear as elements that encourage the user to 'share'. Within the scope of the field research, the social media analysis shows how the cafes with the most location notifications are articulated to the physical urban space by means of tags/signboards and the virtual spaces on Instagram, another social media application with photo and location sharing features. Via the images prompted in the consciousness of individuals via the photos shared and circulated on social media, a cognitive and perceptual identity for Karaköy is created.

4.3. The Analysis of the Transformation of Karaköy Based on Virtual-Spatial Interactions

While Mumhane Avenue has restricted traffic, the most common feature observed in three pedestrianised streets parallel to each other is the purposeful placement of seating outside, belonging to coffee shops. At some points, seating is even spread out to the opposite sidewalk in streets, constituting an identity in the region (Figure 5). Moreover, the use of mobile heaters during the cold winter days enables clients to be the part of the street, contributing to their experience of these shops. Considering the vernacular pattern characterised by small-scale commercial buildings, interior spaces are expected to be reduced to dimensions that can only contain service items.Another striking aspect concerns differing seating arrangements. It is observed some shops prefer small and not-so-comfortable stools, corresponding to their order with the fast flow of clients. Meanwhile, Karabatak, launched in 2011, is the place that started the trend of single-seating units located side to side. The latter are directed from the sidewalk where the shop is located, to opposite walls adorned with ivy or graffiti, appealing to the eyes. In some places, the seating units even interfere with the pedestrian traffic. Public streets acquire aspects of an interior with seating groups, tablecloths, and illustrated walls.

Figure 5 Seating arrangements in Karaköy (Source: Authors, 2023)

In Mumhane Avenue, street art including graffities and murals are other indicators of the spatial articulation from commerce to trade. In terms of the expression of political, societal, and artistic opinions, graffities refer to drawings or illegal writing on surfaces like façade and walls found in public space. Murals are graphic artworks painted on the walls. The graffities and murals painted on empty surfaces like walls and shutters of shops designate virtual-spatial interventions, even during night-time. In Mumhane Avenue, figures of popular culture like Charlie Chaplin, Barış Manço and La Casa de Papel, street writings, drawings of comics and characters give surfaces a particular spatial quality (Figure 6). Through popular, cultural, and abstract images, the street art in Karaköy is continuously articulated, redefining the area. On the streets of Karaköy, many artists, such as Leo Lunatic, have freely created street art, received awards, and collaborated with international brands (Pashayeva, 2018). All these visuals shared via social media posts that act as digital instruments are transported in the virtual space, increasing the popularity and attractiveness of a place. Contributing to the dissemination of topical, cultural and popular images found in venues that relate to consumption and art, location based social media applications render virtual-spatial interventions continuous.

Figure 6 The street art with graffiti and murals in Karaköy (Source: Authors, 2023)

One of the most significant effects of social media concerns the word 'Instragrammable' added to the dictionary. 'Instragrammable places' refer to 'iconic' and unique locations or destinations that appeal to visitors' eyes with their attractive and photogenic features, widely shared on social media platforms like Instagram. Figure 7 illustrates instances of interiors and exteriors designed in line with this purpose. These constituted Instagrammable places exhibit design elements in two-dimension as well as three-dimension. The former contains writings on the walls, pictures, designed boards and colouring among similar visuals. The latter corresponds to the embodied experience of the user in this space, as materialised in shared photos. The promotion of this experience is advertised via the articulation of individuals on these places circulating on social media – thus, via their demonstration effect - which establishes a connection between urban and virtual spaces. In this way, the sensorial and pleasure-oriented experience in urban space is transported to the virtual environment, motivating the users who have not yet tasted it, in situ.

Figure 7 Instagrammable places in Karaköy (Source: Authors, 2023)

Place is not just a physical space but also a sensorial and social structure. Changes in production systems, technological advancements, and the commodification of spaces reshape the sense of place, enhancing their appeal to consumers. Sense of place is directly related to how individuals experience spaces. Individuals create meaning by experiencing and interacting with spaces (Relph, 2009; Seamon, 2018; Tuan, 1975). Besides the design, product and service experience naturally constitutes another factor in contributing the integration of urban spaces with virtual spaces, as clients are encouraged to share theirs on social media. Figure 8 displays such experiences based on food and beverages offered in the urban space, along Mumhane street axe. In pedestrianised streets of Karaköy, the easy access to products such as mulled wine, sahlep, breakfast and mussels is provided, while this experience is improved with design elements. The exhibition and advertisement of products and services at storefronts primarily serves to connect urban and virtual spaces together.

Figure 8 Experiences based on food and beverages offered in the urban space, along Mumhane street axe (Source: Authors, 2023)

Data collected in 2018, nonetheless, indicates that this quick advertisement in situ does not contribute to the sales. Similar services with different products can be seen at the storefronts of several commercial spaces in Mumhane Avenue. This is also intended for the advertisement of these spaces in the virtual environment, as seen with pedestrians pausing and forming a crowd in front of the venues to take pictures and record photos.

5. Discussion

With its hybrid fabric owed to its history, Karaköy neighbourhood is open to rapid structural and functional transformations. The study evaluates this transformation characterised with specific temporal and spatial articulations, by referring to urban layers identifying different historical periods, traces of functional change, social media networks and virtual-spatial interventions. It argues that changing urban intervention forms also determine the involvement of different actors, in accordance with spatial and functional articulations. The concept of urban intervention which defines “collective urban knowledge”, is closely related to the concept of participatory design due to its “context-based” structure (Ataman & Tuncer, 2022). With this perspective, the paper

emphasises the new social and virtual actors of the intervention in Karaköy and it differs from other concepts like urban transformation.

This multi-actor urban intervention has resulted in the change of user profiles in parallel to new functional necessities in the area. The reference to functional transformation in Karaköy is documented with maps from different periods and supported by site analysis. The findings of the field research indicate that functional differentiation at building level is significant in Karaköy, while no sharp structural change in land-use at macro scale has been found. The study points out that small retailers are being replaced by cafes and coffee shops that enable the consumption of 'art' and 'culture' in a fast and glamorous fashion. In his work, Florida (2012) argues that there is a confluence between economic and technological innovation and artistic and cultural creativity. The rise of the creative economy has led to a closer integration of these domains, with a shift towards emphasizing experiences over physical goods. Today, the services that come with a product have been more important than the product itself. In addition, Florida (2005) asserts that talent, technology, and tolerance are the key factors for establishing a successful creative industry. Regions with competitive industries capable of swiftly mobilizing and attracting talent, resources, and capabilities have a distinct advantage in this regard. In this respect, Karaköy emerges as an advantageous location for the creative economy and industries due to its new trades, talent areas, and competitive environment.

Following its designation as the 2010 European Capital of Culture, Istanbul has emerged as a hub for architecture, innovative art, and creative culinary presentations. The city's urban planning and design center under the Istanbul Metropolitan Municipality prioritizes the development of cultural and creative industries to drive urban infrastructure and supports a gentrification policy for focal urban areas. The rise of cultural consumption and related industries has reshaped urban economies, with an increasing focus on cultural symbolism and spatial transformation. The consumption of culture becomes intricately linked with the generation of symbols and spaces, contributing to a shift in economic activities from manufacturing to the culture and creative industries (Göktürk et al., 2010). Furthermore, Zukin (2000) outlines that the culture industry employs various methods, such as leveraging traditional or historical indicators reflecting local identity and sensory product displays, to gentrify urban spaces.

Transformation takes place indirectly via the rapid dissemination of images in the virtual space, transcending conventional physical and functional interferences. A new image of Karaköy cognitively emerges herein and is used to stimulate the user-time-space interaction. This also affects the decision-making process concerning the transformation of the physical space and consumed products, whereby different stakeholders including shop-owners and landowners estimate the preferences of the masses. In this way, social networks intervene in the city, leading to more dynamic virtual-spatial transformations. Via photos, 'check-ins', 'hashtags', comments and notifications, sensory reactions, especially pleasure, are stimulated. Therefore, interiors and exteriors are reconfigured based on the dynamic preferences of the masses, while new trends appear in return, diversifying 'instagrammable places'. In today's cities, many spaces are encoded with artistic images and elements to create "insta-worthy" (a synonym of the "instagrammable") environments and entice users (Lobo, 2023). In other words, the goods, services, and the atmosphere offered by stores – as seen in seating arrangements, street art artefacts like graffiti and murals, visually striking boards advertising services offered in Mumhane Avenue etc. – constitute the indicators of 'instagrammable places', contributing to the familiarity of these places among users. This reveals the impact of social networks on physical urban space and users become the primary actors of this intervention.

José van Dijck and Thomas Poell (2015) describe virtual environment as a new type of public space over social media platforms that have collective and dynamic features. In observing the functional and spatial transformation from commerce to art, this study aims to reveal various forms of spaces re-designed in the virtual environment. Although Mumhane and Tersane avenues have not been subject to sharp structural transformations, we still see the development of a new identity

in the process, given new functions have appeared throughout history. Social media data analyses demonstrate that, apart from commercial and functional purposes, artistic concepts are collectively reconfigured and then consumed, further shaping virtual-spatial interventions. Supported with sophisticated software, contemporary communication tools have greater power in managing interaction: The familiarity of unknown or new places to users are enhanced through posts and location notifications on social media platforms. Tierney (2013) suggests that networking platforms have become intertwined with physical spatial organization. The generated proximity in space and time contributes to venues increasing their gravity in virtual space, by manipulating personal preferences. Cafe and art functions on Mumhane Street are salient in the virtual environment, indicating a significant effect on audiences, ensuring the sustainability of their artistic products and services. Prior to 2011, Mumhane Caddesi stood out with its security problem, showing a sharp difference between day and night times. Its transformation in its commercial axe has also influenced Tersane Avenue. Social media data analysed in the study have detected no place notification or photo sharing on this axe.

The advent of future hotels in Kemankeş Karamustafa Neighbourhood signals inevitably a future transformation: Accompanied with a new user profile, such functional articulation will eventually dictate a further modification in the products consumed and the consumption form. This process is likely to gain speed and intensify, as individuals' recognition and awareness are persistently being shaped via communication tools, underscoring the concept of familiarity. The intertwining of virtual environments with 'real' space will keep producing new intervention forms and new stakeholders.

Furthermore, the new stakeholders are the individuals of the consumer society of the recent period. The geographical area of study has undergone significant transformation, particularly in the Tomtom Neighborhood. The Istanbul Environmental Plan of 2009 designated Tomtom District as an "Urban and Regional Equipment Area". The pedestrianization project of İstiklal Street and the Tomtom neighborhood in the 1980s created a vibrant atmosphere akin to a 'Turkish SoHo', according to Tepeli Türeli (2023). The renovation of "Tomtom Red" building in the heart of Tomtom led to the organization of cultural and art events. The 2011 BIENAL exhibition at the Karaköy Museum of Modern Arts had a substantial impact on the area's transformation. Research indicates that a similar transformation accelerated in Bomonti when a department of Mimar Sinan Fine Arts University relocated there in 2011 (Çağlayan et al., 2019). In recent years, the digital environment has significantly expedited the envisaged transformation process, resulting in the creation of a new historical layer.

6. Conclusion

The study observes the intersection of urban space and virtual space, and their relative impacts. It displays how physical and functional elements used in the design of urban space are composed in the virtual space to make places more attractive and how these elements are further exposed to change via interventions at the spatial level. The study also reveals that virtual and urban space will be more intensely intertwined over time, as the impact of virtual spaces on urban areas will gain more prominence. It thus proposes this practice will increasingly provoke the variation of design elements, leading to new interventions in urban spaces.

The case of Karaköy clearly exhibits that the existing diversity of a place stimulates virtual space in producing new design elements. As a result of the analysis of the two main pedestrian axes of Karaköy, since 2011 the remarkable functional and spatial change has been observed in 35 spaces. This study reached out that the urban intervention differs from conventional planning policies and is influenced by the participation of users through virtual space. Transformation takes place indirectly via the rapid dissemination of images in the virtual space, transcending conventional physical and functional interferences.

In this vein, further research can tackle the comparison of two different urban places, with the potential to offer more elaborate networks considering the intersection of urban spaces with virtual spaces. The main limitation of the study is that it deals with the transformation process of a single

urban space, whereby data are collected via locational photo-sharing for the spatial analysis. That virtual environments are subject to fast changes, even resulting in some of them becoming dilapidated, can impact the course of the study. Consequently, the study indicates the transformation of intervention from traditional planning and design decisions, via channels including social media networks and new actors. By pointing out the ways virtual-spatial interventions play a role in the transformation of urban space, it further proposes that virtuality can transcend material urban space.

The incorporation of digital technologies and virtual environments into urban planning and design is transforming conventional approaches to spatial intervention and public participation. Innovative platforms for social interaction and political organization are emerging through social media and advanced communication technologies (Barlas & Çalışkan, 2006). These advancements are altering social networks, perceptions of place, and community engagement in planning processes (Houghton, 2010). The blending of physical and digital environments presents both opportunities and obstacles for planners and designers, emphasizing the necessity for interdisciplinary collaboration to develop new theories and models (Yamu et al., 2017). Social media data are increasingly employed for urban analysis and modelling across various fields, providing new avenues for public engagement and dialogue. Nonetheless, challenges such as demographic biases and privacy concerns must be addressed when integrating social media data into urban planning (Lin & Geertman, 2019). These developments necessitate a reconsideration of planning and design practices to effectively respond to the growing influence of virtual-spatial interventions.

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Resume

Tuba Sarı is an accomplished architect and academic, renowned for her expertise in architectural history, theory, and design. She holds a Bachelor of Architecture from Eskişehir Osmangazi University (2008), a master's in architectural design from Istanbul Technical University (2010), and a Ph.D. in Architectural History from the same institution (2017). During her doctoral studies, she served as a research assistant at ITU's Faculty of Architecture for six years, contributing to various academic and design initiatives. Since 2018, she has been an Assistant Professor at Bursa Technical University, where she teaches and researches architectural history, contemporary urban design, and emerging global architectural trends. A visiting lecturer at VSB - Technical University of Ostrava in 2024, Dr. Sarı's research encompasses tall buildings, urban imagery, and the intersection of architecture and urban design. She also leads Atölye Hisar, a dynamic urban design studio in Bursa.

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Effect of phase change materials on building heating and cooling load considering different wall combinations

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Abstract

In this study, energy analyzes were carried out on a sample building for wall types where 3 main materials (brick, concrete block, aerated concrete) and 3 different insulation materials were used in different combinations, taking into account the situations with and without PCM. Building heating and cooling loads for 39 different scenarios derived in this way were determined by taking into account the coldest and hottest days of the year and also as the total energy need during the year. Analyzes were made with the Design Builder program and the results are presented with tables and graphs. By comparing and classifying the total energy loads of wall samples created for 39 different scenarios during the year, wall types that gave more positive results were determined. Three different PCM types with melting temperatures of 21 °C, 23 °C and 29 °C were used in the analyses. Based on the main material of the wall, three walls with the best performance among their main materials were initially determined. Then, among the wall types consisting of these 3 main materials (brick, concrete block, aerated concrete), the walls that showed the best performance were determined among the combinations created with the addition of insulation material and PCM. The best results with PCM were obtained for XPS as insulation material and aerated concrete as wall type. According to the results of the simulations, 25% energy savings were achieved when only insulation materials (XPS, EPS, Rock Wool) were used in the building envelope, and 9% energy savings were achieved when only PCM was used. By using PCM and insulation materials (XPS, EPS, Rock Wool) together, 30% energy savings were achieved.PCM, which is used in addition to the insulation materials used in the building envelope to reduce the energy load of the building, has led to a decrease in the annual energy need of the building. The combined use of PCM and insulation material can be recommended for regions where the heating load is high. It will be more effective to use PCMs with low melting points in cold climate regions, and PCMs with high melting points to be used in temperate and hot climate regions. It has been advised using PCM with two melting temperatures instead of using PCM with a single melting temperature in the building envelope as a more advantageous solution.

Keywords: phase change material, design builder, cooling load analysis, heating load analysis, energy analysis, building envelope, simulation

1. Introduction

Energy has become an indispensable requirement that continues to increase in the amount of need from past to present. Today, increasing population and technological developments have led to the depletion of energy resources and the issue of energy to become important. Unconscious and excessive consumption of energy resources used to meet this energy need has led to environmental problems (Yılmaz,2006).

In Turkey, 30% of the energy is used in buildings and a large part of the buildings are made up of residences. The increase in population and building stock causes an increase in energy demands in direct proportion. The use of renewable energy sources, the popularity of which is increasing day by day due to the decreasing energy resources in the world, and in parallel with this, energy efficiency has become an important subject today. This plays a major role in reducing the cost of energy and contributes to the reduction of greenhouse gas emissions, air and environmental

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pollution (Turkish Grand National Assembly 11th Development Plan). In addition to the use of renewable energy sources, thermal storage systems, techniques and materials used to increase energy efficiency are also important and necessary (Narin & Akdemir, 2006).

Heat storage, which is the cornerstone of energy efficiency, reduces energy losses and energy savings. Today, thermal storage can be offered as a solution in order to use energy more efficiently and to save money (Aydın & Okutan, 2010). Apparent heat storage is the most common method used in thermal energy storage. Apparent heat storage occurs due to an increase in temperature. Latent heat storage which is an another method may be evaluated as a better and more effective method than apparent heat storage. The material used changes phase (gas-liquid, liquid-solid, gas-solid) at a certain temperature, takes a large amount of heat energy from the environment or performs heat exchange by giving it to the environment. Since there is no change in temperature when this heat exchange takes place, it is called latent heat storage. The oldest examples are the example of preserving the heat of the environment by using ice and snow (Prakash et al., 1985).

Phase Change Materials (PCM) which have the ability of latent heat storage are generally applied on building envelopes which has an intensive heat exchange. They generally play role as an area of storage in order to protect the heat. PCM can be defined as a modern " thermal mass" which absorbs the heat, store in it, delaying the effects of external climate elements and reducing their amplitudes, transferring them to the interior space and thus preventing the overheating that may occur in the interior. The performance of PCM changes due to climatic regions while they also decrease cooling energy load in summer beside heating energy load in winter times (Konuklu & Paksoy, 2009). PCM is a material suitable for use in light and high heat mass building envelope applications (Kosny, 2015). It also helps to minimize the negative effects between buildings, which can occur with mutual shading and reflections in urban environments, as they increase building inertia while reducing indoor temperature fluctuations (Han & Taylor,2015). On the other hand, if the PCM mass is overestimated, the time required for heat release indoors may be greater than the discharge time and the solidification process cannot be completed. This results in insufficient latent heat storage (Soares et al,2013).

The effect of phase change materials on energy consumption has been the subject of many studies. Kuznık and Virgona (2009), experimentally investigated the thermal performance of a PCM copolymer composite wallboard in a full-scale test room. The test cell is fully controlled (temperature and solar irradiance flux) so that a typical day can be replicated. The effects of PCM were investigated for three conditions by comparing results with and without composite wall sheets: a summer day, a winter day, and a mid-season day. The results showed that for all cases tested, the reduction factor ranged from 0.73 to 0.78. In a study by Kissock et al. (1998), the results were observed by impregnating the walls with 30% commercial PCM paraffin (K18). During 14 days, solar radiation, outdoor temperature were recorded by measuring the temperature values between the tested walls with and without PCM. As a result, it was observed that the region with PCM was 10 °C less than the region without PCM. In a study commissioned by Rubitherm, PCMs were placed on the ground to provide building insulation. When the system used is compared with conventional heating systems, it has been determined that it provides 35% reduction in energy consumption.

Alawadhi (2008) applied the PCM material to the brick and performed thermal analyzes for hot climate zones. As a result of the research, when PCM was included in the brick, a decrease in heat gain and a positive effect were observed when the amount of PCM was increased. In a study by Shukla et al. (2009), the performance of PCM in solar water heaters was investigated. They wanted to take advantage of the thermal storage feature of PCM. As a result of the study, it was seen that it was necessary to use PCM for high latent heat and heat transfer to the large surface in order to provide a higher performance from the water heater. Konuklu and Paksoy (2011), investigated whether there is a reducing effect on the energy consumed in the building by using PCM material in the building envelope. In the research conducted on an area of 4 m^2, it was observed that PCM affected the heating and cooling load. In addition, a better result was obtained in the building

envelope in which insulation materials were used together with PCM, than in the building envelope in which only PCM was used. In the study, it was concluded that the melting temperatures of PCMs used in summer should be higher to give better results, while PCMs used in winter should have lower melting temperatures. It was deemed appropriate to use PCM with two different melting temperatures in order to save energy in the building in summer and winter. Tomlinson and Heberle (1990) investigated the effect of PCM used in gypsum panels in interior spaces on building energy saving. According to the results obtained, it was determined that the cost spent on PCM was paid by the energy savings it provided. It has also been observed that PCM affects energy saving. Castellón et al. (2006) conducted an experimental study to investigate the effect of PCM material on energy saving by applying it to conventional concrete. In the experiment conducted in Spain, the positive effect of concrete using PCM on energy saving was determined. It has also been observed that PCM melts during the day and freezes at night. According to the results obtained, it was stated that night freezing of PCM was considered as an advantage. Izquierdo-Barrientos et al. (2012) conducted a study to examine the effect of PCM on the external wall. The study also concluded the study by producing various scenarios such as increasing or decreasing the melting temperature of PCM and changing the orientation of the building. As a result of the study, it was seen that PCM reduces the heat fluidity passing through the wall and reduces the amount of heat lost in winter. It was determined that PCM increased the thermal load during the day and decreased it at night. In a study conducted by Izquierdo-Barrientos et al. (2013) to examine the behavior of a fluidized tank filled using PCM, it was determined that PCM is a material that can be used in fluid systems to increase heat storage efficiency.

Energy consumption is also increasing due to the increasing human population and the resulting increasing building stock. Achieving energy savings in buildings depends primarily on making the right decisions regarding the variables affecting heating and cooling energy loads. The building envelope separates the indoor and outdoor environments and plays a major role in heat transfer control; It is one of the most important parameters affecting energy consumption with its optical and thermophysical properties. In order to solve this problem, many studies have been carried out with the help of programs that perform energy analysis in buildings. In studies using PCM material, comparisons were generally made by taking advantage of climatic differences.

In this study, analysis studies were carried out on a sample building in Elazığ, based on the hypothesis that PCM reduces the energy load in the building by taking advantage of its thermal storage feature. Due to its various properties, PCM is expected to provide better results in terms of energy saving than insulation materials. In the study, a series of analyzes were carried out to compare the heating and cooling load values obtained by using insulation material in the building envelope of the sample building and the heating and cooling load values obtained by using PCM with insulation material in the building envelope. Analyzes were also made for PCM types with different melting temperatures. Thus, the effect of Phase Change Materials (PCM) on heating and cooling load was also analyzed for different insulation materials and different melting temperatures of PCM. Many programs are available to examine the effect of using different building materials on heating and cooling in the building envelope system. Among these programs, Design Builder was used because it can work in harmony with many programs and is more reliable than other programs related to energy simulations of the building. In the first stage of the study, the building was modeled with Design Builder. In the later stages, the heating and cooling loads obtained by using PCM material in the building envelope in the modeled building were compared and examined. In addition, in this study, the effect of PCM on the energy loads of the structure where it was used only by taking advantage of its thermal storage feature was examined.

2. Methods and Materials

In this study, energy analyzes were carried out on a sample building for wall types where 3 main materials (brick, concrete block, aerated concrete) and 3 different insulation materials were used in different combinations, taking into account the situations with and without PCM. Building

heating and cooling loads for 39 different scenarios derived in this way were determined by taking into account the coldest and hottest days of the year and also as the total energy need during the year. Analyzes were made with the Design Builder program and the results are presented with tables and graphs. By comparing and classifying the total energy loads of wall samples created for 39 different scenarios during the year, wall types that give more positive results were determined. Based on the main material of the wall, three walls with the best performance among their main materials were initially determined. Then, among the wall types consisting of these 3 main materials (brick, concrete block, aerated concrete), the walls that showed the best performance were determined among the combinations created with the addition of insulation material and PCM.

Accordingly, the framework determined in the study is briefly presented below:

- In the study, wall types made of brick, concrete block and aerated concrete were among the scenarios created and were included in the analyzes without insulation.
- In the wall types created, PCM was used close to the outer surface of the wall.
- In the created scenarios, the insulation materials used with PCM were used before PCM and placed closer to the core of the building envelope.
- Generally, PCM thickness is in the range of 1-5 cm, and in order to analyze the relationship between thickness and efficiency, simulations were made for 3 different thicknesses of PCM as 1cm, 5cm, 10cm.
- Considering the climate data of Elazığ province, PCM with 3 types of melting temperatures (21 °C, 23 °C, 29 °C) was used to measure how PCM behaves in the specified province (Rubitherm, 2003).
- As a result of the determined scenarios, the cooling and heating load amounts required on the coldest and hottest days of the year were compared, taking into account the climate data of the building. At the same time, comparisons were made based on the total loads during the year.
- Heating, cooling and total loads are expressed in kWh units.
- The layer details and the properties and locations of the materials specified in the created walls were applied exactly in the simulations.
- Elazığ climate data is from 2002 due to the Design Builder program.
- When determining the indoor temperature, the days when the climatic conditions are most extreme are taken as basis.
- Since the PCM was used in the study, Finite Difference algorithm was used among the existing algorithms.

2.1. Building Specifications

For the study, a single-volume building with only the ground floor, with dimensions of 4m x 4m x 3m, was designed in the climate zone of Elazığ province. There are no elements that will create a shadow in the area where the building is located. The area where it is located is slopeless. A flat roof was used in the building. The slab sits on the floor. In order to benefit from more solar energy in the mass, a window with a height of 0,8 m from the ground, dimensions of 2,8 m x 1,5 m and a transparency rate of 30% and was placed on the south facade. 10 mm double glass was used in the window and 16 mm Argon gas was compressed between it. A door was placed on the north facade. Mechanical ventilation in the structure is excluded. Artificial lighting was used in the building. It is assumed that equipment was used in the building to ensure human life. The 3D visual of the structure is given in Figure 1 while the plan of the square-shaped structure is shown in Figure 2.

Figure 1 3D visual of the structure of the building

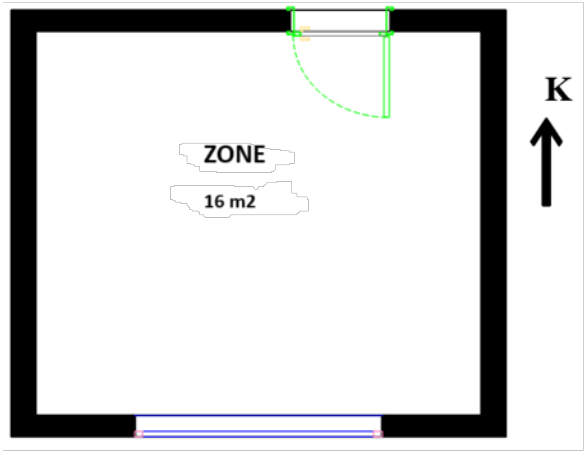


Figure 2 The plan of the square-shaped structure

Elazığ province is located in the 3rd degree day zone (Aksoy & Ekici, 2013). Insulation materials have been added to the elements of the created structure in order to reach the U value standards specified in TS 825 (Thermal Insulation Rules in Buildings). U values of structural elements are given in Table 1 for slab and roof elements while the U value for window and door accepted as 2.484 W/m²K and 2.283 W/m²K respectively.

Table 1 U Values of Structural Elements (Slab and Roof) d: Thickness k: Heat Transfer Coefficient (Yüksek & Sıvacılar, 2017)

Slab	d (m)	k (W/mK)	Roof	d (m)	k (W/mK)
Wood Flooring Cover.	0,018	0,14	**Drywall**	0.0125	0.25
Enhancement Concrete	0,03	1,14	**Leveling Concrete**	0.05	1.14
Polyethylene	0,004	0,33	**Concrete Floors**	0.12	2.5
Polystyrene	0,07	0,034	**Bitumen**	0.003	0.23
Cement Screed	0,05	1,14	**Pcm**	0.05	0.20
Concrete Floors	0.10	1.13	**Xps**	0.16	0.034
			Geotextile Felt	0.01	0.30
			Aggregate	0.05	2
U (W/m²K)	**0,389**		**U (W/m²K) 0,188**		

2.2. Validation

In order to prove the accuracy of the results obtained as a result of the simulations made with the V7.0.2.006 version of the Design Builder program, another energy analysis program, CARRIER Hourly Analysis Program (HAP), was used, and the results obtained with Design Builder were

compared by calculating the heating and cooling load of the building with HAP version 4.90. In this comparison process, all internal and external conditions were kept constant.

Hourly Analysis Program (HAP) was chosen for the validation study because the program is part of E20-II. E20-II which is an HVAC design program. HAP has a versatile structure that is often used for HVAC design in commercial buildings. The HAP program allows HVAC designs to be versatile and building simulations easier. The most important feature of the HAP program is that it analyzes 8760 hours a year, taking into account the climate data, human density, and the heat emitted by the equipment in the building to the environment. The ASHRAE Transfer Function Method is used to create these analyzes (ASHARE Standars and Guidelines). Creating hourly analysis ensures that the results obtained are closer to real data.

The energy loads of the building with the effect of the building components (roof, floor, wall, door, floor) that most affect the heating and cooling load of the building are given in the Table 2. Energy analysis was carried out for 1 space in the building. As a result of building analysis, the heating load was determined as 2839 W for Design Builder and 2947 W for HAP. In cooling load, values of 6146 W for Design Builder and 6261 W for HAP were obtained. A convergence of 4% and 2% was achieved between the two programs for heating and cooling loads, respectively.

Table 2 Comparison of Design Builder and HAP Results

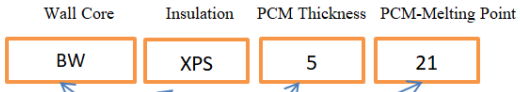
	DESIGN BUILDER	HAP
Cooling Load	6146 W	6261 W
Difference	%2	
Heating Load	2839 W	2947 W
Difference	%4	

2.3. Simulation Details

Simulations were made with the Design Builder program for 39 scenarios created based on the building prototype determined in the study, and the results were analyzed. The process started with 3D modeling of the structure and continued with entering and editing the data required to complete the simulations accurately. Accordingly, firstly, the ratio between the number of people and the area in 1 zone defined in the activity tab of the Design Builder program was determined as 8. The number of people was determined as 2. The temperature range determined for the heating system in the building to operate was applied as -10 °C and 19°C. The temperature range determined for the cooling system in the building to operate was 26-50 °C. In order to meet the needs of the people living in the building, the equipment in the building was activated and allowed to radiate heat by working in a certain program. In this way, it is aimed to have a realistic value for the calculated heating and cooling load of the building. The HVAC system is selected as simple and the ideal loads tab is activated. When the HVAC system was active, the operative temperature values of the climate in which the building was located were checked. The HVAC system is assumed to operate at 100% efficiency without energy loss. The operating hours of the systems in the building are considered active between 07:00-24:00 and passive between 00:00-07:00.

2.4. Studied Scenarios

In order to measure the effect of PCM on the annual heating and cooling load, various scenarios were produced using insulation materials (XPS, EPS, Rock Wool) and PCMs on 3 main wall cores (Brick, Concrete Block, Aerated Concrete). Scenarios were created using examples such as uninsulated wall, wall with PCM, wall with insulation, wall with PCM + insulation material. Figure 3 presents the detailed definiton of codes for scenarios. For example the code of BW-XPS-5-21 reptresents a Brick Wall insulated with XPS and PCM which is 5 mm thick and has a melting point of 21 ^{o}C. Figure 4 also presents the detailed wall sections of main core of studied models in this work. Wall thickness accepted as 20 cm for all structural cores while the insulation thickness used as 5 cm for all insulation materials. The thickness of inner and outer plasters accepted as 2 and 3 cm respectively. Termophysical properties of structural and insulation materials used in the study are presented in Table 3.



Wall Core	BRICK WALL (BW)			CONCRETE WALL (CW)			AERATED CONCRETE WALL (ACW)		
Insulation Materials	XPS	EPS	RW	XPS	EPS	RW	XPS	EPS	RW
PCM with different melting points (ºC)	21	21	21	21	21	21	21	21	21
	23	23	23	23	23	23	23	23	23
	29	29	29	29	29	29	29	29	29
PCM with different thickness (cm)	1	1	1	1	1	1	1	1	1
	5	5	5	5	5	5	5	5	5
	10	10	10	10	10	10	10	10	10

Figure 3 Detailed definiton of codes for scenarios

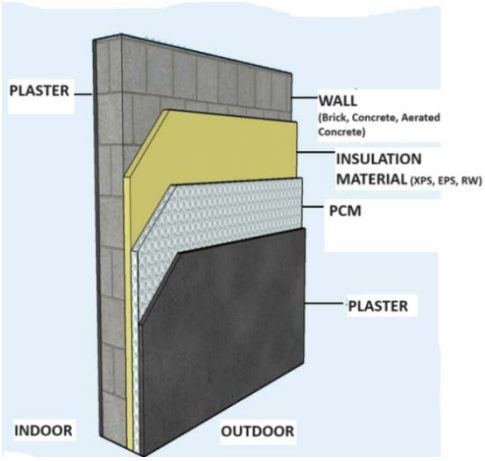


Figure 4 Detailed wall sections of main core of studied models

Table 3 Thermal Conductivity Coefficient (k (W/mK)) of Materials Used in the Scenarios

	d (m)	**k (W/mK)**
Structural Core		
Brick	0,20	0,30
Concrete Block		0,19
Aerated Concrete		0,14
Insulation		
XPS	0,05	0,034
EPS		0,040
Rock Wool		0,037

3. Results and Findings

In the study, 3 types of wall types (brick, concrete block, aerated concrete) with different main cores were used in the envelope of the building created in Elazığ province with Design Builder. Certain scenarios were selected and compared among 39 different scenarios created using these wall types. It is aimed to reveal the effect of PCM on heating and cooling load and also to investigate the effect of PCM on heating and cooling load when used with other building elements. Figure 5 and Figure 6 present the heating and cooling loads for different scenarios for brick wall respectively.

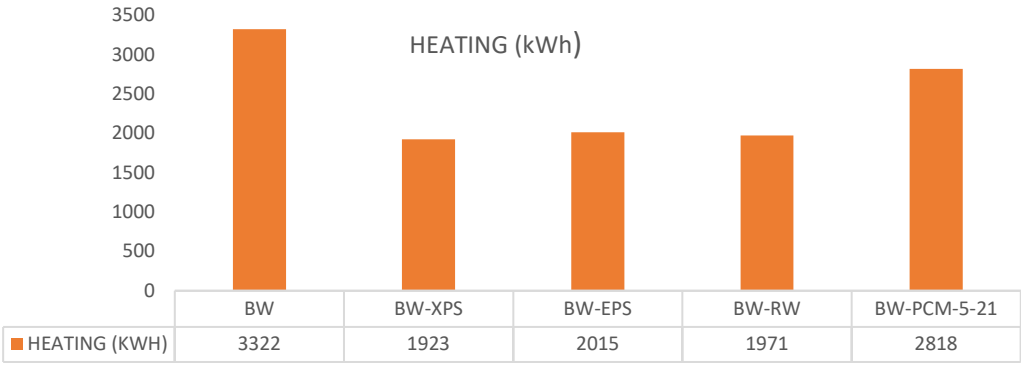


Figure 5 Heating loads for different scenarious on BW

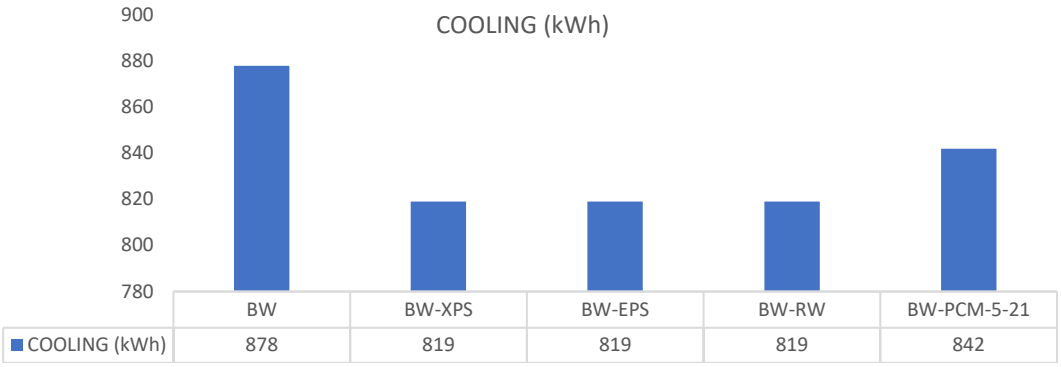


Figure 6 Cooling loads for different scenarious on BW

Heating load values of the created scenarios vary between 3322-1923 kWh. As a result of the simulations, the highest heating load requirement was observed in the BW wall type and the lowest heating load requirement was observed in the BW-XPS wall type. When the cooling load values stated in Figure 6 are examined, the maximum cooling load requirement is 878 kWh for BW wall. The cooling load value for BW-XPS, BW-EPS, BW-RW wall types is calculated as 819 kWh. Total heating and cooling loads of the walls, the main material of the building envelope of which is concrete block, during the year are shown in Figure 7 and Figure 8.

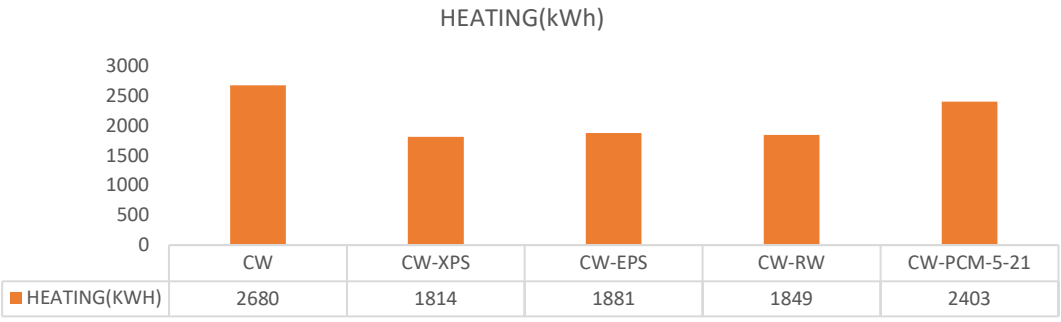


Figure 7 Heating loads for different scenarious on CW

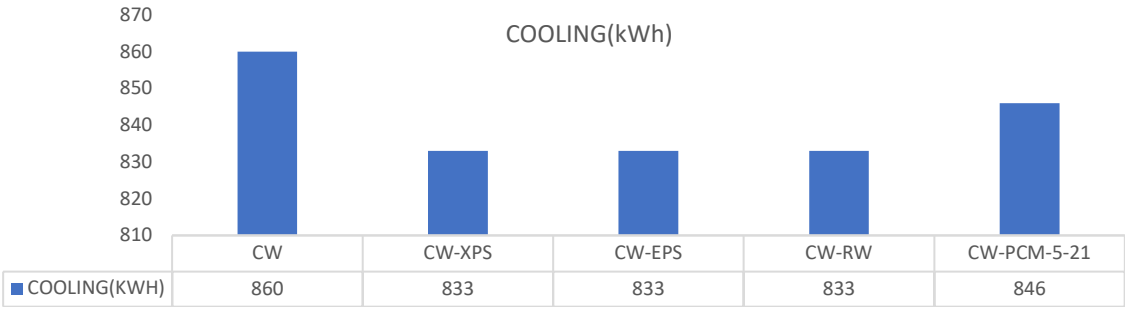


Figure 8 Cooling loads for different scenarious on CW

The wall types with the highest and lowest heating load requirements for the concrete block are CW and CW-XPS, with values of 2680-1814 kWh, respectively. The maximum cooling load requirement was obtained for the CW wall type with a value of 860 kWh. For CW-XPS, CW-EPS, CW-RW wall types, the cooling load requirement is determined as 833 kWh.

Total heating and cooling loads of the walls of which the main material of the building envelope is aerated concrete during the year are shown in Figure 9 and Figure 10 respectively.

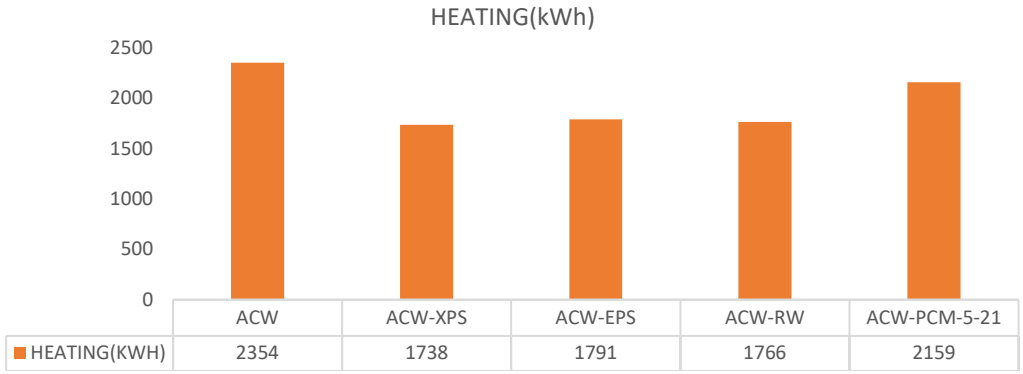


Figure 9 Heating loads for different scenarious on ACW

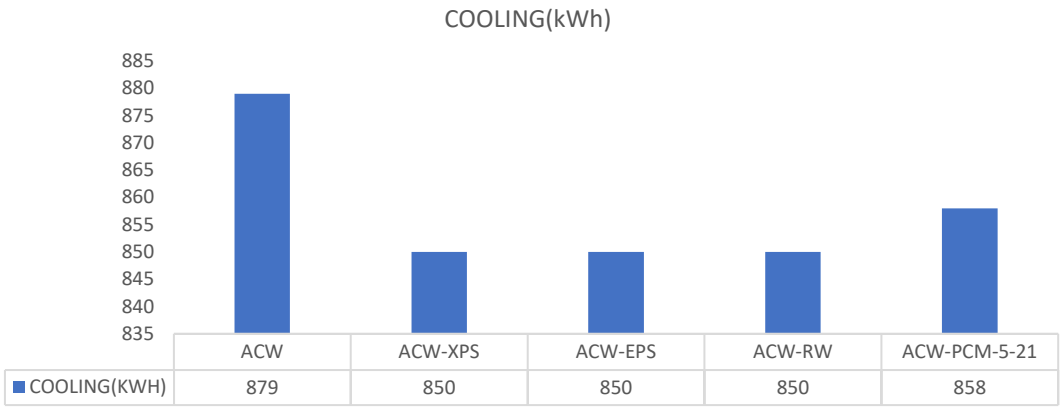


Figure 10 Cooling loads for different scenarious on ACW

When the heating and cooling load graphs of aerated concrete are examined, it is the ACW-XPS wall type with a value of 1738 kWh that gives better results in heating load compared to other wall types. In addition, the wall type with the highest heating load requirement is the ACW wall type with a value of 2354 kWh, without the use of insulation materials and PCM. The value of wall type ACW, which has the highest cooling load as well as heating load, is 879 kWh. The value of the 3 wall types that give the best results (ACW-XPS, ACW-EPS, ACW-RW walls) is 850 kWh. Figure 11 and Figure 12 presents the effect of PCM on the total heating and cooling load in the building, taking into account the melting temperatures. In these scenarios created on the brick wall, 3 different melting temperatures of PCM were applied as 21, 23, 29 °C.

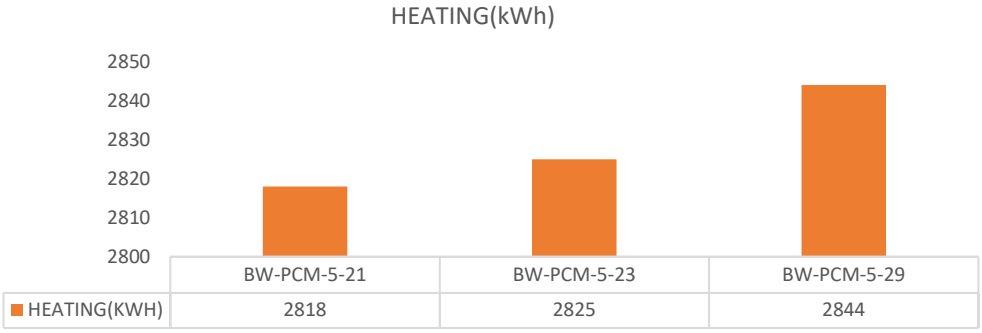


Figure 11 Effect of PCM with different melting points on total heating load

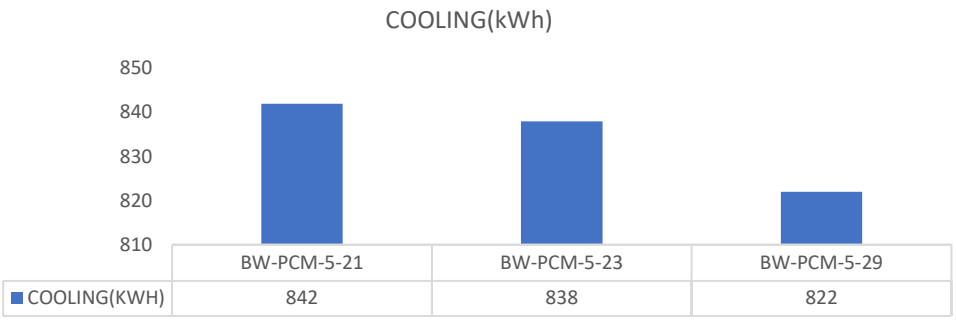


Figure 12 Effect of PCM with different melting points on total cooling load

It has been determined that when PCMs with different melting temperatures are used in the structure, it has an effect on the heating and cooling load of the structure. When the heating loads specified in Figure 11 are examined, the wall type with a value of 2818 kWh, in which PCM with a low melting temperature is used, is determined as BW-PCM-5-21. The wall type that has the least effect on the heating load is the wall type BW-PCM-5-23 with a value of 2844 kWh. When the cooling load is examined, unlike the heating loads, the wall type with the least load is BW-PCM-5-29 wall type with a value of 822 kWh. The wall type with the highest cooling load requirement is the BW-PCM-5-21 wall type with a value of 842 kWh.

During the summer period, the average air temperature in Elazığ is generally higher than 23°C. For this reason, PCMs with a melting temperature of 21 °C and 23 °C used in the building did not have much effect on the cooling load since they were generally in liquid form. However, it was determined that the energy performance of PCM at a melting temperature of 29 °C was better than the others. In winter, since the outdoor temperature remains below 29°C and this type of PCM is in solid state, its effect on the heating load of the building is less than the other two types of PCM with melting temperatures (21°C, 23°C). Effect of PCM thickness on energy loads in the building envelope is given in Figure 13 and Figure 14. Scenarios were created using 3 different thicknesses as 1, 5, 10 cm.

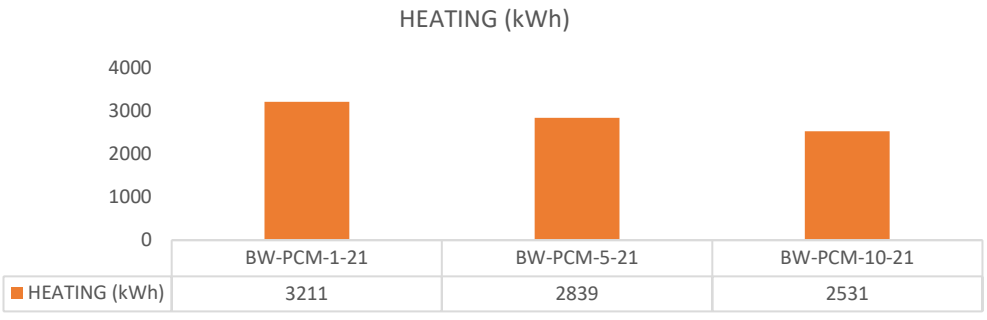


Figure 13 Effect of PCM thickness on heating loads

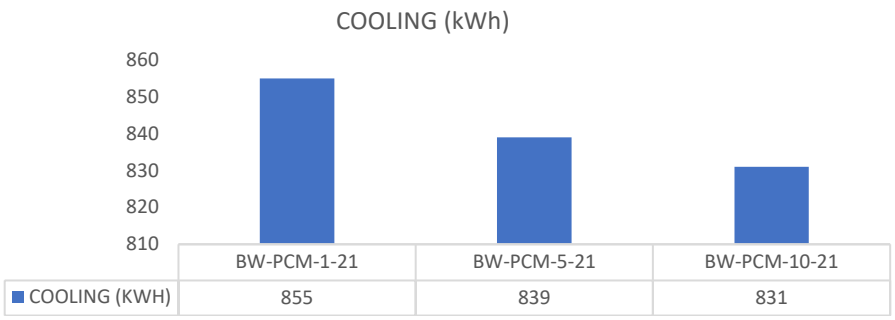


Figure 14 Effect of PCM thickness on cooling loads

Accordingly, it can be seen that when the thickness of the PCMs used in the structure increases, their effect on both cooling and heating loads is the same. When the graphics of cooling and heating loads are examined, the wall type with the least load requirement in both graphics is the BW-PCM-10-21 wall. The heating and cooling load requirement of wall BW-PCM-10-21 is 2531 and 831 kWh, respectively. The wall type with the highest load requirement is the BW-PCM-1-21 wall. The heating load of this wall is 3211 kWh and the cooling load is 855 kWh. The efficiency of PCM is directly proportional to the thickness for heating load. As the thickness increases, energy efficiency also increases. Since melting temparature is also a decisive parameter and used as 21 ^{o}C for this part, the effect of thickness for the cooling load is lower.

The effect of the use of XPS, EPS, Rock Wool materials and PCM used in brick walls on the heating and cooling load of the building are given in Figure 15 and Figure 16.

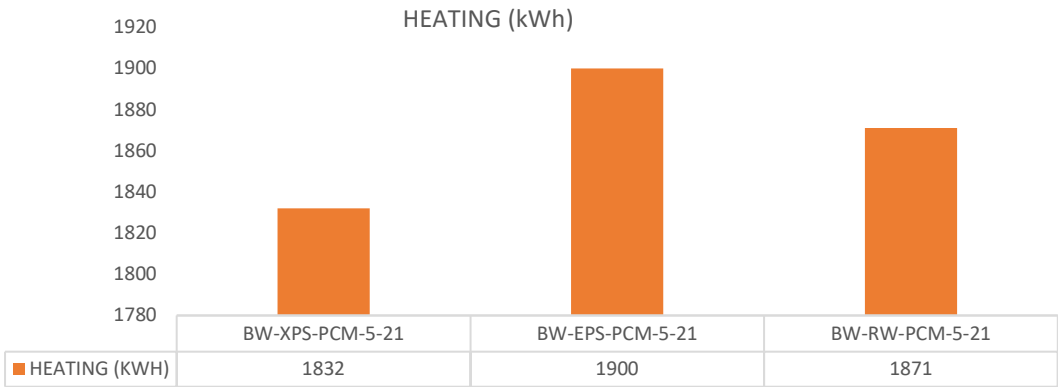


Figure 15 Effect of insulation materials and PCM 21^{o}C on heating load on brick wall

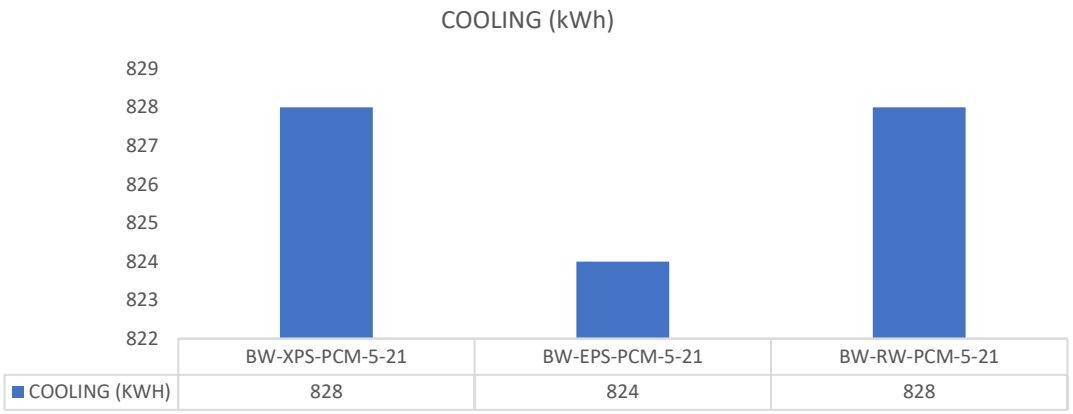


Figure 16 Effect of insulation materials and PCM 21^{o}C on cooling load on brick wall

When the heating and cooling load requirement graphs of the wall types where insulation materials and PCM are used on brick walls are examined, the wall type with a higher heating load requirement compared to other wall types is BW-EPS-PCM-5-21 with a value of 1900 kWh. The wall type with the lowest heating load requirement was BW-XPS-PCM-5-21 with 1832 kWh. In terms of cooling load requirement, BW-XPS-PCM-5-21 and BW-RW-PCM-5-21 walls with 828 kWh are followed by BW-EPS-PCM-5-21 wall type with 824 kWh.

The effect of using XPS, EPS, RW materials and PCM together in concrete block on the heating and cooling load of the building are given in Figures 17 and 18.

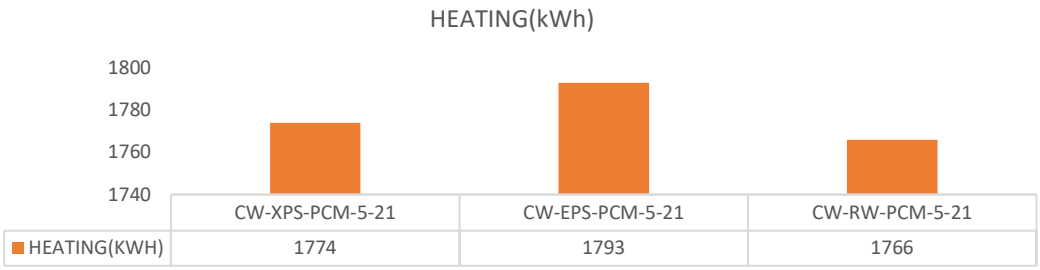


Figure 17 Effect of insulation materials and PCM 21°C on heating load in concrete block

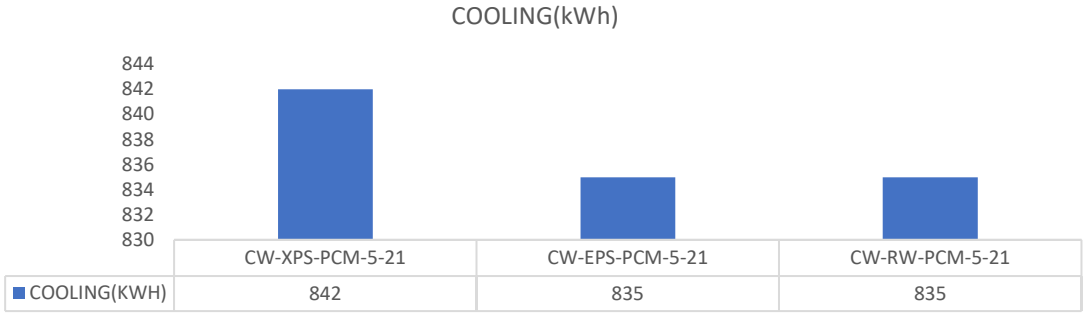


Figure 18 Effect of insulation materials and PCM 21°C on cooling load in concrete block

When the graph in Figure 17 is examined for the heating load requirement, the wall with the lowest load requirement is the CW-XPS-PCM-5-21 wall with a value of 1774 kWh. The wall type with the highest load requirement is the CW-EPS-PCM-5-21 wall with a value of 1793. Additionally, in Figure 18 the types of walls with lowest load requirement are CW-EPS-PCM-5-21 and CW-RW-PCM-5-21 walls with a value of 835 kWh. The wall with the highest load requirement is the CW-XPS-PCM-5-21 wall type with a value of 842 kWh.

The effect of the use of XPS, EPS, Rock Wool materials and PCM used in aerated concrete on the heating and cooling load of the building is given in Figures 19 and 20.

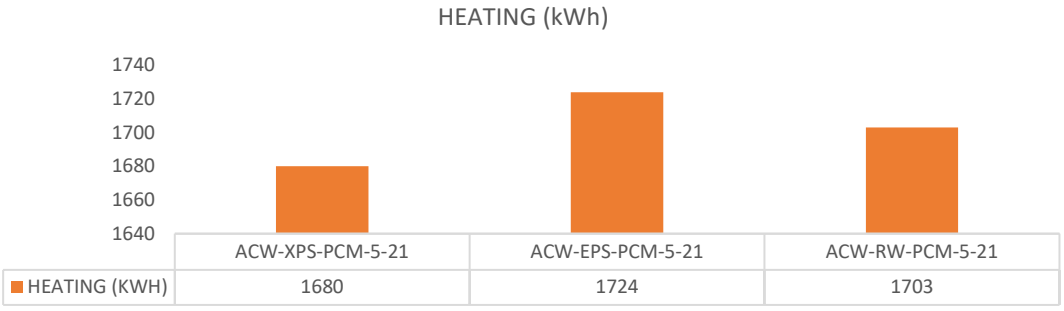


Figure 19 Heating load of PCM 21°C with insulation materials in aerated concrete

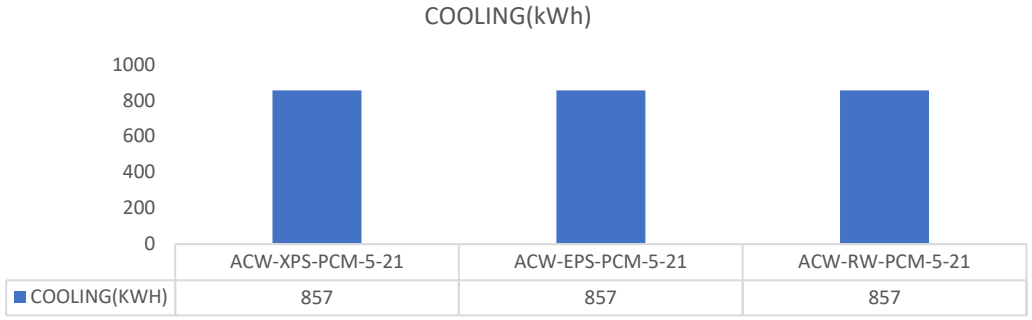


Figure 20 Effect of insulation materials and PCM 21°C on cooling load in aerated concrete

When the scenario results of aerated concrete are examined, the wall type that gives the best results for the heating load is the ACW-XPS-PCM-5-21 wall, which has a value of 1680 kWh. The wall type with the highest load requirement is the ACW-RW-PCM-5-21 wall with a value of 1703. When the cooling load requirement is examined, the cooling load requirement for the 3 wall types has a value of 857 kWh.

For heating load XPS with PCM presented better results for all Wall types while it is obligated for EPS with PCM when cooling load is the case. For heating load XPS which has a lower heat transfer coefficient provides better heat resistance and cause a decrease for the heating load. On the other hand melting point of PCM is again a decisive parameter for cooling load and it gives better result with EPS for all wall types.

4. Conclusion

In this study, the effect of phase change materials (PCM) on energy efficiency was investigated based on the Elazığ climate region. In the structure designed for the region, 3 wall cores (brick, concrete block, aerated concrete) were determined. In the analysis studies where the heating and cooling load values of the building were calculated, 39 scenarios were produced as a result of different combinations of uninsulated walls, PCM walls and insulation materials (XPS, EPS, Rock Wool). Scenarios are classified as use of insulation and PCM on the external wall, use of only insulation material, use of only PCM and use of PCM + insulation material. In addition, various scenarios were produced using different melting temperatures (21°C, 23°C, 29°C) and thicknesses (1cm, 5cm, 10cm) of PCM. As a result of the simulations made in the Design Builder program for all scenarios created, the total annual heating and cooling loads of the building were determined. In general, among the scenarios created on 3 types of wall cores, AEW-XPS-PCM-5-21, AEW-RW-PCM-5-21 and AEW-EPS-PCM-5-21 scenarios were determined to have the best performance in their groups.

In conclusion based on the uninsulated wall, it was determined that the use of PCM alone in all 3 wall types had an effect on both heating and cooling load. In wall types, the heating and cooling load required as a result of using only insulation material is lower than the energy required as a result of using only PCM. This shows that the effect of the insulation material on the heating and cooling load is better than PCM. This result was also supported by Konuklu and Paksoy (2011) previously as she studied the effect of PCM on building heating and cooling load for a 4m2 dwelling.

The effect of insulation materials on heating load gives different results in all 3 wall types. However, the cooling load values within each group were the same for all 3 insulation materials. It is seen that PCM has a positive effect on the annual heating load as a result of increasing its thickness in all 3 wall types as it was also determined by Alawadhi (2008). However, the energy savings provided in the cooling load did not continue in direct proportion to the thickness of the PCM, as in the heating load.

PCM with various melting temperatures (21°C, 23°C, 29°C) used in the building envelope has been decisive on the thermal energy efficiency of the building. Since PCMs with a melting temperature of 21 °C and 23 °C are generally in liquid form, they did not have much effect on the cooling load. However, it was determined that the energy performance of PCM at a melting temperature of 29 °C was better than the others. Konuklu and Paksoy (2011) also had concluded that the melting temperatures of PCMs used in summer should be higher to give better results.

Among the scenarios created, the wall scenarios with the best energy performance among the 3 wall types were the scenarios in which PCM and insulation material were used together as concluded by Castellón et al. (2006) and Konuklu and Paksoy (2011). The insulation material that gives the best results when used with PCM was determined to be XPS while in scenarios where PCM was used, its use with aerated concrete wall type gave the best results in terms of energy performance.

In general scenarios, 9% energy savings were achieved when PCM was used alone on an uninsulated wall, 25% when insulation material was used alone, and 30% when PCM and insulation material were used together.

As a result, PCM, which is used in addition to the insulation materials used in the building envelope to reduce the energy load of the building, has led to a decrease in the annual energy need of the building. The combined use of PCM and insulation material can be recommended for regions where the heating load is high.

According to the results obtained, it will be more effective to use PCMs with low melting points in cold climate regions, and PCMs with high melting points to be used in temperate and hot climate regions. In order to ensure the energy efficiency of the building both in summer and winter, using PCM with two melting temperatures instead of using PCM with a single melting temperature in the building envelope can be recommended as a more advantageous solution. Thus, the energy needs of the building can be reduced both in summer and winter.

The use of PCM, which is a different and innovative material from insulation materials, is increasing day by day due to its features such as its long life and its effect on heating and cooling load according to ambient conditions. Although it is expected that the use of PCM will increase further in the coming years, it is important to investigate the economic aspect of PCM and include it in studies in order to provide optimum benefit both in terms of energy and economy.

Acknowledgements

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Field study on determining the impact of design decisions on energy efficiency at settlement scale

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Abstract

Urban settlement patterns are a major factor affecting regional energy consumption and are also one of the causes of energy consumption from buildings on a global scale. For this reason, it is an important and necessary approach to ensure energy efficiency in settlement and structural scales, especially in large-scale projects designed in dense urban fabric, considering the various effects they will cause. Within the scope of this study, the effects of buildings on their surroundings at the settlement and structural scales are analyzed through a group of buildings that contain many functions within the urban fabric and spread over a large area. It is planned to determine the effects of the buildings within the scope of a multi-unit project consisting of a total of 10 blocks in Sakarya Serdivan and opened in 2021, which is clearly separated from the surrounding settlement, on the dense residential, commercial and educational units around them, considering environmental factors in the context of energy efficiency. With this study, it is aimed to reveal the importance of the decisions taken at the design stages for sustainable settlement planning within the urban texture. For this purpose, firstly, a literature review was conducted on the contribution of decisions taken at the settlement and structural form scales in preventing/reducing energy consumption and energy efficient design criteria for the geographical location of the building group under consideration. In this direction, it is aimed to determine the compliance of the buildings in the existing design with these criteria and the effects of the buildings on the built environment at close scale and on the built environment with Autodesk Forma software, which can perform solar analysis, microclimate and comfort analysis with artificial intelligence support by enabling environmental analysis at these scales. Thus, the environmental impacts caused by the building group within itself and within the urban fabric and their relations with settlement geometries such as building layout types, building orientation and forms of buildings were evaluated.

Keywords: artificial intelligence, autodesk forma, energy efficiency, settlement scale

1. Introduction

Today, a large part of the population is concentrated in cities due to changing factors, especially social and economic factors. This situation leads to a rapid increase in urbanization. It is estimated that two-thirds of the world's population will be in urban settlements by 2050 with the population concentrated in these cities and the continued increase in urbanization (UN DESA, 2014). However, energy consumption in urban settlements is increasing with the effect of today's living standards. Urban settlements are responsible for 75 per cent of global primary energy consumption and 70 per cent of global carbon emissions (UN-Habitat, 2020).

Considering all these, it is seen that cities play a major role in reducing energy consumption. Energy performance assessments at settlement scale are limited and less developed compared to building scale and regional scale studies. In this case, lack of assessment tools and difficulties in accessing data are the main reasons. However, studies at this scale are important as they consider urban form and energy performance. While energy systems in buildings can be changed in the

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shorter term and occupants' behavior can change, urban form can have a longer lasting impact on energy consumption, both positive and negative. This is because the performance of the energy system depends on the behavior of building occupants, but compact urban forms are not affected by user behavior (Beygo & Yüzer, 2017; Wener & Carmalt, 2006). For this reason, energy saving measures to be taken at urban scale are of great importance in our country where urban settlements are increasing rapidly.

Stromann-Andersen and Sattrup concluded that the geometry of the settlement has an impact of up to 19% in residential buildings and 30% in office buildings on total energy consumption and revealed the importance of design (Stromann-Andersen & Sattrup, 2011). However, since there are many variables in residential design, it is not possible to reach an absolute truth among unlimited alternatives by making generalizations (Oke, 1988). At this point, for each design, location-dependent analyses and planning should be made according to the design parameters. Since the design decisions taken at the settlement scale will have an impact on energy consumption throughout the lifetime of the buildings, it is important to develop solutions that will provide optimum energy performance according to energy efficient design parameters.

Research on this topic in the context of sustainable urban settlement in terms of energy consumption in Turkey and the Mediterranean region: In order to minimize energy demand and environmental impact for a sustainable 'urban balance' and sustainable urban growth in general, significant energy savings can be achieved by combining passive heating, cooling and daylighting techniques as well as the integration of renewable resources to minimize energy demand and environmental impact, taking into account building design parameters such as the location of buildings, building form, orientation relative to each other, as well as environmental data at the design stages (Ascione et al., 2017; Ayçam et al., 2020). Similar studies have evaluated the impact of outdoor microclimate improvements on building energy performance, and studies have been conducted to determine the best building layout size that can optimize building energy performance and energy production (Cardinali et al., 2020).

To address such urban solutions and challenges, the rapid development of computing technology, including Artificial Intelligence (AI), offers new opportunities in various sectors, including urban design (Batty, 2018). Therefore, the use of AI in urban design integrated with the smart city concept not only responds to today's challenges, but also paves the way for developing smarter, more efficient and sustainable cities in the future (Kurniawan et al., 2024). In this context, Forma, Autodesk's next generation architecture software, was used for modeling the case study and performing analysis simulations within the scope of the study. Another main objective here is to investigate the role of technology in supporting sustainable urban planning and the data and services offered by the software to the user.

1.1. Methodology

Within the scope of the study, through literature review, the design parameters affecting the suitability of buildings as energy efficient settlement and form according to different climatic and geographical positioning were determined and the climatic and geographical characteristics of the region where the selected building group is located were specified. In this way, for the buildings considered in the study, certain design parameters have been put forward to ensure energy efficiency at the settlement scale. In line with these parameters, Autodesk Forma, which offers analysis and simulations developed with new architectural software technologies, was used to examine the energy efficiency of the selected building group and its effects on the surrounding settlement. Inferences were made on the suitability and energy efficiency of the buildings in the case study according to the local design parameters, and the energy performance and energy performance of a dense building group, which was created on an almost empty land where there was only one low-rise building before, and which was positioned higher than its surroundings, were analyzed. Thus, the importance of designing buildings on an urban scale, especially buildings that will be spread over a large area as in the example, by taking advantage of the fast data provided by

the developing architectural software technologies in this context, by considering the energy efficiency of the buildings according to their climatic and geographical characteristics has been revealed (Figure 1).

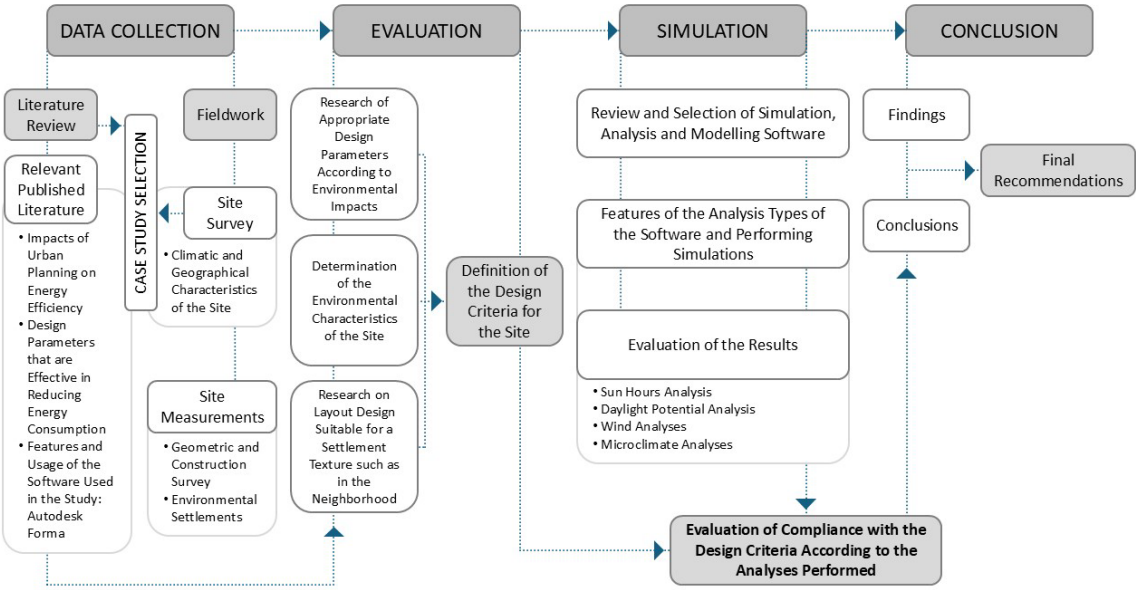


Figure 1 Methodology of the study

1.2. Research Questions

What are the appropriate criteria that can be proposed to ensure the energy efficiency of buildings in different climatic conditions in form and layout scales, according to the characteristics of Sakarya/Serdivan region within the scope of the study, how do today's architectural technologies affect the applicability of these criteria in new or existing buildings, and what kind of strategy can be proposed?

2. Parameters Affecting Energy Efficiency

2.1. Climate

Climate is the name given to the average of meteorological phenomena such as temperature, humidity, air pressure, wind, precipitation, precipitation pattern observed in a place over a long period of time. Climate types can be classified by looking at conditions such as temperature and precipitation regime. However, the most widely used classification system today is the Köppen climate classification (Figure 2) developed by Wladimir Köppen (Climate, 2024). According to Köppen climate classification, Turkey, which is located in the temperate climate zone, is considered as five climate zones as hot-humid, hot-dry, temperate-humid, temperate-dry and cold (Erinç, 1996; Yılmaz & Çiçek, 2016; Zeren, 1978; Zeren, 1987; Koca, 2006).

Figure 2 Map of Turkey's climate zones (Koca, 2006)

Climates are formed by the combination of temperature, pressure, wind, humidity and precipitation. These directly affect the built environment organization as observable and measurable climate variables (Kısa Ovalı, 2009). Accordingly, it can be said that climate should be considered as a leading factor in the context of energy efficiency in the design phase of buildings.

2.2. Location and Orientation

The existing building layout, vegetation, sun and wind are important environmental factors that should be considered in the context of energy efficiency of buildings. The topographical positioning and orientation of buildings, together with the climate factor, directly affect solar gain and indirectly affect heat losses and gains. For this reason, it is necessary to choose a suitable location in the topographical layout according to the climate, taking into account the solar radiation and air currents that constitute natural data in the early stages (Figure 3) (Umaroğulları & Cihangir, 2019; Beygo & Yüzer, 2017).

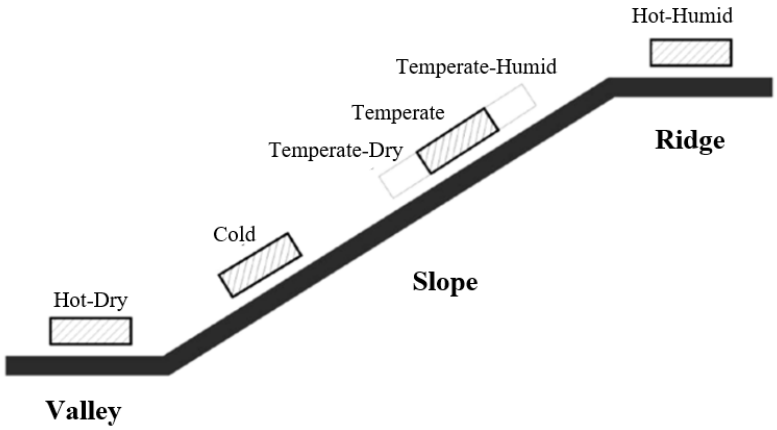


Figure 3 Suitable topographic locations according to climatic characteristics (Zeren, 1978)

When orienting the facades of the buildings, an appropriate orientation created depending on the direction of the sun and wind will minimize the energy loads and the negative effects of the climate (Table 1; Table 2).

Table 1 Suitable Building Orientations According to Different Climate Zones (Orhon et al., 1988)

Hot-Humid	Hot-Dry	Temperate-Humid	Temperate-Dry	Cold
Large surface: S → 3° E Open to wind	Large surface: S → 18° E Openings in courtyard direction	Large surface: S → 13° E Giving large surface to the wind	Large surface: S → 27° E Not giving wide openings to the wind	Large surface: S → 24° E Closed to wind

Table 2 Suitable Building Orientations According to Different Climate Zones (Orhon et al., 1988)

Climate Zone	Optimum Direction S E	Good Directions W S E
Hot-Humid	3°	10° 19°
Hot-Dry	18°	0° 40°
Temperate-Humid	10°	13° 35°
Temperate-Dry	27°	10° 56°
Cold	22°	20° 45°

2.3. Building Form

Solar radiation and wind effects should be taken into consideration when determining the form and shape of buildings in order to ensure minimum heat loss and minimum heat gain (Orhon et al., 1988). Compactness in building volumes is one of the most important criteria in energy efficiency (Koca, 2006).

As compact forms minimize heat transfer, they also reduce energy consumption, while building designed by giving a large surface to the optimum direction has more opportunity to benefit from solar radiation than other forms and positioning. In buildings that give a large surface to the prevailing wind, an increase in heat losses and a decrease in heat gain can be achieved compared to compact forms. These variables should be evaluated in harmony with the climate where the building is located (Table 3). Positioning the building elements according to the sun and prevailing wind reduces the heating and cooling loads of buildings (Orhon et al., 1988; Bayraktar & Yılmaz, 2007; Beygo & Yüzer, 2017). For different forms surrounding the same volume, the external surface area of the building and the amount of heat lost and gained from the external surfaces will also be different (Yılmaz et al., 2000).

Table 3 Building Forms Suitable for Different Climatic Zones (Orhon et al., 1988)

Hot-Humid	Hot-Dry	Temperate-Humid	Temperate-Dry	Cold
Surface open to the wind, raised from the ground, close to a long rectangle.	With courtyard, square base, with surfaces open to the interior.	Rectangular or free plan, S, S → 13° E with large surface to the wind at ESD.	Closed to the wind at EASD, S, S → 27° E with large surface, compact form close to square.	Facing the wind with little surface, minimizing the outer surface, giving a large surface to S, S → 24° E, compact, square, etc. based.

2.4. Building Envelope

The building envelope is one of the most important parameters under the control of the architect in providing energy and climatic comfort, consisting of all horizontal, vertical and inclined building components that separate the indoor environment from the outdoor environment, shaped depending on the physical environmental factors (Kısa Ovalı, 2009; Koca 2006). Properties of the building envelope such as absorption, transmittance and reflectivity properties against solar radiation related to heat and moisture transfer, slope of the envelope, total heat transmission coefficient, time delay, amplitude reduction factor are very effective in determining the heating, cooling and lighting energy costs of the building (Zorer, 1992; Umaroğulları & Cihangir, 2019).

For this reason, while designing the building envelope, it is necessary to determine the heat, light, humidity and sound permeability in a way to provide the necessary comfort, considering the climatic and environmental conditions of the region (Table 4).

Table 4 Building Envelope Properties Suitable for Different Climate Zones (Orhon et al., 1988)

	Hot-Humid	Hot-Dry	Temperate-Humid	Temperate-Dry	Cold
Surface Texture	Rough. Shaded (horizontally).	Horizontally and vertically with large indentations and protrusions.	Smooth	Smooth	Smooth

Surface Color	Light color (reflective)	Light color (reflective)	Color lightness at average value	Color lightness at average value	Dark color (absorbent)
Roof Shape and Orientation	Flat or pitched. S → 3° E Shaded Double layered (Cold roof)	Flat or pitched. S → 18° E Shaded Double layered (Cold roof)	Flat or pitched. S → 13° E Double-single layered	Pitched S → 27° E Double-single layered	Pitched S → 24° E Single Layered

2.5. Planning of Settlement Area

Analyzing the settlement areas where the buildings are planned and positioning them in a suitable area constitutes an important design criterion in terms of energy efficiency as it will affect solar and wind gains according to the distances, heights and locations of the surrounding settlement texture and open spaces within itself (Beygo & Yüzer, 2017; Umaroğulları & Cihangir, 2019; Kun, 2005). The location of the buildings in densely built-up areas such as cities and the location of the buildings in rural areas with less built-up areas constitute an important difference in terms of energy efficient design. In addition, it should be taken into consideration that the settlement texture, scales and interrelationships of the buildings, streets, green areas such as parks directly affect the microclimate (Umaroğulları & Cihangir, 2019; Kun, 2005).

Reducing the exposure of buildings to sunlight in summer and increasing it in winter, increasing natural ventilation in summer and providing protection from the wind in winter according to the prevailing wind direction and speed will contribute to reducing the energy required for heating. Preventing wind corridors between buildings in terms of comfort is another point to be considered. Topography, neighboring buildings, vegetation, solar radiation, wind direction and speed have a very important effect on energy efficiency (Beygo & Yüzer, 2017).

Table 5 Suggestions for the Positioning of Buildings in the Formation of the Settlement Texture according to Different Climatic Zones (Orhon et al., 1988)

Hot-Humid	Hot-Dry	Temperate-Humid	Temperate-Dry	Cold
Shifted so as not to interfere with wind direction and spaced greater than 7H apart. Spaced greater than 2 1/2H with no obstruction to sunlight at EASD. Homogenous height.	Compact, with courtyards, blocking the sun's rays on vertical and horizontal surfaces in ESD. Horizontally spread and low-rise.	Spaced less than 5H downwind at EASD, shifted downwind at ESD and spaced greater than 7H. Spaced greater than 3H, not blocking solar radiation at EASD. Homogenous height.	Compact, spaced less than 5H in the wind direction at EASD.	Intermittent to less than 5H in EASD in wind direction. Not obstructing sunlight at EASD. 2 Spaced greater than 1/5H. Homogeneous spread and height.

3. Case Study

The building group selected as a sample is in the middle of a settlement of smaller-scale building units and one similar-scale building with a similar function to the north, located in Sakarya/Serdivan, which has a temperate-humid climate. The project, which includes residential areas, offices, shops and indoor/outdoor car parks in addition to its commercial function, was opened for use in 2021. Consisting of 10 blocks and spread over 52 thousand square meters, the building group divides the land into two areas with the concepts of ‘indoor shopping center’ and ‘street bazaar’ at the city ground level (Figure 4).

On the west side facing the boulevard, there are 1 floor above ground 1 floor trade and 3 floors of office blocks above; on the south side facing the axis coming from the city center, there is 1 floor above ground 1 floor trade and 2 floors of apartment units/studio apartments above. The blocks are higher than the other buildings in the neighborhood and are positioned parallel to the street side of the parcel with a 6° deviation from the north-south axis towards the west.

Figure 4 Project site plan and views (Evrenol Architects)

The site's environment and location are design criterion that has an impact on climate control and energy consumption. Near the site, there are 4-5 story apartment buildings with commercial units on the ground floor, 2-3 story villa type residences and education units, although not too many. Serdivan Shopping Mall located in the north of the area is the largest commercial building and with its large car park in the south, it makes the building group open to the prevailing wind coming from the north (Figure 5).

The compact forms and layouts of the building masses, which are generally positioned on the east-west axis around the area, reduce the heat gain of north-south winds, while the low heights of the buildings enable the utilization of solar radiation.

Figure 5 Urban form in and around the selected area

In the study area, the land is orientated towards the west with a deviation of approximately 6°. The plot spreads over a flat area without any slope. The plot continues its commercial function between the shopping center to the north and the bazaar axis to the south, and is framed by smaller commercial units, residential and educational units around the plot. (Permissions were obtained from the relevant authorities and architectural office for the visuals used in the modeling and presentation of the site.)

3.1. Study Area and Climate

Serdivan is located in the west of Sakarya Province center in the Eastern Marmara Region. Serdivan is one of the closest settlements to the transport network. It is built on the hills at the extreme points of the Adapazarı plain. A part of Sapanca Lake is within the borders of the district. While the ratio of forested area to the general area of Sakarya Province is around 44%, this figure is quite low for Serdivan. Serdivan forest and green area ratio is 16,8%. The general quality of the

forests is in the type of degraded grove and normal coppice. Oak type trees are predominant. Serdivan has become the fastest growing and most favorite district of Sakarya. The region, which has productive agricultural areas until today, has become a preferred place for residence in recent years (URL2).

Climate of the Site: It should be noted that in addition to the standards in zoning regulations, the geographical structure and climate play a role in the preference of Serdivan district. In addition, factors such as the ground structure of the hills; the relatively low humidity rate in the climate compared to other districts in the metropolitan area and the wind-receiving situation; the fact that a part of Sapanca Lake is within the borders of the district are effective on preferences (URL3).

Average High and Low Temperature in Serdivan (Figure 6):

- Black Sea climate and temperate climate prevails. Serdivan is generally windy.
- Summers in Serdivan are warm, humid and clear, while winters are cold and partly cloudy.
- The hottest month is August, and the average temperature is 23°C, the coldest month is January, and the average temperature is 6°C. The average annual temperature in Serdivan is 14°C.

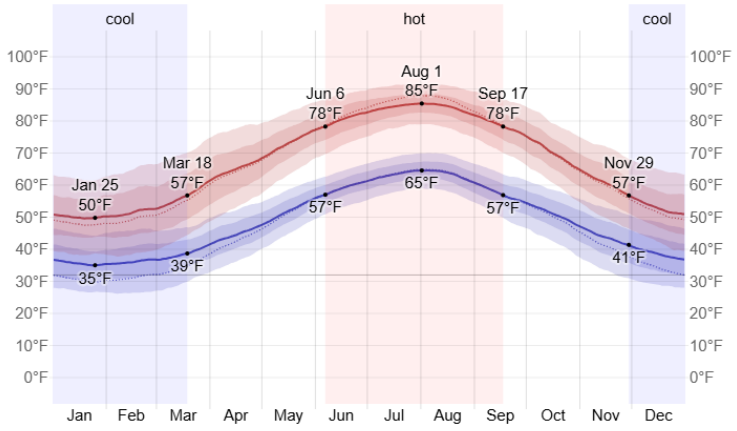


Figure 6 Average high and low temperature in Serdivan (URL4)

Sunny Hours and Cloud Cover: Serdivan day length varies significantly throughout the year (Figure 7).

- In 2024, the shortest day occurs on 21 December with 9 hours and 15 minutes of daylight, while the longest day occurs on 20 June with 15 hours and 6 minutes of daylight.
- The mean percentage of cloud cover in the sky in Serdivan shows extreme seasonal variations throughout the year.
- The clearest month of the year in Serdivan is July; during this month the sky is 95% clear, mostly clear or partly cloudy.
- The cloudiest month of the year in Serdivan is December, during which the sky is overcast or mostly cloudy 62% of the time.

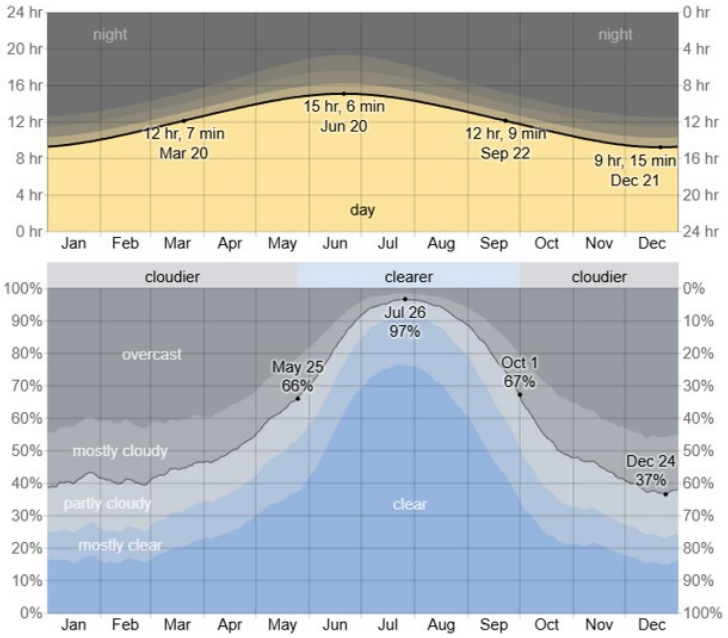
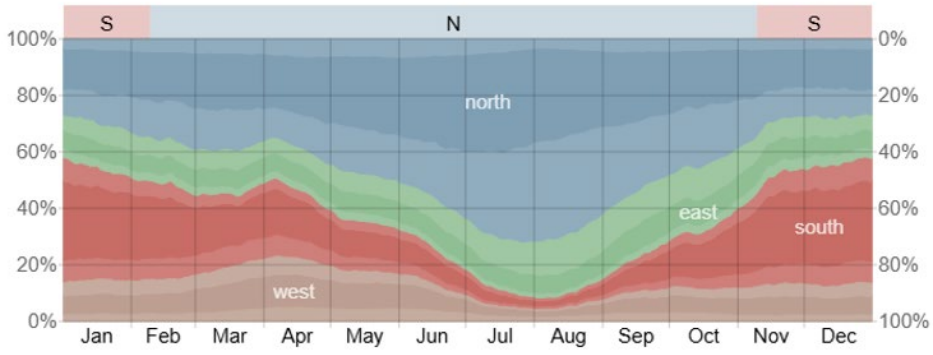


Figure 7 Serdivan sunrise and dawn hours, cloud cover categories (URL4)

Microclimate, Wind and Humidity: Serdivan is generally windy. The prevailing average hourly wind direction in Serdivan varies throughout the year (Figure 8).

- The wind was generally from the north for 9.0 months from 9 February to 9 November with a maximum of 72% on 26 July.
- The wind generally blows from the south with a maximum of 44% on 1 January for 3.0 months from 9 November to 9 February with a maximum of 44%.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wind Speed (mph)	6.8	7.1	6.7	5.9	5.5	5.8	6.6	6.8	6.2	6.0	6.1	6.6

Figure 8 Wind direction and speed in Serdivan (URL4)

There are extreme seasonal variations in the perceived humidity in Serdivan (Figure 9).

- The muggiest period of the year lasts for 3.1 months from 10 June to 14 September, during which time the comfort level is muggy, oppressive or unbearable by at least 13%. The muggiest days in Serdivan are in August, during which the weather is muggy or worse for 13.7 days.
- 21 February is the least muggy day of the year and muggy weather conditions are almost non-existent.

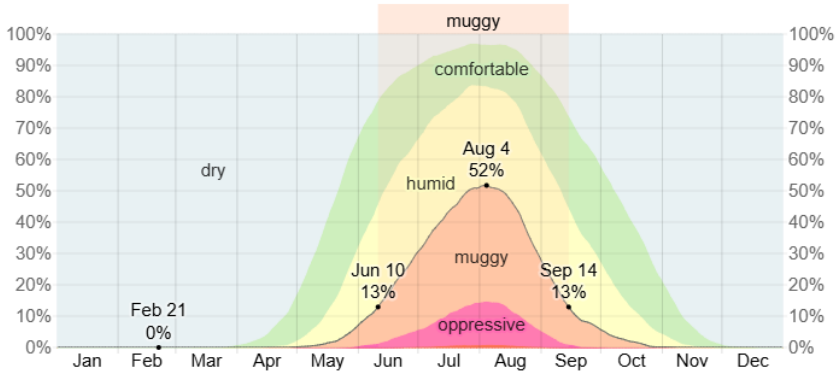


Figure 9 Serdivan humidity comfort level (URL4)

3.2. Appropriate Design Criteria's According to Characteristics of the Site

Due to the temperate-humid climate in Sakarya/Serdivan, where the study area is located, buildings should aim to protect from the wind and benefit from the sun as heat and illumination in the cold period, while in the hot period, wind should be used to break the uncomfortable power of humidity, natural ventilation should be created and designs should be created to provide protection from the sun (Table 6).

These climate zones provide the most architectural solutions. By establishing a close relationship between nature and housing, planning should be organized freely. In particular, the negative effect of humidity should be reduced by organizing the space in a way to create natural air flow (Kısa Ovalı, 2009).

Table 6 Climatic Design Criteria for Buildings in Temperate-Humid Regions (Orhon et al., 1988)

Location and Orientation	Building Form	Building Envelope	Planning of Settlement Area
• Large surface: S → 13° E • Optimum direction: 10° south to south-west • Good orientations: 13º southwest to 35º southeast • Current orientations: 23º south-west - 49º south-east	• Large surface to the wind in ESD. • Rectangular or free plan. • S, S → 13° E with wide surface.	• Smooth surface • Color lightness at average value • Pitched or flat roof types • S → 13° E roof direction • Double-single-element roof form	• Less than 5H in EASD in the direction of the wind, intermittent to intermittent • Shifted in the wind direction at ESD and intermittent greater than 7H • Spaced larger than 3H, not blocking solar radiation in EASD. • Homogeneous height

3.3. Modelling and Analysis Tool Used in the Study: Autodesk Forma

Autodesk Forma is a browser-cloud based conceptual design toolkit that offers AI-powered environmental analyses. Forma also enables modelling in the context of the city, bringing in open city data to place the design on the existing skyline.

Looking beyond modelling capabilities, Forma supports real-time environmental analyses across key intensity and environmental attributes such as wind, daylight, sunlight, and microclimate, delivering results that do not require a lot of deep technical expertise. Forma is based on a unified database that can store all data from an AEC project in a 'data lake'. The move from a world managed by files to a single unified database provides a wide range of benefits, not only for collaboration but also for individual users (AEC Magazine).

This software was preferred both to measure the energy performance of the building group at the settlement scale and to evaluate Autodesk's new generation artificial intelligence and cloud-based tool in BIM.

The whole of the buildings in the area were analyzed with Autodesk Forma Artificial Intelligence Based BIM tool in terms of their environmental impacts during the usage phase. The impact of each building unit on the site and its surroundings was evaluated. In Forma, the area to be analyzed and its surroundings were determined on the map, and the buildings in the area and the surrounding settlement were modelled with height and floor area data (Figure 11 & 12). Then, the area was selected as a selection zone and sunshine hours, daylight potential, wind and microclimate analyses were performed for the buildings and their surroundings (Figure 10).

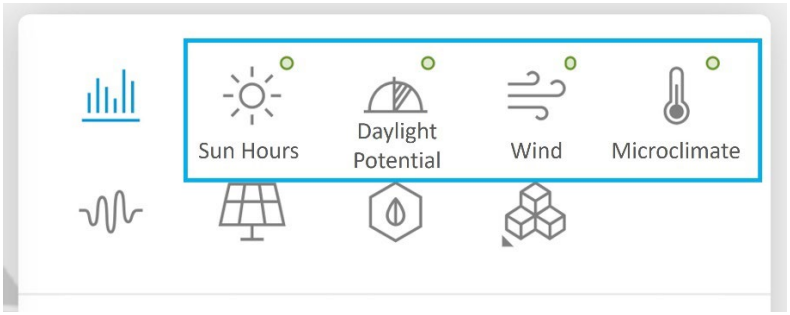
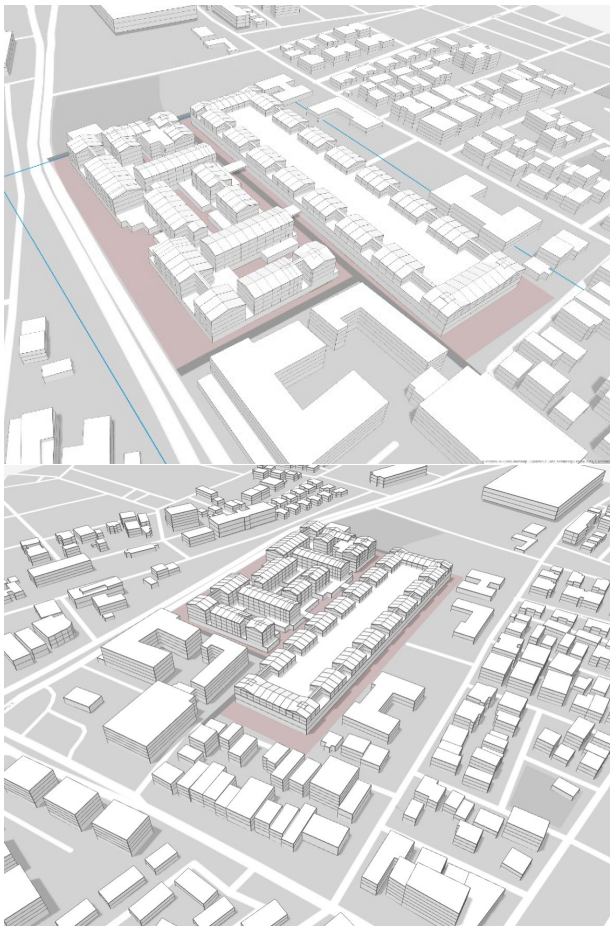


Figure 10 Analyses used in the study context



Figures 11 & 12 Model created in Autodesk Forma

3.4. Performing Analyses

3.4.1. Sun Hours Analysis

With this analysis, sunlight hours on site and in buildings are calculated using ray tracing techniques as well as sun positions throughout the day for the location on earth and the selected date. It is also possible to analyze the percentage of direct sunlight hours on building facades and ground surfaces (Table 7) (Autodesk). The purpose of its use in the study is to ensure that the

sunshine hours, which have a negative effect in summer and a positive effect in winter, are evaluated within the scope of all blocks.

Table 7 Characteristics of the Sun Hours analysis (Autodesk)

Areas and objects included	Shading from project surroundings within the model such as buildings or other objects, terrain, vegetation.	**Area coverage**	Buildings within the entire model area or buildings and ground area within the selected site limit or zone.
Technology and calculation	Uses ray tracing technology (OptiX™ Ray Tracing Engine by NVIDIA). Rays are traced from each measuring point in the direction of the sun to determine if the point is in shadow at a given time.	**Assumptions**	• Clouds/weather are not considered in the sunlight calculation. • The analysis accounts for daylight savings time. • Sun rays are sampled every 6 minutes.
Time to complete	30s to 3min depending on the area size.	**Data sources and models**	Sun positions for each time and location is calculated using Bretagnon's VSOP 87 theory.

For this analysis, June 20, the longest day of the year in Serdivan, December 21, the shortest day of the year, and March 21, when the day and night periods are equalized, were selected according to the information on the climatic characteristics of the area in the previous titles in order to analyze the insolation periods of the ground and buildings in the area according to different periods.

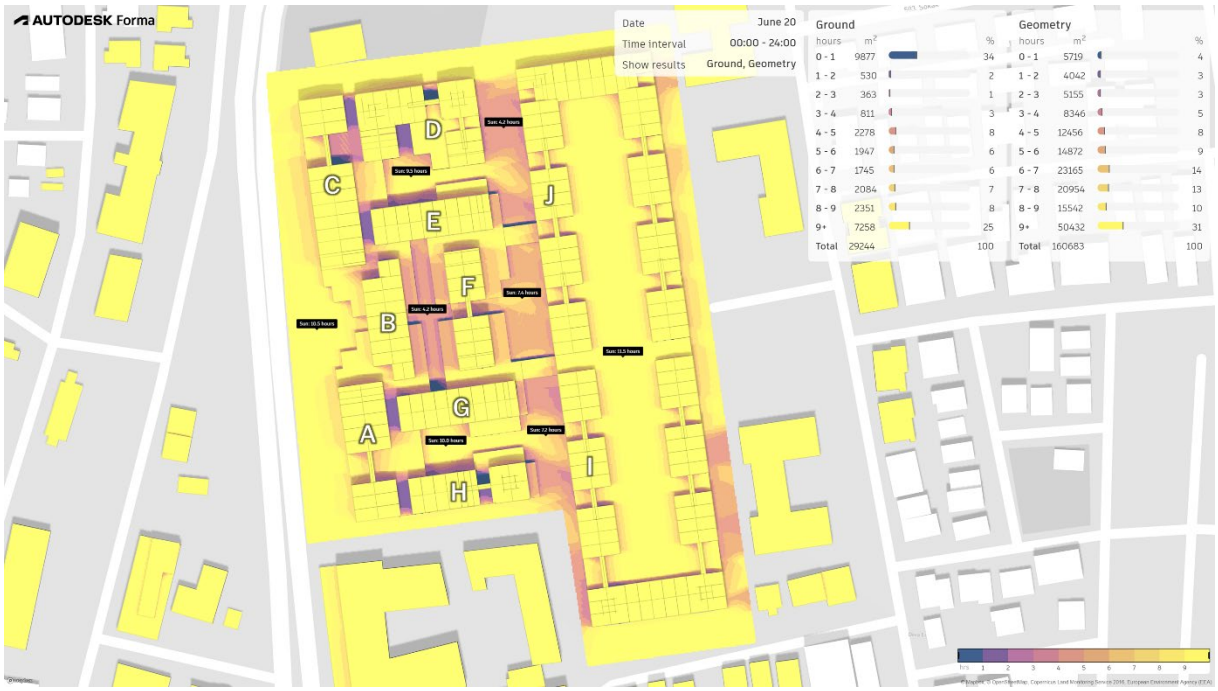


Figure 13 Sun hours analysis for June 20

On this date the day length is 15 hours, and solar gain needs to be reduced (Figure 13);

- The courtyards created offers comfortable open spaces at this date.
- The compact form of block D and the north orientation of its large surface make its summer behavior a little more energy efficient than the other blocks in the area.
- It is seen that heat gain will be high in blocks J and I.
- In blocks J and I, cooling energy consumption is expected to be high due to their relatively empty surroundings and high exposure to solar radiation from the flat roof over the covered shopping center.

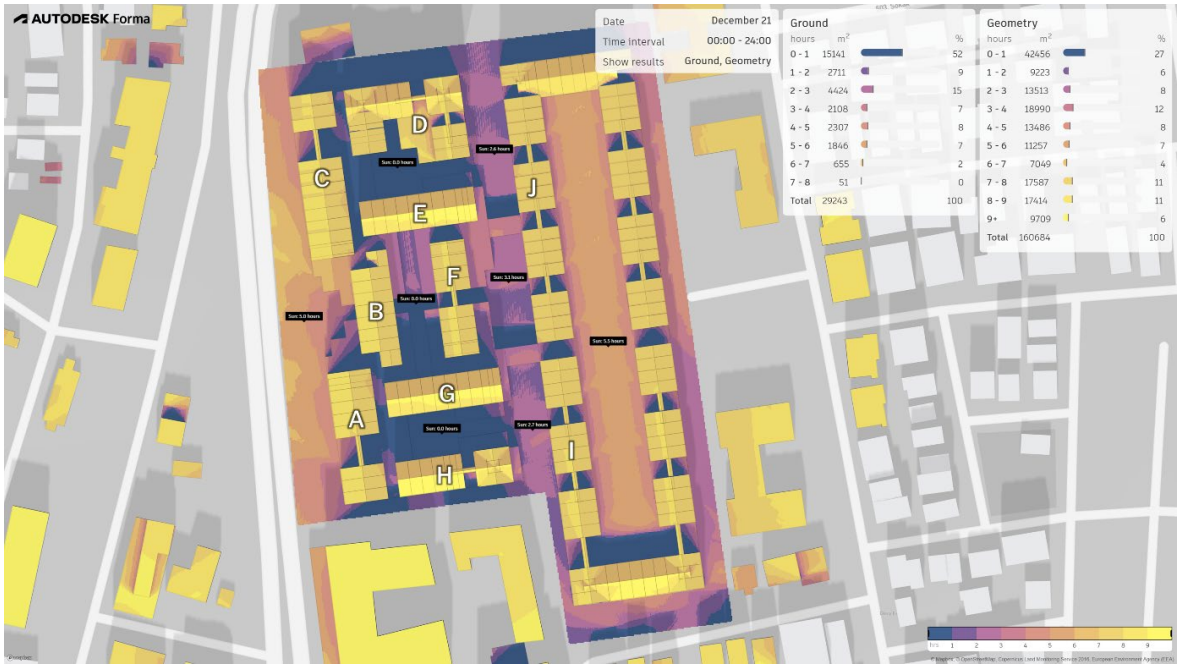


Figure 14 Sun hours analysis for December 21

At this date that solar gain should be increased (Figure 14);

- Heat loss is high in the courtyards and corridors.
- Although D block has a more compact form compared to other blocks, it is clear that the energy consumption required for heating is high in D block and G block.
- The energy consumption will be lower in block I in the cold cycle compared to other blocks in the area.
- It is seen that the building group has reduced the solar gain of the two educational units on the east side.

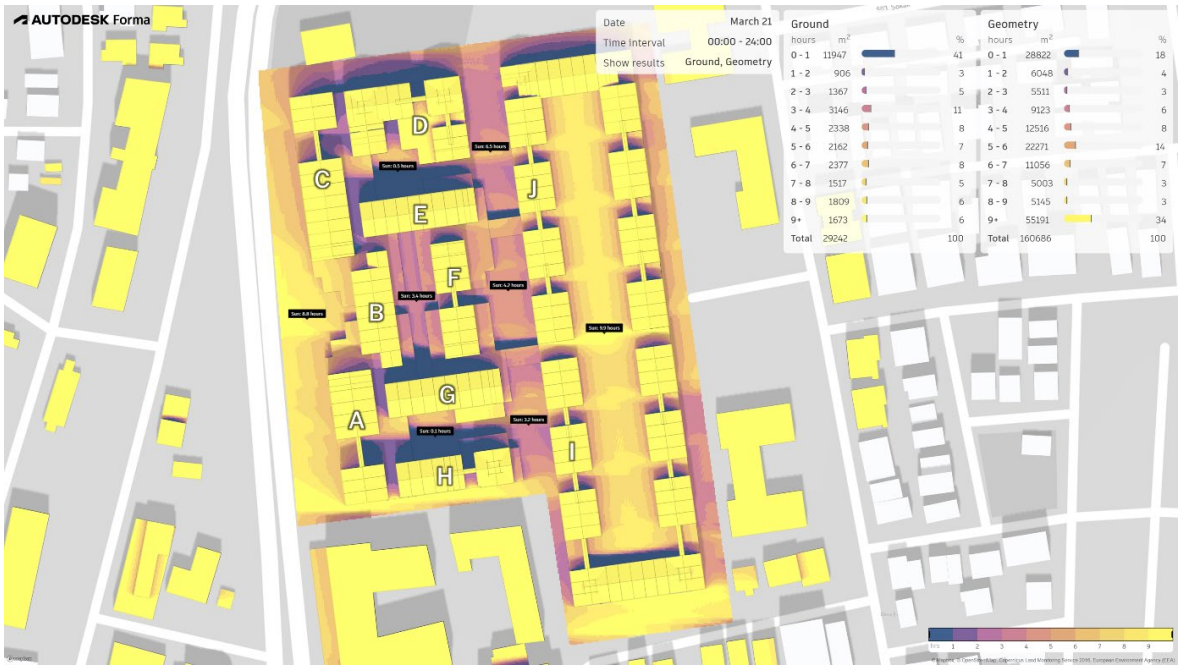


Figure 15 Sun hours analysis for March 21

At this date, when the heat flow is intended to be delayed (Figure 15);

- It is seen that the difference in sun hours between different areas in the landscape is high.

- The courtyards will be cooler during the day.
- The temperature difference between the north and south facing facades of blocks H and I-J will be high.

3.4.2. Daylight Potential Analysis

This analysis visualizes the daylight potential in the context of the surrounding buildings and environment.

This Analysis uses a cloudy sky model and estimates the illuminance on building surfaces using the Vertical Sky Component (VCS) score percentage method. This percentage indicates how much light from the sky illuminates the surfaces in your model relative to the illumination on an unobstructed horizontal surface. The maximum score for the Vertical Sky Component score is approximately 40%. The analysis results are divided into color groups using the thresholds in this table (Tables 8 & 9). For non-vertical surfaces the scores can go up to 100% (Autodesk).

The aim here is to examine the illumination effect of the blocks on each other and on other buildings according to the illumination percentages of the facades of the blocks. Thus, it is to identify the parts of the facade that have less access to daylight.

Table 8 Characteristics of Daylight Potential Analysis (Autodesk)

Areas and objects included	Takes into account shading from project surroundings in the model such as buildings or other objects, terrain, vegetation.	**Area coverage**	Buildings within the model area or selected site limit or zone.
Technology and calculation	The analysis uses a model of an overcast sky and predicts illumination on building surfaces using the Vertical Sky Component (VCS) method. The illumination is predicted using ray tracing technology (OptiX™ Ray Tracing Engine by NVIDIA).	**Assumptions**	• The overcast sky model is independent of the sun and weather conditions and represents a heavily clouded day, September 21st • The geometry of trees is included in the analysis, treated in the same way as other geometries • The terrain outside of the defined map area in the respective project is not considered • The VSC analysis do not take into account window sizes, building materials, room sizes or room functions.
Time to complete	30s to 3min	**Data sources and models**	CIE standard overcast sky model.

Table 9 Vertical Sky Component Scores

VSC < 5%	5%< VSC < 15%	15% < VSC < 27%	VSC ≥ 27%
Achieving reasonable daylight is often impossible.	Difficult to provide adequate daylight.	Larger windows/changes in layout are usually needed.	Conventional window design usually satisfactory.

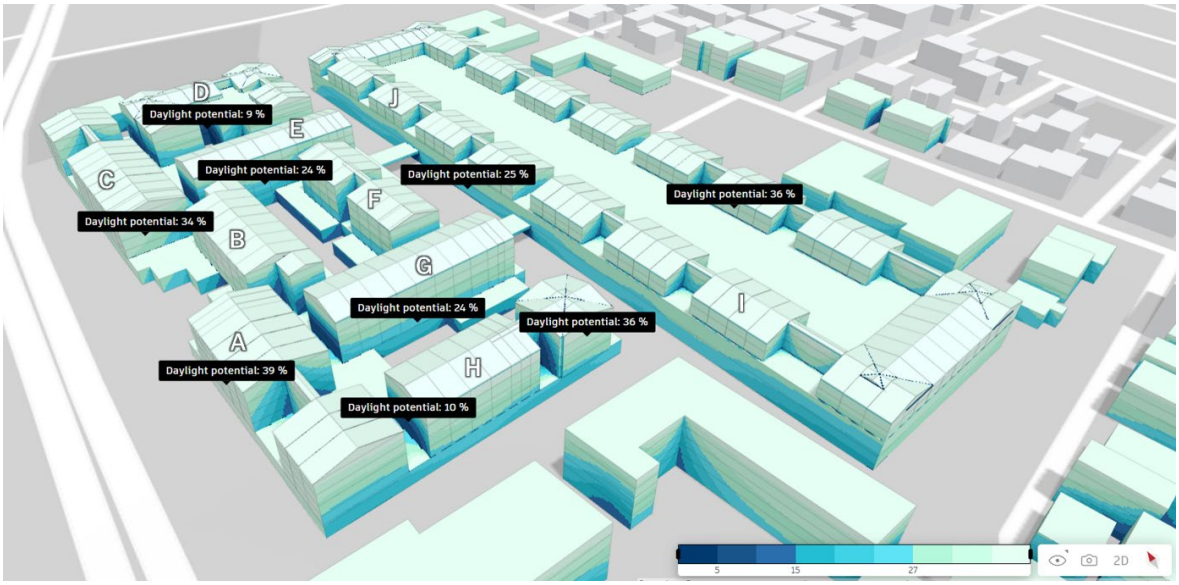


Figure 16 Daylight potential analysis performed in the study area

As a result of the analysis, the forms of the buildings and their positions to each other and the light and shadow areas formed on the facades were determined. The results show that the daylight potential is low on the ground and first floors and in the corridors between the blocks. This shows that cooling energy will be higher on the upper floors in summer and heating energy will be higher on the lower two floors in winter (Figure 16).

3.4.3. Wind Analyses

Wind analysis shows building and site effects on local air flow patterns. There are two types of wind analysis in Autodesk Forma: Fast Wind analysis and Detailed Wind analysis. In Detailed Wind analysis, results are obtained in a long time compared to computational fluid dynamics simulations, while in Fast Wind analysis, results are obtained in a few seconds compared to previous simulations with artificial intelligence support. In both analyses, wind-related comfort and wind speed data are presented to the user (Autodesk).

The purpose of using this analysis in the study is to evaluate the effects of the air flow created by the blocks between each other and the surrounding structures. Thus, comfort and velocity analyses will be obtained with the north direction wind prevailing in the region during the summer season when the positive effect of the wind will be examined, and with the south and north direction wind prevailing in the region during the winter season when the negative effect of the wind will be examined.

3.4.3.1. Rapid Wind Analysis

Rapid wind analysis can be performed within a circular area with a variable between 150 m and 350 m. It performs a rapid analysis using an Artificial Intelligence-supported predictive wind model. It has been put into use in order to provide instantaneous wind control especially when designing (Table 10).

Table 10 Characteristics of Rapid Wind Analysis (Autodesk)

Areas and objects included	Considers terrain, vegetation, proposal buildings and context buildings in a square centered around the analysis circle - 100m out from the analysis circle in all directions.	**Area coverage**	The rapid analysis area is a circle of variable radius between 150 m (~500 ft) and 350 m (~1100 ft)
Technology and calculation	Uses a machine learning model trained on previously run	**Assumptions (if applicable)**	• The same assumptions as the detailed wind analysis.

	calculations of our detailed wind analysis simulations, to replicate the dynamics of those simulations and hence the physics of wind.
Time to complete	1 second - 3 seconds

	• Buildings taller than 100 m will be clipped at 100 m in the rapid analysis input.
Data sources	Previous runs of the detailed wind analysis.

Figure 17 Rapid wind comfort analysis

Figure 18 Rapid wind speed-direction analysis

With this quickly generated analysis data, there is a state of wind protection in the courtyards, and the wind is felt more in the north-south oriented corridors. This shows that the building group creates wind corridors in the long, north-south axis gaps that it creates within itself and with the surrounding settlement (Figures 17 & 18).

3.4.3.2. Detailed Wind Analysis

In the detailed wind analysis, a circular flood area as same as rapid wind analysis can be determined. This wind analysis provides a more accurate calculation but takes longer to complete. A detailed wind flow and wind comfort analysis is run to obtain a more accurate simulation of different wind directions and speeds (Table 11) (Autodesk).

Table 11 Characteristics of the Detailed Wind Analysis (Autodesk)

Areas and objects included	Considers all elements in the canvas. This means that terrain, buildings both proposal and context, and vegetation all are geometry that impacts results.	**Area coverage**	150m up to 350m radius (492 feet --> 1 138 feet)
Technology and calculation	Computational fluid dynamics (CFD), through the computational tool OpenFOAM.	**Assumptions (if applicable)**	• The volume occupied by the fluid is divided into discrete, hexahedral, cells (the mesh). We make sure that no cells around important areas are larger than 1 meter. However, this means that geometries with more intricate details than 1 meter may not impact the wind flow. Although we make sure that e.g. corners stay sharp also in the analysis. • The height of the wind domain is 4 times higher than the difference in height between the lowest point of the terrain and the highest point on top of the buildings. Max height for our wind domain is 600 meters (1 969 feet) from the highest point on the terrain. • The total coverage (analysis domain) extends at least 350 meters (1 138 feet) beyond the Area coverage described above. • The analysis will not run with high terrain variations
Time to complete	40-200 min	**Data sources**	Wind rose: Global wind atlas Surface roughness: ERA5 surface roughness data.

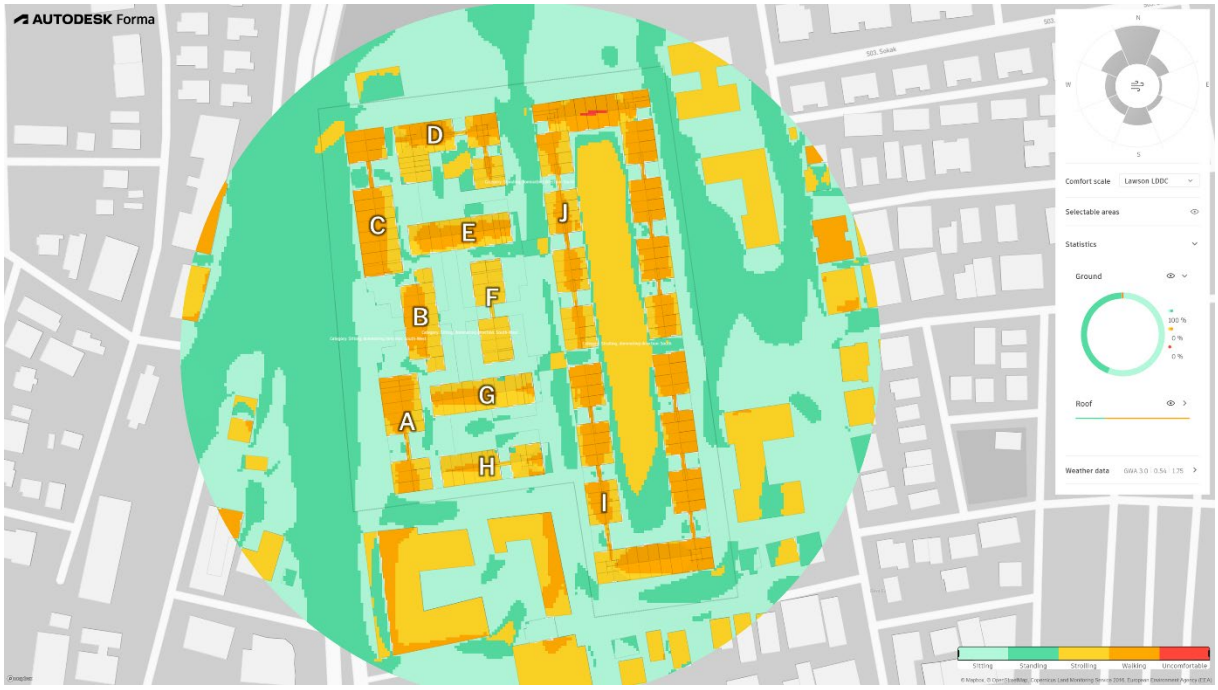


Figure 19 Detailed wind comfort analysis

In the comfort analysis based on the Lawson LDDC scale, it can be said that the courtyards formed by the blocks intersecting the north-south axis are more comfortable. Especially since there is a large parking lot just north of the area and there are no buildings, the winds blowing from the north prevailing wind direction are effective in the corridor designed as Street Market in the project (Figure 19).

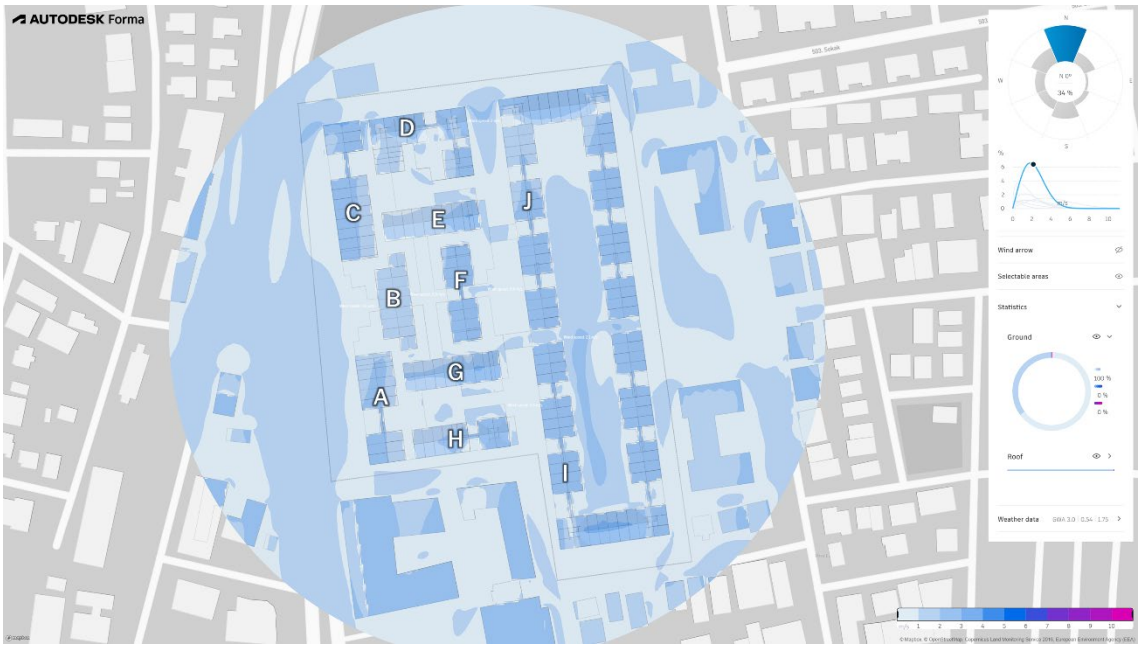


Figure 20 Detailed wind speed-direction analysis

In the wind speed analysis, it is obvious that the wind speed is high on the green roof cover of J and I block according to the north wind direction, which is the dominant wind direction. The wind speed, which is higher at the northern entrance between blocks D and J, decreases as it passes to the courtyards. It can also be predicted that the cooling energy in the summer season will be lower than the other blocks because of the D and J blocks, which are orientated towards the prevailing north wind and benefit from the prevailing north wind in summer (Figure 20).

3.4.4. Microclimate Analyses

This analysis combines the results of solar, daylight and wind analyses with local weather conditions to calculate the perceived temperature on site. In this way, it helps to understand the perceived temperature according to the shade and wind conditions created by the design of the local climatic conditions. Microclimate analysis is a hybrid model that combines many different analyses (Table 12) (Autodesk).

The purpose of using this analysis in the study is to understand and evaluate how the local climatic conditions can react to the shade and wind conditions created by the design.

Table 12 Characteristics of Microclimate Analysis (Autodesk)

Areas and objects included	Microclimate considers all elements.	**Area coverage**	Can be run on a circular area with radius between 150 and 500 meters (or 492 and 1138 feet).
Technology and calculation	A hybrid model that combines our sun, daylight, and wind analyses with local weather data.	**Assumptions (if applicable)**	• Does not yet include the effects of surface or ground materials • For wind, sun, and daylight, see respective analysis assumptions
Time to complete	1 min without wind results, 40-200 min with wind results	**Data sources**	The weather data includes information about e.g. solar radiation, and cloud coverage, all from the ERA5 dataset provided by the Copernicus Climate Change Service. Wind roses are retrieved from the Global Wind Atlas, unless a custom wind rose is uploaded in the wind analysis

In the month selection in the analysis settings, August, the hottest month of the year, and January, the coldest month of the year, were selected for Serdivan. In the time selection, the existing 13.00 value in the settings of the analysis was not changed.

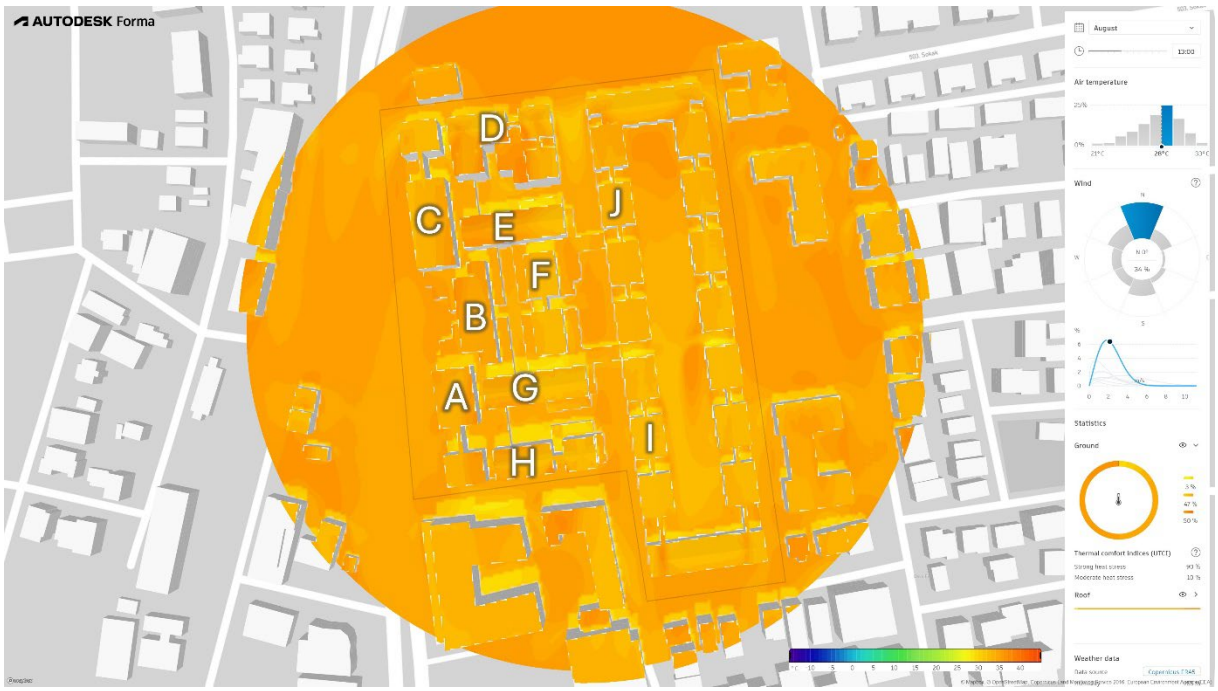


Figure 21 Microclimate analysis for august

Except for the northern facades of the blocks, high temperature stress was observed in general. Although the corridors created take the prevailing north wind into the area, it is seen that the sweltering effect cannot be prevented in the summer period in the area with high humidity. It can be said that the courtyards created in this picture do not make a big difference in the felt temperature (Figure 21).

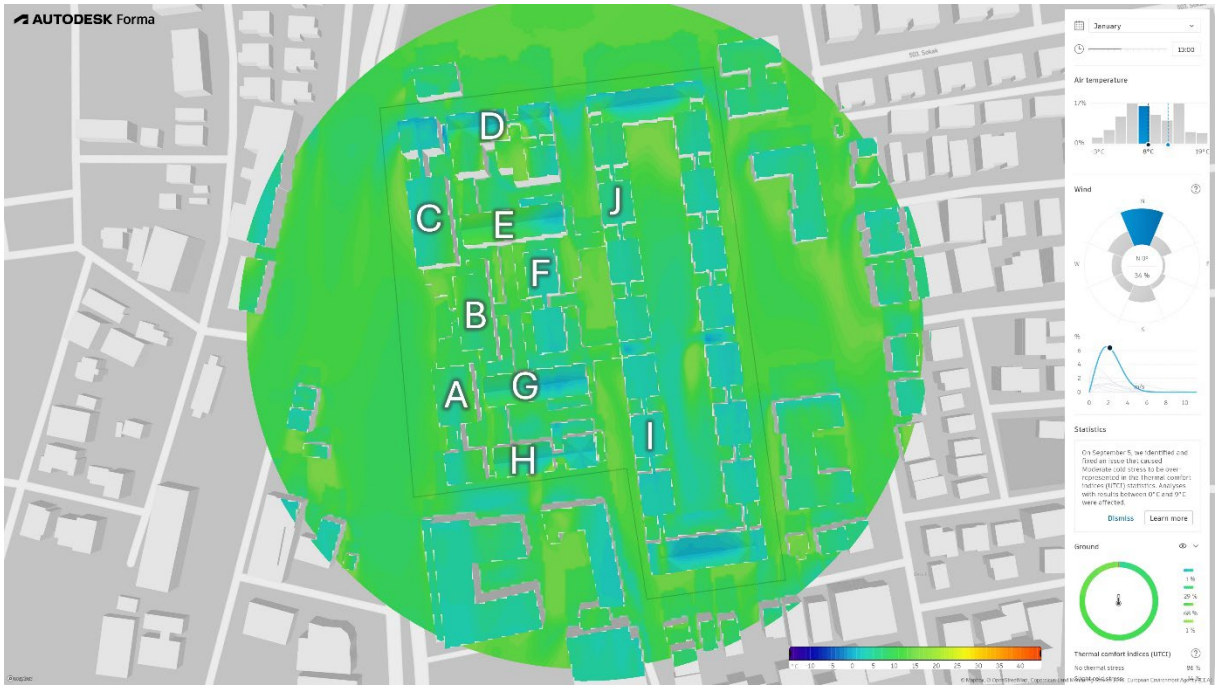


Figure 22 January microclimate analysis

It is seen that there is no high cold stress, and the temperature felt in the area is balanced. The colder temperatures are not felt in the openings but in the gorges between the masses (Figure 22).

According to the results of the microclimate analysis, the presence of the building group does not have any significant effect on the surrounding settlement in this context, as the humidity balances the perceived temperature.

4. Results and Findings

The building group was evaluated as a result of the analyses made within the framework of climate, location and orientation, layout of the settlement area, building form and building envelop parameters.

In terms of compliance with temperate-humid climate design criteria: The buildings comply with most of the criteria in this context with their good orientation range, not blocking the sunlight of each other and the buildings around them, homogeneous heights, rectangular plans and appropriate envelope form.

According to solar and wind analyses: It was found that the courtyard layout reduces the heat gain for the blocks located in the central region and the openings in these areas, the green roof above the mall of blocks J and I increases the heating-cooling energy load since it is clearly exposed to the sun and wind, the heating energy consumption is high in winter in blocks D and G, and the cooling energy consumption is high in summer in blocks H, I and J.

And according to microclimate analyses: Except for block D, the masses where large surfaces are not positioned against the prevailing north winds have created an uncomfortable effect for the user and a negative effect for ensuring energy efficiency due to the high humidity and solar radiation in the summer season. The passages that create the possibility of wind corridor formation with north winds in the winter season do not pose a major problem due to the prevailing wind

direction being south in this season, and it has been observed that a settlement form that reduces energy consumption and increases comfort has been created.

The existing building group selected for analysis, according to the design parameters obtained as a result of literature research and according to the analysis made with Forma, it has been seen that it may create some negative aspects for users and energy consumption due to its layout. However, it has been concluded that it does not have much impact on the surrounding residential fabric, except for blocking the illumination and creating wind corridors.

Evaluation about the software: Forma contributes to the provision of energy efficient designs with environmental analyses in the early design phase. Compared to some design criteria required by the climate, it is possible to evaluate energy performances and make suggestions about the values of building parameters and building forms with Forma's settlement scale analyses. However, in the Rapid Wind analysis and Microclimate analysis, data cannot be obtained in the modelled geometry, and evaluation cannot be made in the open spaces created on the first level and on the roof of the indoor shopping mall as in this example. This may cause problems for the designer during the form design phase.

5. Conclusion and Recommendations

This research seeks to answer the research question and thus highlights the importance of collaboration between energy efficient layout, form design, artificial intelligence (AI) and architectural technologies in the process of sustainable urban design. It reveals the potential of next-generation architectural tools to increase efficiency and innovation in urban design creation for existing or future developments. Thus, the study reveals the importance of the effects of the decisions taken at the building and settlement design stages on energy efficiency in future large-scale projects. Furthermore, energy efficiency assessments at the design stages of urban planning are likely to be more efficient than interventions at later stages.

Although the software used in this study contributes to the development of architectural software that will help designers who are interested in sustainable and energy efficient urban planning mentioned in the introduction of the study to predict some environmental impacts at the design stages while planning at the settlement scale, the fact that an existing building group was analyzed in this study showed that it would be useful in identifying advantages and disadvantages for existing settlements/building forms and taking necessary precautions.

This research reveals great opportunities for future urban design for more innovative and efficient planning processes, considering environmental factors and collaborating with a new generation of architectural tools. The use of artificial intelligence in urban design integrated with the sustainable city concept not only responds to today's challenges, but also paves the way for developing more efficient and sustainable cities in the future. This analysis provides recommendations on the tools and methodologies necessary to achieve results in energy efficiency and adaptation at the settlement scale for the studied region and can be compared with similar examples of medium-sized cities at the international level.

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Resume

Ceren Aydan Nasır is currently pursuing her master's degree in architecture at Gebze Technical University in Kocaeli, Turkey. She started her architectural education at Sakarya University in 2018 with a Bachelor of Architecture degree and graduated in 2022. In 2023, she started her master's degree at Gebze Technical University in Kocaeli to continue her studies in the field of Building Information Modeling and Artificial Intelligence in Architecture, where she is still studying. Her research focuses on Building Information Modeling, Artificial Intelligence in Architecture, energy efficient buildings and sustainable buildings, revealing her commitment to technological solutions in developing environmentally conscious architectural practices.

Elif Özer Yüksel graduated from Yeditepe University with a bachelor's degree in architecture and landscape architecture. She had completed her master's degree at Yıldız Technical University in 2012 and completed PhD at İstanbul Technical University in 2019 on Building Science Programme. She worked as a research assistant at Gebze Technical University between 2011–2019 and has been working as an assistant professor at the same institution since January 2020. Her research area is about sustainable design, energy-efficient facade design, green walls and green facades, human comfort in buildings, thermal performance of building elements and performance requirements of building components.

Seher Güzelçoban Mayuk completed her bachelor's degree in architecture at Yıldız Technical University between 2001-2005 as the top student. She had completed her doctorate and master's degrees on Building Science Programme of Architecture. She has been working in various positions since 2012 at Gebze Technical University. Her interests are detail design of building elements, and digital technologies use in construction phase and use in building science education of architecture. She is also interested in how to improve existing buildings in Turkey by a sustainable way. Building science education related to generation Z is one of her interests.

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The effects of Sinop province's relative humidity values on bioclimatic comfort and urban and landscape planning

İlknur Zeren Çetin*

Abstract

This study examines the monthly average relative humidity values in different districts of Sinop province and evaluates the impact of these data on urban and landscape planning. The relative humidity rates from January to December showed significant differences between districts. The highest relative humidity values were mostly observed in the Erfelek district, while the lowest values were recorded in the Türkeli and Boyabat districts. Seasonal changes caused fluctuations in relative humidity rates, with higher humidity levels detected particularly during the winter months. These data are crucial for understanding the climatic conditions of Sinop province and for making strategic decisions in areas such as agriculture, water management, and urban planning. The study specifically recommends the development of landscape planning and water conservation strategies in areas with high relative humidity. Additionally, it emphasizes the need to study the long-term effects of climate change and the necessity of continuous monitoring. Finally, this study provides an important data source for local governments and future research.

Keywords: climate data, humidity and environmental effects, relative humidity, seasonal relative humidity changes

1. Introduction

Climate plays a decisive role in vegetation, water resources, and human health. In this context, relative humidity refers to the ratio of water vapor in the atmosphere to the maximum capacity of water vapor the air can hold, playing an important role in determining climatic conditions. Relative humidity, which has a direct impact on agricultural activities, water management, and urban life quality, is a critical parameter for the health of both natural ecosystems and the sustainability of human settlements. Relative humidity is crucial for the health of natural ecosystems and the sustainability of human settlements (Allen et al., 2011).

Sinop province, under the influence of the Black Sea climate, experiences fluctuating relative humidity values throughout the year, shaping the dynamics of local ecosystems. The climate of the Black Sea region is characterized by high humidity levels, particularly in the summer months, which directly affect agriculture and natural vegetation (Güven et al., 2016). Specifically, relative humidity is critically important in terms of agricultural productivity and biodiversity. High humidity promotes plant growth, while low humidity levels can lead to water stress and plant diseases (Pereira et al., 2002).

The aim of this study is to examine the monthly average relative humidity values in Sinop province and to evaluate the impact of these data on urban and landscape planning. The relative humidity levels observed in different districts of Sinop provide important information regarding local climate conditions and biodiversity. Relative humidity is a factor that directly affects agricultural activities, water management, and urban life quality (Kumar & Singh, 2014).

Sinop province, which is under the influence of the Black Sea climate, experiences fluctuating relative humidity values throughout the year, shaping the dynamics of local ecosystems. This study aims to examine the monthly average relative humidity values in Sinop province and to evaluate the impact of these data on urban and landscape planning. The relative humidity levels observed in

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different districts of Sinop provide important information regarding local climate conditions and biodiversity. In this context, high relative humidity values show the positive effects on plant growth and agricultural productivity, while low relative humidity rates highlight the need to reconsider water management and agricultural strategies.

The purpose of this study is to analyze the seasonal variability of relative humidity and its impact on ecosystems, agriculture, and urban planning, as well as to propose how these data can be used for sustainable development. Ultimately, the findings related to relative humidity will provide an important basis for addressing climate change at the local level and for the efficient use of natural resources.

In conclusion, this study aims to analyze the seasonal variability of relative humidity and its impact on ecosystems, agriculture, and urban planning. The findings will provide an important foundation for addressing climate change at the local level and for the efficient use of natural resources.

2. Material and Method

The study was conducted within the borders of Sinop province. Sinop province is located in the Black Sea Region and has a total area of 5,862 km². As of 2023, the total population of the province is recorded as 218,408 (Sinop Provincial Directorate of Culture and Tourism, 2024). The study area and relevant geographical location information are presented in Figure 1.

Figure 1 Geographical location of Sinop

In this study, relative humidity data for Sinop province were used. The data were obtained from meteorological stations in different districts of Sinop. The districts covered in the study are Merkez, Boyabat, Türkeli, Erfelek, Ayancık, and Durağan. The monthly average relative humidity data were obtained from the Turkish State Meteorological Service (MGM, 2024) database and cover a 12-month period as of 2023.

The relative humidity data were obtained from meteorological stations in the designated districts of Sinop province. These stations regularly measure and record various meteorological parameters. Monthly relative humidity values were calculated based on the daily measurements from the stations, with averages taken for each month.

The analysis of the obtained data was carried out following the steps below:

Descriptive Statistics: Descriptive statistics (mean, median, minimum, maximum, standard deviation) were calculated for the monthly average relative humidity values. This allowed for a general evaluation of the variability of humidity in each district.

Comparative Analysis: Relative humidity rates between the relevant districts were compared through graphs and tables. This comparison was made to observe the seasonal variations in relative humidity values.

Bioclimatic Comfort Map Production: Using the obtained relative humidity data, a bioclimatic comfort map of Sinop province was created. This map provides a visual representation of the relative humidity levels in different regions, offering insights into the area's climatic characteristics.

During the data analysis process, Geographic Information Systems (GIS) software (such as ArcGIS) was used to analyze the spatial data. These tools were employed to examine the spatial distribution of relative humidity values and to conduct mapping processes.

The accuracy of the obtained data was ensured by comparing the meteorological station data with the relative humidity values from the existing literature. This helped increase the reliability of the dataset.

The findings obtained through this method aim to contribute to a more comprehensive understanding of the climate characteristics of Sinop province. The results will provide valuable information for addressing climate change and managing resources sustainably at the local level.

3. Results

The monthly average relative humidity values of Sinop province are closely related to climate change and local microclimatic conditions (Figure 2). In general, the variability of relative humidity throughout the year affects the dynamics of local ecosystems and agricultural activities.

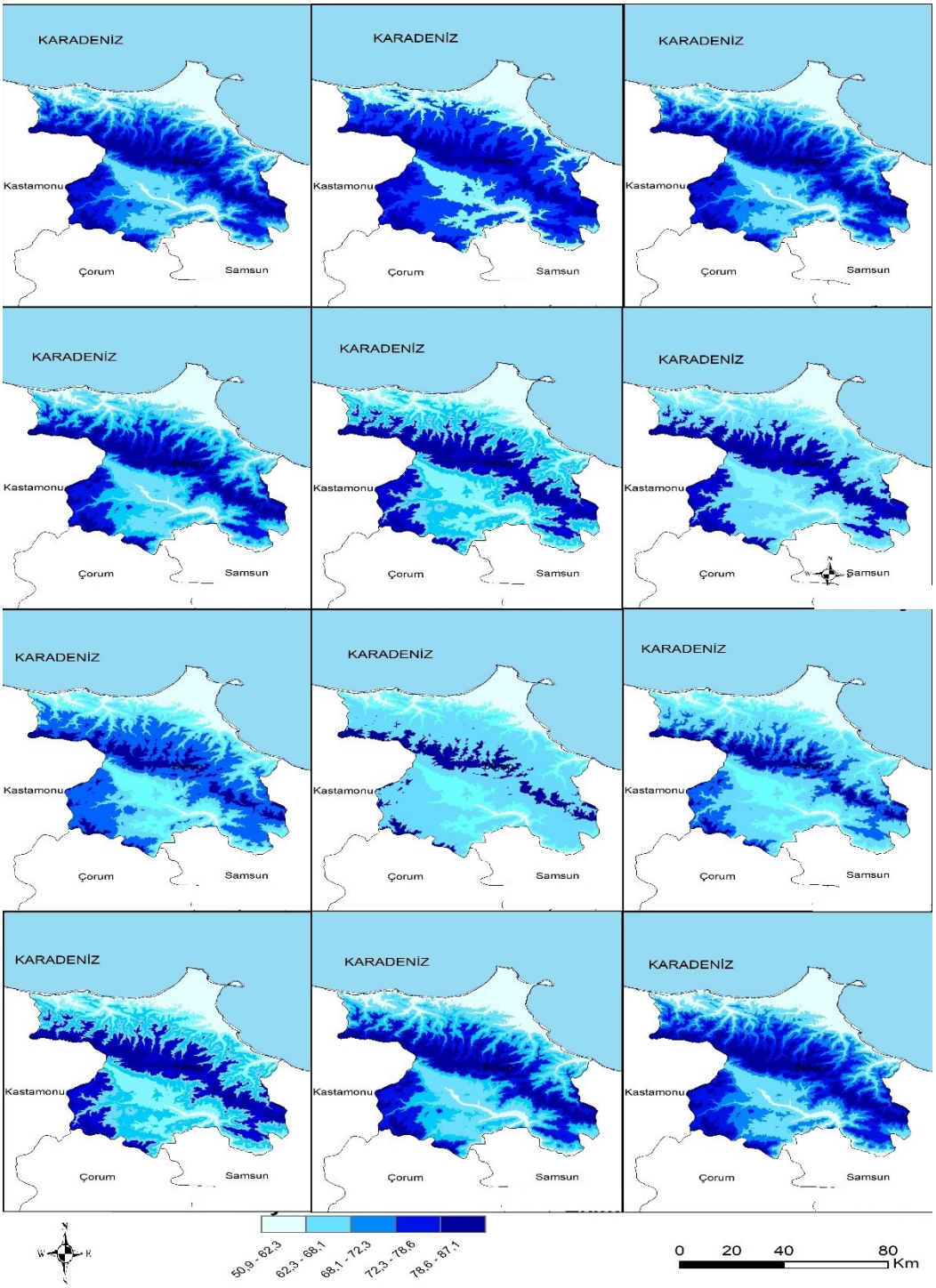

Figure 2 Relative humidity bioclimatic comfort map of Sinop province

Relative Humidity Variability: In January, relative humidity rates ranged between 66.8% and 81.2%, showing higher values during the winter months. This situation can directly affect agricultural production and water resource management. In particular, the high relative humidity values in the Erfelek district provide an advantage for irrigation and agricultural activities, while the lower values in the Türkeli district may increase irrigation needs.

Decrease in Summer Months: Relative humidity values observed in July and August, ranging from 51.9% to 78.1%, create a risk of agricultural drought with the increase in temperatures. This period should be considered a risky time for agricultural planning. It is necessary to implement water-saving techniques in agriculture and develop alternative irrigation methods.

Microclimate Effects: Differences in relative humidity between the various districts of Sinop reflect microclimate effects. This is an important criterion for landscape planning. For example, it is recommended to preserve areas with high humidity values as more green space and agricultural land to maintain the ecosystem balance.

4. Discussion

The relative humidity status of Sinop province is a crucial factor to consider in urban and landscape planning. While relative humidity determines the effects of climatic conditions on ecosystems, it plays a critical role in areas such as agriculture, water management, and green space design. Below is a more in-depth discussion of these topics.

The seasonal variability of relative humidity values in Sinop province can directly affect agricultural productivity. Studies have shown that high relative humidity levels have positive effects on plant growth and productivity (Danneberger, 2000). However, it should not be forgotten that excessive moisture conditions can also have negative effects on diseases and pests (Sinha et al., 2020). Particularly, the lower relative humidity values in the Türkeli district may make drought conditions more apparent, increasing the need for irrigation.

The differences in relative humidity observed between the various districts of Sinop reflect local microclimate conditions. These microclimate differences should be considered in landscape planning. Studies have shown that increasing green areas can help raise relative humidity levels and reduce temperature fluctuations (Tzoulas et al., 2007). Therefore, it is recommended to preserve and develop green areas in regions with high relative humidity levels.

Climate change is a significant factor that affects relative humidity values. The increase in temperature can change the amount of water vapor in the atmosphere, leading to changes in relative humidity. Various studies have examined the impacts of climate change scenarios on relative humidity, revealing that these effects may have long-term consequences for agricultural productivity (Lobell et al., 2011). Therefore, monitoring the relative humidity status in Sinop is crucial for developing climate change adaptation strategies.

The variability of relative humidity throughout the year is another factor that should be considered in water management. An increase in irrigation requirements during periods of low relative humidity can put pressure on water resources. Studies have shown that the integration of water-saving techniques and rainwater harvesting can enhance water management strategies (Allen et al., 1998; Abbaspour et al., 2009; Viviroli et al., 2011; Bhaduri et al., 2010). Therefore, developing water management plans based on relative humidity values in Sinop is of great importance.

5. Conclusion

In this study, the monthly average relative humidity values of Sinop province were thoroughly examined, and a comprehensive evaluation was made regarding the variations in different districts. The results obtained provide important findings for both the region's climatic characteristics and urban and landscape planning.

The monthly relative humidity values in Sinop province generally fluctuate throughout the year. Erfelek district, in particular, reached the highest relative humidity rates during many months of the year, while the Türkeli district recorded the lowest relative humidity values. This situation is considered an important indicator of the region's climatic differences and local characteristics.

Relative humidity rates vary depending on seasonal changes. During the winter months, especially in January and February, relative humidity rates are generally high. In the summer months, it is observed that relative humidity rates decrease. This is of critical importance for agricultural activities, water resource management, and overall climate adaptation. The positive

effects of high relative humidity on health and the potential for drought conditions due to low relative humidity should be considered.

The relative humidity map of Sinop province provides essential information for urban and landscape planning. The relative humidity levels in different regions contribute to decision-making processes in areas such as green space design, water resource management, and the positioning of structures. Particularly in regions with high relative humidity rates, strategies such as water-saving measures and plant selection should be developed.

The data obtained also highlight the region's risk of exposure to climatic changes. The impacts of climate change may lead to significant changes in relative humidity. In this context, continuous monitoring and analysis of current data are of vital importance for local governments. The effects of changes in relative humidity on agriculture, health, and water resource management should be examined, and strategies should be developed accordingly.

The results of this study provide a foundational dataset for future research. Long-term studies on relative humidity are important for better understanding the effects of climate change and developing local adaptation strategies. Additionally, evaluating the data obtained from these studies from a broader perspective will contribute to local communities' efforts to combat climate change.

The relative humidity status of Sinop province is a critical factor that should be considered in urban planning and landscape design. The analysis of monthly average relative humidity values provides important data for developing strategies that will enhance agricultural productivity, manage water resources, and promote sustainable urbanization. Protecting and managing areas with high relative humidity will play a significant role in ensuring the sustainability of natural resources.

The monthly average relative humidity values in Sinop province provide valuable data for understanding local climatic conditions and urban and landscape planning. This study revealed significant findings regarding the seasonal variability of relative humidity, which should be considered in various areas.

Seasonal Variability and Ecosystem Impacts: The relative humidity values observed throughout the year in Sinop play a decisive role in agricultural productivity and ecosystem health. Particularly, the high relative humidity rates in the Erfelek district contribute to the growth of vegetation and the increase in biodiversity. However, in regions with lower relative humidity, such as Türkeli and Boyabat, water management strategies are more important.

Urban Planning and Sustainability: Relative humidity values should also be considered in the planning of urban areas. Increasing green spaces and integrating climate-friendly designs in Sinop can help raise relative humidity levels and improve the microclimate. Green infrastructure applications are vital for enhancing the quality of urban life and efficiently using natural resources.

Connection to Climate Change: Climate change affects the dynamics of relative humidity. The changes in relative humidity observed in Sinop may have long-term effects on agriculture, water management, and ecosystem health when evaluated with future climate scenarios. In this context, proactive strategies need to be developed to address climate change.

6. Recommendations

This Water Management: Irrigation systems in agricultural areas need to be optimized, and water-saving methods should be adopted. The low relative humidity values observed during the summer months should be considered, providing flexibility in irrigation planning.

Increasing Green Spaces: In regions with high relative humidity rates, more green space and afforestation projects should be encouraged. This is important for both combating climate change and preserving biodiversity.

Education and Awareness: Agricultural producers and urban residents should be educated about the effects of relative humidity, raising awareness of climate change and local microclimate conditions.

Supporting Research: More academic research should be conducted on the relative humidity situation in Sinop, which will help in developing climate change adaptation strategies. This will ensure that planning is based on scientific data.

In this context, the relative humidity status of Sinop province is an important factor for maintaining climatic and ecological balance, and the use of this data plays a critical role in urban planning and landscape design processes.

Data Monitoring: Continuous monitoring of relative humidity values and collecting updated data is crucial for responding to local climate changes.

Green Infrastructure Applications: Integrating natural design elements such as green roofs, parks, and water pools into urban planning can help balance relative humidity.

Education and Awareness: Educating farmers and local people about the importance of relative humidity can promote the adoption of water-saving and sustainable agricultural practices.

Green Space Management: Careful selection of plant species and landscape arrangements should be made in regions with high relative humidity.

Climate Monitoring Systems: Continuous monitoring and analysis of meteorological data in Sinop province will assist in developing effective strategies to cope with climate change.

Public Education: Raising public awareness about climate change and the importance of relative humidity can contribute to environmental sustainability.

In conclusion, the relative humidity status of Sinop province is a critical factor to consider in terms of local ecosystem health, agricultural productivity, and urban planning. This study aims to promote the more effective use of relative humidity data and encourage the development of sustainable development strategies.

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Resume

Assistant Prof. Dr. Ilknur Zeren Cetin, from Ondokuz Mayıs University's Faculty of Architecture, Depertment of City and Regional Planning, Samsun, Türkiye, specializes in urban and regional planning with a focus on climate dynamics, land use changes, urban ecology, and plant-environment interactions. Her research spans two key areas: ***Climate Space Perception and Bioclimatic Comfort****, exploring environmental comfort through diverse methods, and* ***Sustainable Urban Development and Climate Impacts****, examining climate effects on land use and sustainable strategies. Dr. Cetin's expertise includes bioclimatic comfort, sustainable urban design, landscape ecology, GIS, and air quality analysis. Her recent work emphasizes the role of green campuses in enhancing sustainability and well-being, integrating socio-cultural and ecological perspectives. She investigates urban climate interactions to promote livable and environmentally aligned communities, addressing urbanization and climate change challenges through innovative approaches.*

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Diyarbakır Hasan Pasha Inn: A thorough evaluation of risk analysis and accessibility concerns

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Menşure Kübra Müezzinoğlu[**]

Abstract

The importance of accessibility in maintaining historical and cultural structures is evident across all facets of society. It is crucial to ensure that these structures remain secure, readily available, and sustainable, as they represent significant cultural heritage for both the local community and tourists. In this study, the risk analysis and accessibility status of the historic Hasan Pasha Inn in Diyarbakır's Sur district were thoroughly explored. The Inn holds a significant historical and cultural location on Gazi Street, across from the Ulu Mosque. The primary goals of the research are to identify current risks, conduct a methodical analysis, and offer suggestions for risk mitigation. The Inn's accessibility was assessed by aligning headings with the accessibility guide. The analysis utilized the 5x5 L-type matrix method to systematically evaluate risks based on specific criteria and determine their relative importance. Risk factors were categorized as minor (0–6), medium (8–12), major (16–20), and disaster (25 and above). A total of 31 risks were identified and grouped under different headings. Precautions were suggested for each risk with the goal of reducing the Inn's overall risk levels. Measures such as improving physical access, enhancing emergency preparedness, implementing safety measures, and undertaking maintenance and repair projects are being pursued to promote tourism and enhance safety in the neighborhood for both locals and visitors. The study concludes by outlining the necessary actions to improve accessibility and safety at the Hasan Pasha Inn, while also contributing to the preservation of this historic building. The proposed measures aim to make the Inn more accessible to both locals and tourists, and to ensure the sustainability of this culturally significant site. The findings of the study will serve as a valuable resource for enhancing accessibility standards and conserving historic buildings. The limited number of publications on accessibility in historical buildings reveals the need to raise awareness in this field and offer solution suggestions; Therefore, the work we carry out is of great importance. It is expected that this study will offer insights for future risk analyses and accessibility evaluations of similar structures.

Keywords: Diyarbakır Hasan Pasha Inn, accessibility, risk analysis, cultural heritage, risk assessment

1. Introduction

Turkey, with its rich history and geographical diversity, is home to many significant cultural heritage sites. The preservation and accessibility of cultural heritage are crucial issues that not only affect physical structures but also directly influence social participation and public life. Accessibility refers to the ability of all individuals, from children of different age groups to the elderly, to freely reach their desired destinations from their current locations (Ateş, 2024). In this context, accessibility in cultural heritage sites involves not only the removal of physical barriers but also the necessary social, cultural, and mental adjustments to ensure equal access for all. These structures, beyond serving as cultural values that carry the traces of the past, should be accessible to everyone to contribute to the future (Miroğlu & Çıkan, 2022).

Every structure must be usable and accessible for users, as accessibility is a fundamental principle that must be considered in the design of structures (Müezzinoğlu et al., 2023). Historical and cultural structures' accessibility is crucial for their physical state as well as their influence on

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social life and participation (Karadoğ, 2020). Accessibility is not only a need but also a necessity for the sustainability and tourism potential of historical buildings (Altın et al., 2024).

According to Güler and Tutal (2017), these structures stand out as essential markers of identity for societies. Protecting and integrating them into daily life becomes possible by providing access and functionality. However, creating access in historical buildings is a more complex process compared to modern buildings, as it is crucial not to damage the authentic fabric of the building during such interventions. Accessibility regulations should not only address physical access but also ensure access to information and services. Therefore, regulations related to accessibility in historical buildings must strike a balance between preservation and use, implementing reasonable solutions (Güler & Tutal, 2017).

Vardia, Khare, and Khare (2016) argue that historical buildings are unique and irreplaceable resources that reflect a nation's cultural and natural values. However, most of these areas were not designed for people with disabilities and other special needs. Implementing inclusive design principles contributes to the social, environmental, and economic sustainability of these spaces. Thus, accessibility in historical areas is not just a need but also an obligation to ensure social justice (Vardia et al., 2016).

According to Ölmez (2022), the reuse of historical buildings is one of the most effective methods for their preservation. However, in this process, ensuring accessibility requires not only considering the physical characteristics of the building but also the spatial comfort of new users. Historical buildings, especially those repurposed for public use, should be designed so that all individuals can benefit equally. Accessibility is crucial not only for preserving historical buildings but also for integrating them into social life (Ölmez, 2022).

Diyarbakır, with its rich cultural and historical heritage, stands out in this regard. With its 3.5-kilometer-long city walls, mosques, churches, and other historical structures, Diyarbakır holds significant cultural importance at both local and international levels (Işık, 2022). Diyarbakır, located in the Southeastern Anatolia Region, has a history spanning thousands of years and has been home to many civilizations. It has maintained its historical texture to this day (Dağtekin & Halifoğlu, 2024). The city walls of Diyarbakır, which are included in the UNESCO World Heritage List, play a key role in preserving the historical fabric of the city, along with the surrounding structures. The focal point of this study, Hasan Pasha Inn, is located on Gazi Street, one of the main routes of the city's historical walls. This historical building is an important meeting point for both local residents and visitors, and it is an integral part of Diyarbakır's cultural fabric (Cebe et al., 2019). Hasan Pasha Inn is a three-story building with a courtyard, originally constructed for commercial purposes (Yıldırım, 2017). The basement houses a restaurant and stationery, the first floor contains shops, and the second-floor features breakfast establishments (Yıldırım, 2012). However, the accessibility of this building has become an important issue for modern-day users.

In this context, the Accessibility Guide published by the Ministry of Family, Labour and Social Services will be used to evaluate the accessibility conditions and risks of Hasan Pasha Inn in detail. This guide provides specific standards for both external and internal accessibility of buildings and plays a significant role in this study (ACSHB EYHGM, 2020). In the analysis of Hasan Pasha Inn, the L-Type Matrix Method will be employed to systematically identify risks. This method assesses risks based on cause-and-effect relationships in a 5x5 table, allowing for the early detection of existing risks and the implementation of preventive measures (Doğan & Keskin, 2023). Through this analysis, deficiencies and risks in Hasan Pasha Inn will be identified, and accessibility strategies will be developed to mitigate these risks.

The primary aim of this study is to comprehensively examine the current accessibility status and risks of Hasan Pasha Inn. In this context, the following questions will be addressed:

- *What are the current risks of Hasan Pasha Inn, and what preventive measures can be implemented to reduce the effects of these risks?*

- *Has Hasan Pasha Inn been evaluated in terms of its compliance with the Accessibility Guide? Has the building been designed to be accessible to all individuals?*
- *What is the likelihood of making the building fully accessible to everyone by eliminating the current risks?*

This research will not only discuss the current deficiencies in the accessibility of Hasan Pasha Inn but also explore the accessibility strategies that can be developed for such structures. Furthermore, the proposed strategies will shed light on both the assessment of the current situation and future improvement efforts. In the conclusion section, recommendations will be presented based on the answers to these questions, with a focus on strategies to enhance accessibility while emphasizing the historical and cultural significance of Hasan Pasha Inn. This process will contribute to the preservation of the historical structure while supporting the goal of making it accessible to a wider audience.

2. Method of Research

The study area is in Diyarbakır province, in the Southeastern Anatolia Region of Turkey. Hasan Pasha Inn, situated on Gazi Street—one of the main thoroughfares in the Sur district, commonly known as Old Diyarbakır—is a historically and culturally significant site. The Inn is positioned directly across from the Ulu Mosque to the west of Sipahi Bazaar and to the southeast of the Jewelers Bazaar, offering significant convenience in terms of transportation due to its strategic location (Figure 1). Being part of the historic district, the area is surrounded by many ancient mosques, churches, and Inns, adding to the region's rich cultural heritage. The scope of this research focuses on Hasan Pasha Inn and its immediate surroundings (Figure 5).

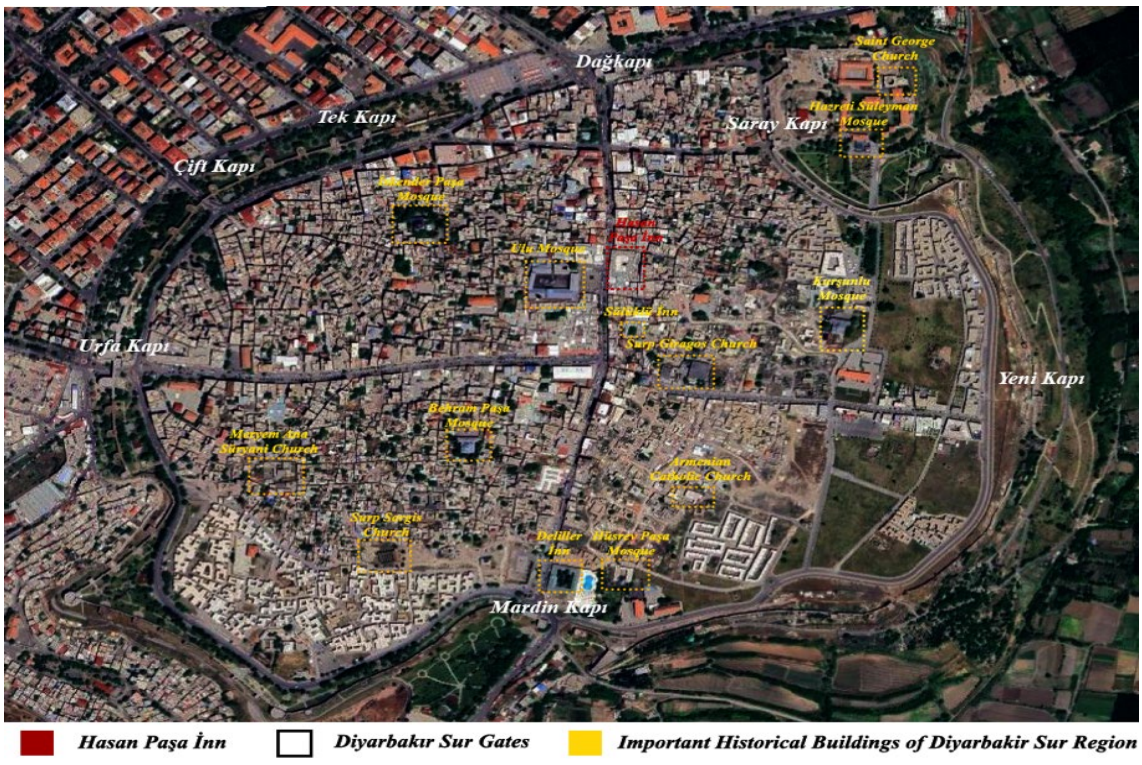


Figure 1 Map of the old city of Diyarbakır and the location of the inn (Barış, 2024)

Hasan Pasha Inn is a three-story structure, consisting of a basement, ground floor, and first floor. The basement is accessible via two separate staircases and houses a variety of services, such as a bookstore, restaurant, and toilets (Figure 4). The ground floor contains shops and cafés, while additional services are available on the first floor (Figure 2). The cafe is in the center of the courtyard. Access to the first floor is facilitated by four separate staircases, and the floor provides

breakfast and café services in its porticoed areas (Figure 3). Vertical circulation within the building is solely provided by stairs, as there is no elevator.

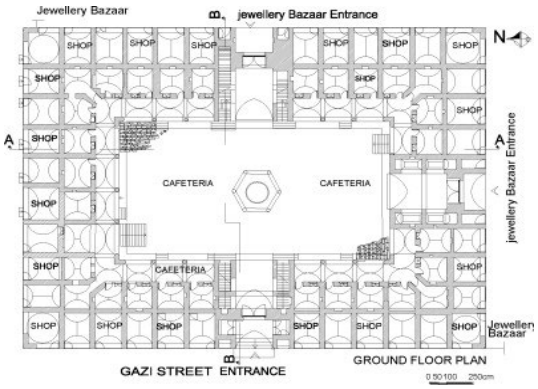


Figure 2 Ground floor plan (Yıldırım, 2012)

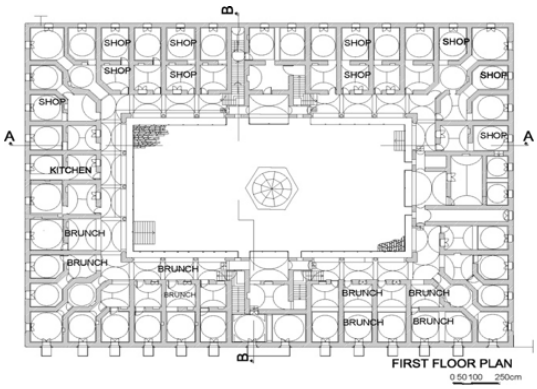


Figure 3 First floor plan (Yıldırım, 2012)

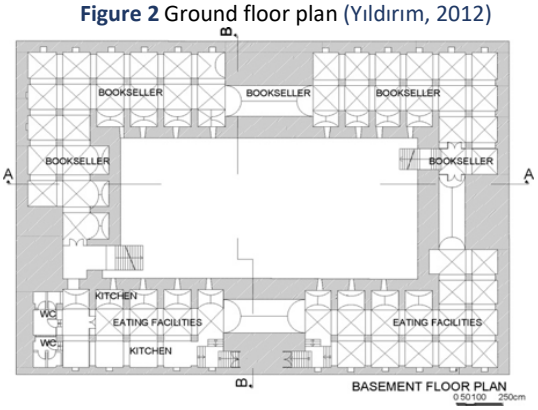


Figure 4 Basement floor plan (Yıldırım, 2012)

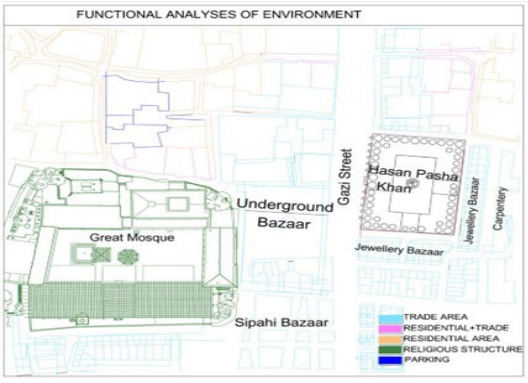


Figure 5 Site and environmental plan (Yıldırım, 2012)

Given the Inn's location in a historically significant area, it is surrounded by numerous other historical mosques, churches, and Inns, which collectively contribute to the region's rich cultural heritage. Both the Inn itself and its surrounding context are key to understanding the cultural fabric of Diyarbakır. The primary objective of this study is to evaluate the accessibility of Hasan Pasha Inn and its surroundings, perform a risk analysis, and propose solutions to address the accessibility challenges faced by historical buildings.

This research will provide a comprehensive assessment of the Inn, systematically identifying its deficiencies and risks, with particular emphasis on the accessibility guide. A detailed risk assessment will be conducted using the 5x5 L-Type matrix method, allowing for an objective ranking of the identified risks based on their relative importance. Furthermore, strategies to improve the building's accessibility will be developed, and recommendations for mitigating the identified risks will be thoroughly explored. This analysis will form the basis for future improvement projects and will set a benchmark for evaluating the current state of accessibility.

2.1. Risk Assessment Method

In this study, an L-type matrix approach was used for risk stratification. This is a method of systematically measuring risk using a 5x5 scoring system (Doğan et al., 2024). Probability refers to the likelihood of a particular risk occurring; Severity refers to the seriousness of the consequences of the risk. The product of these two criteria gives the risk score, which is the important criterion that determines the degree of acceptability of this risk (Ünverdi & Çetinyokus, 2021). With the L-type matrix, risk scenarios can be predicted, and adequate preventive measures can be implemented.

2.2. Probability Assessment

According to their likelihood of occurring, probabilities are categorized into five groups, offering a methodical approach to analysis (Bedir et al., 2024). The purpose of this probability rating is to assess the likelihood that a specific risk will materialize (Table 1).

Table 1 Probability Rating (Özkılıç, 2005)

Point	Probability
1	Very Low
2	Low
3	Probable
4	Frequent
5	Very frequent

With a score of 1, "Very Low" is the category with the lowest probability, meaning that the risk will hardly ever materialize. This level of risk is typically regarded as insignificant or as a situation that doesn't need to be addressed. A score of 5 indicates that the risk will occur very frequently, making it the highest probability category (Kıray, 2023). This level of risk must be viewed as an emergency that needs immediate attention.

2.3. Severity Rating

To Risks are evaluated to determine the seriousness of an incident and its potential consequences, which helps assess the level of intervention required (Yılmaz & Gedik, 2022) (Table 2).

Table 2 Severity Rating (Özkılıç, 2005)

Point	Severity
1	First aid required
2	First aid and outpatient treatment required
3	Minor injury
4	Serious injury
5	Death

The rating system uses a scale of 1 to 5 points. Situations requiring only first aid are rated 1, indicating minor injuries that do not need emergency assistance (Karahan & Aydoğmuş, 2023). A score of 5 represents incidents that result in death, posing serious risks to life and having significant societal consequences.

2.4. Calculating Risk Scores

One of the fundamental elements of the 5x5 L-type risk analysis matrix is the risk score, which is calculated using probability and severity levels (Table 3). This matrix offers a scoring system that is derived by multiplying each risk's probability by the seriousness of the outcomes that would follow if it materialized. Severity levels indicate how serious an event is, whereas probability levels establish how frequently an event occurs (Başar & Ceylan, 2020).

Table 3 Risk Scores (Özkılıç, 2005)

PROBABILITY	SEVERITY				
X	**1 (Very minor)**	**2 (Minor)**	**3 (Medium)**	**4 (High)**	**5 (Very high)**
1 (Very low)	1 (Insignificant)	2 (Minor)	3 (Minor)	4 (Minor)	5 (Minor)
2 (Low)	2 (Minor)	4 (Minor)	6 (Minor)	8 (Medium)	10 (Medium)
3 (Probable)	3 (Minor)	6 (Minor)	9 (Medium)	12 (Medium)	15 (Major)
4 (Frequent)	4 (Minor)	8 (Medium)	12 (Medium)	16 (Major)	20 (Major)
5 (Very frequent)	5 (Minor)	10 (Medium)	15 (Major)	20 (Major)	25 (Disaster)

While lower scores (such as 4–8) suggest that current risks are manageable, higher scores (such as 16 or above) indicate serious risks that call for immediate action. In this case, risk scores allow for a proactive approach to potential risks in addition to evaluating the current situation.

2.5. Risk Acceptability Values

A crucial criterion that establishes the type of precautions to be taken in accordance with specific risk levels is risk acceptability values (Table 4). These values unambiguously show which risks, in terms of the structures' safety, are acceptable at the degree of tolerance and which ones call for immediate action (Özkılıç, 2005).

Table 4 Acceptability Values of Results (Özkılıç, 2005)

RISK LEVEL	DESCRIPTION
Intolerable (25 point)	Until the designated risk is removed, the action must be halted; if the risk score does not drop, the activity must be blocked.
Greater Risks (16-20 point)	Until the risk has decreased, action must not be taken; instead, risk-related actions must be taken and continued based on their outcomes.
Medium Risks (8-12 point)	To lessen the risks that have been identified, action must be taken.
Small Tolerable Risks (1-6 point)	It may not be necessary to implement additional control procedures; it is crucial to preserve current controls.

This table effectively delineates which risks are deemed acceptable and when immediate action is warranted. The study comprehensively assesses the risks at the Hasan Pasha Inn using the 5x5 L-type matrix method and offers recommendations for enhancing safety.

3. Research Findings

This section will go into detail about the risk factors and how they affect the Hasan Pasha Inn. Findings about the risks surrounding the Inn and their potential consequences are shown below.

3.1. Immediate Surroundings

Hasan Pasha Inn has a strategic location in the historical Sur district of Diyarbakır province. Jewelers' Bazaar is in the south and east of the Inn, Süleyman Nazif Street is in the north, and Gazi Street is in the west (Table 5). Due to its central location, the Inn has three entrances: The main entrance is on Gazi Street (Visual 1 and 3), the other two are in the Jewelers' Bazaar. Located in the heart of the lively market area in the historic Sur district, the Inn's surroundings are always lively and lively. Since Gazi Street is one of the main roads leading to Sur, traffic density is high (Visual 2).

Table 5 Hasan Pasha Inn's Immediate Surroundings

Visual 1 Photograph: Google, 2024

Visual 2 Photograph: Barış, 2024

Visual 3 Photograph: Barış, 2024

Due to the high density of both people and cars, the area surrounding the Hasan Pasha Inn is potentially hazardous. Crossing Gazi Street presents a serious risk, particularly for users wishing to get to the Inn's entrance. During this transition, the car accident risk score was evaluated as 15 (Table 6). Because of this high-risk score, immediate action is required. To improve crossing safety, it is advised that pedestrian crossings be equipped with both visual and auditory signals.

Another risk that jeopardizes user circulation is the store stands surrounding the Inn. Despite the possibility of accidents due to the presence of these stands, the risk score of 6 is still lower (Table 6). However, by taking these stands down, the risk can be avoided.

Table 6 Immediate Surrounding Risks

Nr	ACTION	DANGER	AFFECTED GROUPS	RISK	RISK SCORE	MEASUREMENT
1	Getting to the Hasan Pasha Inn	Crossing Gazi Street	Visitors Employees Business owners	Risk of car accidents	15	Controlled pedestrian crossing
2	Arriving at the Inn and circling it	Store stands on sidewalks	Visitors Employees Business owners	Risk of hitting stands	6	Shop stands must be removed
3	Arriving at the Inn and circling it	Uneven and broken sidewalks	Visitors Employees Business owners	Risk of tripping or falling	9	Sidewalks must be repaired

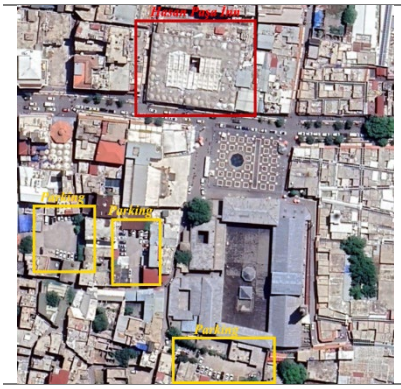
Uneven and broken sidewalks are a major concern. They don't just pose a risk to people staying at the Inn but also to anyone walking nearby. The cracked pavement and poorly placed lighting make it easy for someone to trip and fall. To prevent these kinds of accidents, the local municipality needs to step in and take care of the repairs and maintenance.

The problems outlined not only heighten the risk of accidents but also hinder the accessibility of the Inn. Issues such as unmarked pedestrian crossings, the absence of ramps, and narrow walkways pose significant obstacles for individuals with limited mobility. However, with some straightforward improvements, Hasan Pasha Inn could become more inclusive, benefiting not only people with special needs but all visitors. Implementing these changes would allow a broader range of people to experience and enjoy the space. Establishing a well-designed risk management strategy is essential for preserving the historical integrity of the Inn while making it accessible to everyone.

3.2. Parking Areas

The Hasan Pasha Inn does not have a direct parking lot (Table 7). Parking around the Inn is nearly impossible due to the Jewelers' Bazaar's congested streets and narrow streets. The nearest parking lots to the Hasan Pasha Inn are 150–200 meters away, as shown in Visual 4. Even though there are private company parking lots close by (Visuals 5 and 6), access to these areas is made possible by the narrow streets. Due to this circumstance, drivers must cross unpaved and uneven roads to get to Gazi Street after parking.

Table 7 The Connection Between the Parking Areas and the Hasan Pasha Inn



Visual 4 Photograph: Barış, 2024

Visual 5 Photograph: Barış, 2024

Visual 6 Photograph: Barış, 2024

Every user is seriously at risk due to the scarcity of parking spots near the Hasan Pasha Inn. When crossing Gazi Street to get to the Inn, drivers searching for a private parking spot may divert their focus from the road and pedestrians, which could result in accidents. Installing big, illuminated parking lot signs is advised to help avoid these kinds of mishaps. Drivers can reduce the risk and find parking spaces more easily in this way. Additionally, drivers must cross Gazi Street to access the Inn after parking. Pedestrians could be struck by cars during this transitional phase. This risk must be removed as soon as possible because of its high-risk score (15), (Table 8). This risk can be considerably decreased by establishing controlled pedestrian crossings.

Table 8 Risks of Parking Areas

Nr	ACTION	DANGER	AFFECTED GROUPS	RISK	RISK SCORE	MEASUREMENT
1	Access by car	Driving and finding a parking space	Visitors Employees Business owners	Risk of car accidents	15	Signs indicating private parking spaces
2	Access by car	Crossing Gazi Street	Visitors Employees Business owners	Risk of car accidents	15	Controlled pedestrian crossing

Another significant factor affecting the Inn's accessibility is the lack of parking. There are various barriers to accessibility, especially for vulnerable groups such as the elderly, people with disabilities,

and families with young children. The additional measures proposed aim to make Hasan Pasha Inn accessible to all. These steps will not only ease the use of the Inn but also reduce safety risks. As a result, both residents and tourists will have a safer and more convenient experience.

3.3. Entrances

The Hasan Pasha Inn features three main entrances. The most prominent entrance is situated on the west side of Gazi Street (Visual 8). Access to the Jewelers Bazaar is available through two entrances on the east and south sides. The east side gate, with its shop stands, is relatively small (Visual 7). In contrast, the south side entrance provides a larger space and a more gradual approach (Visual 9). The courtyard's ground level is lower than the entrances, and all these entrances lead to it. As a result, each entrance is equipped with stairs. However, the absence of ramps presents significant accessibility issues (Table 9).

Table 9 Entrances of the Hasan Pasha Inn

Visual 7 Photograph: Barış, 2024

Visual 8 Photograph: Barış, 2024

Visual 9 Photograph: Barış, 2024

The entrances of the Hasan Pasha Inn present several hazards (Table 10). The absence of ramps is a significant barrier, especially for underprivileged populations such as the elderly, disabled individuals, and families with infants. These individuals are unable to access the Inn due to the lack of accessible entrances. The stairs pose a high risk of falling, slipping, and tipping. To address this issue, an immediate solution would be to add a ramp to at least one entrance without compromising the historical structure's texture and aesthetics (Table 10).

When the basalt stones deteriorate and become wet, the absence of non-slip tape on the stairs increases the likelihood of slips. Applying non-slip tape to the stairs is a practical way to mitigate this risk. Additionally, the lack of railings at the entrances raises the possibility of falls and endangers all users. Therefore, designing and installing railings is necessary (Table 10).

Table 10 Entrance Risks

Nr	ACTION	DANGER	AFFECTED GROUPS	RISK	RISK SCORE	MEASUREMENT
1	Entrance to the Inn	Lack of ramp	Visitors Employees Business owners	Wheelchairs and strollers tipping over	12	A ramp must be constructed.
2	Entrance to the Inn	Lack of non-slip materials on stairs	Visitors Employees Business owners	Slip and fall	16	There must be non-slip material on the stairs
3	Entrance to the Inn	Stands narrowing the entrance	Visitors Employees Business owners	Tripping and falling	6	Stands at entrances must be removed
4	Entrance to the Inn	Lack of railings	Visitors Employees Business owners	Loss of grip and falling	9	Railings must be installed

The existence of commercial stands at the entrances poses a significant risk as well. These stands make the entrance area smaller and increase the risk of tripping and incidents. To avoid such hazards, the stands at the entrances must be taken down.

3.4. Gates and Windows

For the Hasan Pasha Inn to be both functional and aesthetically pleasing, the gates and windows are crucial components (Table 11). The windows are essential for natural lighting and ventilation, even though the gates offer horizontal circulation. These openings require routine upkeep and repairs because the building is historic (Visual 11). As seen in visual 10 and visual 12, elements of the Hasan Pasha Inn such as windows and doors also need maintenance.

Table 11 Gates and Windows of the Hasan Pasha Inn

Visual 10 Photograph: Barış, 2024

Visual 11 Photograph: Barış, 2024

Visual 12 Photograph: Gokcel, 2023

Gates and windows carry certain risks for users, even though their risk scores are typically low (Table 12). Primarily, it is essential to regularly inspect and maintain old iron gates. Regular maintenance is crucial because the gate may fall or cause serious injuries if not properly maintained.

The probability of visitors hitting their heads is increased by the low height of store gates. It is advised that warning signs be hung on the gate to avoid this circumstance. Similarly, the windows on the first floor are situated close to the ground, which increases the likelihood of accidental collisions. Therefore, it would be advisable to place warning signs along the edges of the Windows.

Table 12 Risk of Gates and Windows

Nr	ACTION	DANGER	AFFECTED GROUPS	RISK	RISK SCORE	MEASUREMENT
1	Entrance to the Inn	Historical iron gate	Visitors Employees Business owners	Risk of gate falling	10	Regular maintenance of the historical gate
2	Use in commercial stores	Store gate	Visitors Employees Business owners	Bumping your head when walking through a gate	9	Warning sign indicating that the gate height is low
3	Use in commercial stores	Store window	Visitors Employees Business owners	Bumping to a window	9	Warning sign indicating that the window height is low
4	Use in commercial stores	Store gate	Visitors Employees Business owners	Tripping over steps in gateways	6	Steps on gate thresholds must be removed

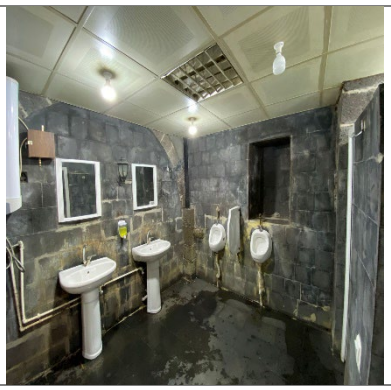
Steps on gate thresholds pose a danger, especially for people with limited mobility. There is a risk of users tripping over these steps and falling. Therefore, eliminating the steps on gate thresholds will improve accessibility while also guaranteeing general safety.

3.5. Toilets

The Hasan Pasha Inn needs accessible toilets. Currently, the toilets are only situated in the basement, accessible only by stairs (Visual 13 and 15). This poses a significant challenge for people with disabilities and limits the overall usability of the Inn. The toilet facilities at the Hasan Pasha Inn are insufficient, with only two toilets for each gender (Visual 14). Moreover, there is no provision for disabled individuals, and the only access is via stairs, posing a challenge for these groups (Table 13).

Table 13 Toilets of the Hasan Pasha Inn

Visual 13 Photograph: Barış, 2024



Visual 14 Photograph: Barış, 2024

Visual 15 Photograph: Barış, 2024

Access to the toilets is solely by stairs, increasing the risk of slipping and falling. Additionally, the absence of non-slip tape on the stairs exacerbates this risk (Table 14). To address this concern, it is recommended to install non-slip tapes and add railings to the stairs, effectively reducing the risk of accidents and injuries (Table 14).

Table 14 Risks of Toilets

Nr	ACTION	DANGER	AFFECTED GROUPS	RISK	RISK SCORE	MEASUREMENT
1	Access to toilets	Having only stairs	Visitors Employees Business owners	Falling and slipping	12	Elevator for the disabled and non-slip tapes must be used.
2	Use to toilets	Flooding	Visitors Employees Business owners	Falling and slipping	6	Regular maintenance and inspections must be performed on the installation.

The risk of toilet flooding is a significant concern. Without regular inspections, blockages and flooding may occur, leading to an increased risk of slips and falls. To mitigate these risks, it is essential to regularly inspect toilet installations and perform necessary maintenance. Access to toilets presents significant challenges for underprivileged groups, particularly those with disabilities. To ensure easy toilet access for disabled individuals, the installation of an elevator must be considered. This will guarantee that everyone, regardless of ability, can use the toilets at the Hasan Pasha Inn and meet their needs.

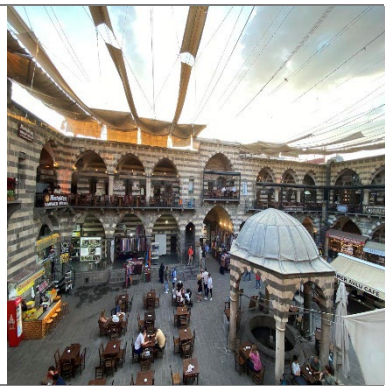
3.6. Horizontal and Vertical Circulation

Buildings need to have both horizontal and vertical circulation to allow people to move around space easily. Since Hasan Pasha Inn has a 3-storey structure including the basement, it should be examined in terms of both vertical and horizontal circulation (Visual 18). Vertical circulation in Hasan Pasha Inn is provided by stairs, as seen in visual 16 and 17, but there is no elevator (Table 15). The effectiveness of the circulation system at the Hasan Pasha Inn is crucial for ensuring safety and meeting the needs of all user groups. The following section identifies the potential risks that could arise during circulation.

Table 15 Horizontal and Vertical Circulation Visuals of the Hasan Pasha Inn

Visual 16 Photograph: Barış, 2024

Visual 17 Photograph: Barış, 2024



Visual 18 Photograph: Barış, 2024

There are several risks for visitors at the Hasan Pasha Inn (Table 16). Because of the height variations on the steps, the vertical circulation stairs could pose significant risks. In the event of negligence, these variations may have lethal results. Therefore, posting warning signs on the stairs must raise awareness. An additional risk is also presented by the stairs' railings and the absence of non-slip tape. The installation of non-slip tapes and the installation of any missing railings are crucial steps in preventing these circumstances.

Table 16 Horizontal and Vertical Circulation Risks

Nr	ACTION	DANGER	AFFECTED GROUPS	RISK	RISK SCORE	MEASUREMENT
1	Circulation of the Inn	Differences in stair step height	Visitors Employees Business owners	Risk of falling, slipping and injury	16	There must be warning signs and railings.
2	Circulation of the Inn	Lack of elevator	Visitors Employees Business owners	Risk of injury to disabled, children and elderly people when climbing up to the floors	16	To preserve the historic architecture, the elevator must be added from the outside.
3	Circulation of the Inn	Level differences on the ground	Visitors Employees Business owners	Risk of falling, slipping and injury	6	There must be warning signs
4	Circulation of the Inn	Insufficient safeguarding on the arcaded floor	Visitors Employees Business owners	Risk of falling	10	There must be protective equipment and warning signs
5	Circulation of the Inn	Level difference between ground floor stores	Visitors Employees Business owners	Risk of falling, slipping and injury	16	There must be railings and non-slip tape
6	Circulation of the Inn	Lack of non-slip tapes on the stairs	Visitors Employees Business owners	Risk of falling, slipping and injury	16	There must be non-slip tapes

There is also a probability of falling due to the ground floor's elevation variations. Warning signs can help lower this risk. Because the ground-floor commercial shops in the courtyard area must be accessed by stairs due to their height, there is a risk of falls. This risk can be reduced by installing railings and raising awareness with warning signs. Safety nets must be installed because the iron railings on the arcaded floor might not be enough. For safety, railings must be maintained on a regular basis.

The lack of an elevator is a significant disadvantage for groups with access issues, even though it does not endanger visitors. Children, the elderly, and people with disabilities can more easily and safely access the upper floors thanks to the addition of an elevator. As a result, the Hasan Pasha Inn becomes a welcoming and secure location for everyone.

3.7. Alarms and Installations

A building's safety of use is greatly influenced by its architectural design as well as the efficiency of its safety measures and installation systems (Table 17). For the comfort and safety of the users, the alarms and installations in Hasan Pasha Inn, seen in visuals 19, 20 and 21, were meticulously examined.

Table 17 Alarm and Installation Visuals of the Hasan Pasha Inn

Visual 19 Photograph: Barış, 2024

Visual 20 Photograph: Barış, 2024

Visual 21 Photograph: Barış, 2024

The Hasan Pasha Inn poses several risks for its occupants. The most significant of these hazards is the absence of a fire alarm system, as indicated in Table 18. If a fire goes undetected, it could result in fatal injuries. Therefore, installing a fire alarm system is essential to prevent a potential disaster. Additionally, there is a significant risk associated with exposed electrical installations, also noted in Table 18. Leaving electrical cables uncovered poses the risk of electric shock. These installations must be regularly inspected and securely covered.

Table 18 Alarm and Installation Risks

Nr	ACTION	DANGER	AFFECTED GROUPS	RISK	RISK SCORE	MEASUREMENT
1	Usage and circulation of the Inn	Lack of fire alarm	Visitors Employees Business owners	Risk of failing to detect the fire	10	Fire alarm must be installed
2	Usage and circulation of the Inn	Open electrical installations	Visitors Employees Business owners	Risk of electric shock	8	Exposed electrical cables must be removed
3	Usage and circulation of the Inn	Gas chimney passing through the courtyard	Visitors Employees Business owners	Risk of gas leakage	6	Gas chimney maintenance and control must be done.
4	Usage and circulation of the Inn	Insufficient lighting	Visitors Employees Business owners	Risk of falling and bumping	10	Lighting equipment must be more
5	Usage and circulation of the Inn	Lighting equipment	Visitors Employees Business owners	Risk of lighting equipment's falling	6	Lighting equipment must be checked and maintained.

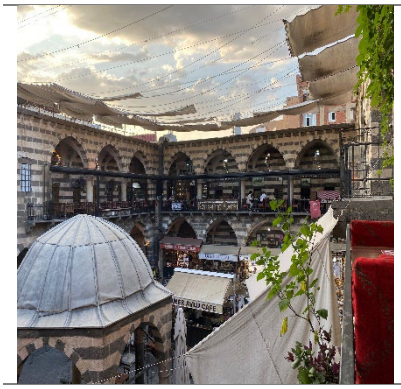
Users, particularly those walking in dark areas, run the risk of falling and bumping by inadequate lighting. To improve night lighting, it is advised to use strong lighting equipment like projectors. In addition to improving safety, this will make it possible for people to use the area more securely and comfortably. Another significant risk factor is the gas chimney that runs through the courtyard. The potential for gas leaks can result in dangerous accidents. Gas chimneys must be regularly maintained and inspected to reduce this risk.

The Hasan Pasha Inn has a lot of lighting equipment for illumination and decoration. Every six months, these pieces of equipment must be inspected to make sure they don't fall and pose a risk. As a result, the condition of the alarms and installations directly affects the Hasan Pasha Inn's safety. The measures to be taken will support the facility's overall operation in addition to improving user safety. As a result, everyone will have access to a secure environment.

3.8. Signboards and Signs

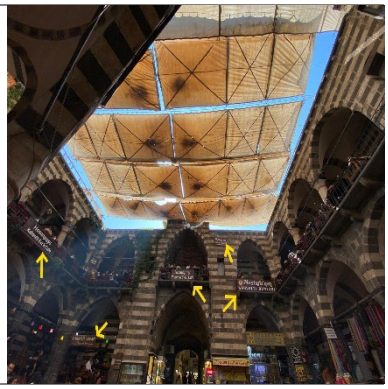
The interior and exterior of Hasan Pasha Inn hosts various commercial enterprises. For this reason, there are signs seen in visuals 22 and 24 to guide and inform users. However, there are some risks arising from the shortcomings of the current system. There are also awning and tension shading systems to protect the Inn from the noon sun (Visual 23). All these systems and signs pose a risk to users (Table 20).

Table 19 Signboards and Sign Visuals of the Hasan Pasha Inn



Visual 22 Photograph: Barış, 2024

Visual 23 Photograph: Barış, 2024



Visual 24 Photograph: Barış, 2024

The Both inside and outside, the Hasan Pasha Inn is home to a variety of commercial enterprises. Thus, to direct and instruct users, an efficient signage system is required. However, there are several risks associated with the current system's shortcomings (Table 20).

Table 20 Risks of Signboards and Signs

Nr	ACTION	DANGER	AFFECTED GROUPS	RISK	RISK SCORE	MEASUREMENT
1	Usage and circulation of the Inn	Awnings	Visitors Employees Business owners	Risk of awning collapse	10	Awnings must be inspected and maintained.
2	Usage and circulation of the Inn	Signs	Visitors Employees Business owners	Risk of signboard falling	12	Signs must be checked and maintained.
3	Usage and circulation of the Inn	Tension shading system	Visitors Employees Business owners	Tension shading system collapse risk	10	Tension shading system must be controlled and maintained.
4	Usage and circulation of the Inn	Lack of signs and directions	Visitors Employees Business owners	Risk of falling, slipping and injury	10	Signs and directions must be added

Awning and tension shading systems are useful for sun protection, but they also pose the risk of collapsing or being blown away. Regular maintenance and inspections are necessary for these systems to prevent potential injuries. Similarly, the signs in the Inn also carry the risk of falling. Injuries could result from improper placement or maintenance of the signs. These incidents can be avoided by conducting thorough inspections of hazardous areas and examining the signs. Additionally, the absence of signs and instructions could pose significant risks. It is essential to install clear signs and directions to facilitate quick identification of potential hazards and emergencies, minimizing the risk of users getting confused or taking the wrong route.

That is why it is crucial for safety reasons that the Hasan Pasha Inn's direction and signage systems be strengthened. These steps will improve the venue's overall safety while also improving the user experience.

3.9. Tactile Walking Surface Indicators (Twsis)

For visually impaired people, Tactile Walking Surface Indicators are crucial to ensuring their mobility in the area. These signs make it easier for people with visual impairments to navigate their environment and get to the places they need. However, the Hasan Pasha Inn's lack of these markings creates a significant challenge for those who are visually impaired (Table 21).

Table 21 Risk of Tactile Walking Surface Indicators

Nr	ACTION	DANGER	AFFECTED GROUPS	RISK	RISK SCORE	MEASUREMENT
1	Usage and circulation of the Inn	Lack of Tactile Walking Surface İndicators	Visitors Employees Business owners	Risk of falling, slipping and injury for visually impaired citizens	20	Tactile Walking Surface İndicators must be installed

The absence of Tactile Walking Surface Indicators at the Hasan Pasha Inn poses a significant danger to visually impaired individuals. This increases the risk of slipping, falling, and injury, and makes it nearly impossible for visually impaired individuals to navigate the space. The risk score has been determined to be 20, categorizing the situation as a "major risk". Therefore, it is crucial to take action to reduce this risk as soon as possible.

The installation of Tactile Walking Surface Indicators will not only enhance safety but also significantly improve the accessibility of the Inn. These markings will assist visually impaired individuals in navigating the space independently, making the Hasan Pasha Inn a more inclusive and accessible place for everyone. It is crucial that these markings are designed and placed according to specific standards. Tactile Walking Surface Indicators must be placed prominently on the floor and designed with consideration for factors such as friction, ensuring safe movement for visually impaired individuals.

4. Conclusion and Recommendations

This study provides a comprehensive evaluation of the risk analysis and accessibility of the historic Hasan Pasha Inn in Diyarbakır's Sur district. Utilizing the 5x5 L matrix risk analysis method, the study identifies current risks and proposes measures to mitigate their impact. It encompasses an assessment of the Inn's current risks, strategies to minimize their effects, compliance with accessibility guidelines, and efforts to ensure the building's accessibility to all.

4.1. Current Risks and Preventive Measures

What are the current risks of the Hasan Pasha Inn?

The structure's primary risks are significant components that have a direct impact on user safety. Among these dangers are:

- Stands at the entrance: This restricts people's movement in crowded areas, increasing the risk of accidents and falls.
- Slippery stairs: These can cause accidents, especially during wet conditions, due to the increased likelihood of slipping.
- Inadequate lighting: Dark areas make it difficult for people to navigate the space safely, particularly in the evening.
- Exposed electrical installations: Exposed cables pose a risk of electric shock in case of an emergency.

- Lack of directional signs: This makes it challenging for people to find their way during an emergency, leading to disorientation.

What preventive measures can be put in place to lessen the effects of these risks?

The recommended preventive measures can be listed as follows to both increase safety and improve user experience:

- Entrance arrangements: To minimize the risk of falling and injury, it's advisable to remove the stands at the entrance, expand the area, and apply non-slip tape to the stairs. Regular maintenance of the entrance gate is also important for safe use.
- Lighting improvements: Enhancing the lighting systems in the interior and exterior areas of the structure, and adding powerful lighting equipment, especially in dark areas, will enhance safety during nighttime use.
- Electrical safety: Safely covering or placing exposed electrical cables underground will significantly reduce the risk of electric shock.
- Directional signs: Adding missing signs and directions will make it easier for users to find their way and reduce possible risks of falling and hitting. It is also crucial to design special signs for disabled individuals.
- Toilet access: Installing portable disabled elevators for access to toilets and applying non-slip tape to the stairs will ensure that all individuals have access to these areas. This will enable disabled individuals to use toilets independently.

The impact of current risks will be greatly diminished by the methodical application of these measures.

4.2. Compliance with Accessibility Guidelines

What risks does the Hasan Pasha Inn currently face, and what precautions can be put in place to lessen their impact?

There are serious accessibility issues with the structure in question. Accessibility issues for people with disabilities are caused by narrow passageways and slippery stairs. This needs to be corrected because it does not adhere to the accessibility guide's requirements.

What opportunities does this structure offer for accessibility for all people?

In addition to people with physical disabilities, the structure creates access challenges for underprivileged populations like the elderly, young children, and expectant mothers. These groups find it challenging to use the space comfortably due to narrow passageways and slick floors, which lessens the possibility that the building will be a location that is accessible to all.

4.3. Accessibility Potential

Is it possible to remove the existing risks at the Hasan Pasha Inn and make the structure accessible to all?

It is feasible to make the structure accessible to everyone by removing the risks. The structure will be safer and more user-friendly if the accessibility issues are resolved with the solutions. Accessibility will significantly improve with the implementation of the following components in particular:

- Ramps and railings: People with limited mobility will find it easier to access areas on the ground floor and stairs if ramps and railings are installed. Particularly for the elderly and disabled, this is an urgent need.
- Installing an elevator: This will greatly improve access between floors without causing any damage to the historic building. The elevator will be very convenient, especially for older people and those with disabilities.

- Education and awareness: Setting up accessibility awareness training for users and business owners will help create a more considerate stance on this matter. Both staff and guests' behaviors will be influenced by the training to make the building more accessible.

As a result, this historic building may become accessible to all if the hazards at the Hasan Pasha Inn are decreased, and the required upgrades are completed. All people will have a safe and accessible environment, and the structure's cultural and social functionality will be enhanced. The Hasan Pasha Inn will maintain its historical and cultural significance while becoming a location that is open to all. Both residents and tourists will benefit greatly from this process, and the building will be recognized as an excellent example of accessibility.

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The effects of COVID-19 on the agglomeration of high-tech knowledge-intensive business services in Ankara, Istanbul, and Izmir

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Abstract

This study investigates the effect of COVID-19 on the concentration and agglomeration of jobs related to high-tech knowledge-intensive services (HKIS). The main objective of the study is to determine how COVID-19 measures have changed the HKIS agglomeration in three major metropolitan cities of Türkiye—Ankara, Istanbul, and Izmir. Data from 2019 were used as the pre-COVID-19 period, from 2020 as the COVID-19 period, and from 2021 as the post-COVID-19 period, and the agglomeration was calculated using the location quotient. Of the number of HKIS employees in Türkiye, 71.65% worked in Ankara, Istanbul, and Izmir in 2019, but during the COVID-19 period (2020) when the pandemic measures were implemented, the proportion increased to 79%. During the post-COVID-19 period (2021), the percentage of HKIS workers in Türkiye was 78.68%. The observations suggest that the agglomeration of HKIS activities in these three cities continued to increase after the COVID-19 pandemic measures were implemented and removed.

Keywords: COVID-19, high-tech knowledge-intensive business services, sectorial agglomeration

1. Introduction

1.1. KIS and HKIS

Knowledge-intensive services (KIS) refer to services that create, accumulate, or disseminate knowledge (Miles et al., 1995; Muller & Doloreux, 2009; Skorska, 2018). KIS has a broad scope that includes activities such as consulting, advertising, communication and computer services, financial and insurance activities, legal and accounting activities, and security and investigation activities. It can also be defined as a specific, technical, or functional area associated with professional knowledge or expertise (Windrum & Tomlinson, 1999). In another definition, KISs provide specialized knowledge to companies and are a vital source of information, advice, and expertise for other industries (Toivonen, 2004; Aslesen & Isaksen, 2007). Numerous cities aim to compete through knowledge creation and innovation (Benneworth & Ratinho, 2014). In knowledge-based societies, knowledge has taken the place of major capital and KIS industries have emerged as one of the main mechanisms of the contemporary economy (Yum, 2019). KISs offer a competitive advantage with cost and scale advantages (Aslesen & Isaksen, 2007; Vaillant et al., 2012; Mejri et al., 2018).

The Organization for Economic Co-operation and Development (OECD) classifies industries into four categories according to the level of research & development: 1) high-technology industries, 2) medium-high-technology industries, 3) medium-low-technology industries, and 4) low-technology industries (Vaillant et al., 2012). Similarly, in a study titled "EUROSTAT indicators on High-tech industry and Knowledge-intensive services Annex 3 - High-tech aggregation by NACE Rev.2," the European Statistical Office (EUROSTAT) categorizes KIS under the following headings: 1) Knowledge-intensive market services (excluding high-tech and financial services) 2) High-tech knowledge-intensive services (HKIS) 3) Knowledge-intensive financial services 4) Other knowledge-

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intensive services 5) Less knowledge-intensive services (LKIS) 6) Less knowledge-intensive market services 7) Other LKIS. This study focuses on HKIS (EUROSTAT, 2008).

1.2. KIS and Agglomeration

In general, KIS concentrates in big cities (Shearmur & Doloreux, 2008; Wood, 2002; Ženka et al., 2017; Santiago, 2020; Muller & Doloreux, 2009). Urban agglomeration theory suggests that economies of scale, especially economies of scope, competition, diversification, and promotion of specialization will benefit from the quality of services in and around cities more than elsewhere (Wood, 2002). Since its positive externalities can lower businesses' unit production costs and have a major impact on effects related to economies of scale, spatial agglomeration can enhance the growth of the economy (Fan & Scott, 2003; Peng et al., 2022). Although advances in communication technologies have significantly reduced communication costs, spatial agglomeration remains important as it facilitates face-to-face interaction in high-tech innovative activities because of the uncertainties associated with new technologies (Hu et al., 2006). Agglomeration has a positive impact on KIS firms in terms of innovation, development, and diffusion of technologies (Peng et al., 2022). The economic benefits and the benefits of face-to-face interaction have led KIS firms to favor spatial proximity, with spatial agglomeration and clustering often occurring in metropolitan areas, within proximity to their customers and labor pool (Aslesen & Jakobsen, 2007; Vissers & Dankbaar, 2013; Miles et al., 2021). Vaillant et al. (2012) argue that spatial proximity has a positive effect, and drawing on an OECD report (2006), emphasize that KIS firms are both sources and carriers of knowledge that influence and improve the performance of industry clusters in all sectors of the economy.

1.3. COVID-19 Precautions, Remote Working, and KIS

The COVID-19 coronavirus outbreak imposed negative impacts not only on humans but also on the global economy, including small and medium enterprises (Omar et al., 2020). Although KIS provided knowledge management, infrastructure, and services to companies, customers, and stakeholders (Zbuchea et al., 2023; Milasi et al., 2021) during the fight against COVID-19, they were impacted directly and indirectly by their customers who were affected by the health and safety measures. The innovation capabilities and the individual, organizational, and demographic attributes of KIS were impacted during COVID-19 (Kotsopoulos et al., 2022). Hrivnák et al. (2021) state that COVID-19 has had a relatively negative impact on the global economy and that the measures taken to prevent the spread of the virus can cause unemployment in many sectors. In addition, from an economic point of view, long-term effects may be observable in innovation activities for several years. In their study titled "OECD Productivity Working Papers," Milasi et al. (2021) report that working from home and teleworking in KIS in the European Union were also present before COVID-19. However, the measures taken to prevent the spread of COVID-19, such as stay-at-home calls, lockdowns, and social distancing practices, have led to increases in teleworking (Belzunegui-Eraso & Erro-Garcés, 2020; Vasic, 2020), remote work (Espitia et al., 2022; Kylili et al., 2020), and working from home (Bick et al., 2020; Birimoglu-Okuyan &Begen, 2022; Bolisani et al., 2020).

One of the most important changes from the COVID-19 pandemic is the attention to remote working methods. Practices such as remote working have brought up a very important question. Miles et al. (2021) state the question as follows: "If more professionals take opportunities to live and work outside of the major metropolitan areas that traditionally house them, as well as their firms, what happens to these cities?" This question constitutes the main problem addressed in this study. The main objective of the study is to determine how COVID-19 has affected HKIS agglomeration. Several important questions are addressed in this study: "Does the agglomeration of HKIS continue in metropolitan cities after practices such as telecommuting become ubiquitous?" "How has COVID-19 caused a change in HKIS sub-service sectors?"

2. Material

Annual statistical data from the Social Security Institution (SSI) were used in this study. Data on the distribution of insured and workplace statistics, workplaces within the scope of the SSI 4/a category, and compulsory insured persons by activity group and provinces were taken as the basis of this investigation. Agglomeration was calculated based on the number of HKIS employees according to the Nomenclature of Economic Activities (NACE) codes. Table 1 shows the NACE codes defined by EUROSTAT and the services corresponding to the codes.

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Table 1 High-Tech Knowledge-Intensive Services (Source: EUROSTAT, 2008)

NACE Rev. 2 codes	2-Digit Level High-Tech Knowledge-Intensive Services
59	Motion picture, video, and television program production, sound recording, and music publishing activities
60	Programming and broadcasting activities
61	Telecommunications
62	Computer programming, consultancy, and related activities
63	Information service activities
72	Scientific research and development

3. Method

Haig (1926) emphasized that location was effective for describing agglomeration in terms of consumption and production and explained the relationship between location and the labor force. In addition, Haig (1926) presented the relationship between employment data and location and regional specialization as the basic analysis of urban economics (Crawley et al., 2013; Cummings & Epley, 2014; Morrissey, 2016). Specifically, the location quotient (LQ) has been employed in urban and regional economic development studies since the 1940s (Miller et al., 1991; Oka, 2023). Mattila and Thompson (1955) used the LQ to calculate specialization at the local and national levels. In the 1970s, Leigh (1970), Mayer and Pleeter (1975), and Isserman (1977) used LQ for discussing regional specialization in their studies. More recently, LQ has been used in the study of regional clustering (Azhari et al., 2017; Carroll et al., 2008). LQ is effective for determining the concentration of sectors (Chiang, 2009) and is one of the fundamental parameters used in economic analyses (Cummings & Epley, 2014).

In practice, there are some disadvantages of using LQ. First, evaluating sectors that have very close LQ values is difficult (Azhari et al., 2017). Second, in the calculation made with LQ, different analysis methods are needed for competitiveness, inter-sectoral connections, and export characteristics (Carroll et al., 2008; Hill & Brennan, 2000). Third, LQ data cannot be accepted at face value, for example, additional research and data are needed regarding the potential for further expansion of a sector (Miller et al., 1991). The last negative aspect of LQ is that it is insufficient especially for input-output analysis; in addition, LQ value data are not sufficient for providing clustering (Crawley et al., 2013).

In a study conducted by Chiang (2009), it is stated that the LQ is effective in identifying agglomeration economies in regional economic development. As a geographical indicator and a tool for spatial analysis (Miller et al., 1991; Cromley & Hanink, 2012), LQ has been used predominantly to identify and compare local characteristics (Moineddin et al., 2003), industrial specialization, clustering, and economic aggregation in a geographic location or region, as well as promote regional growth (Glaeser et al., 1992; Porter, 2000; Henderson, 2003; Crawley et al., 2013; Tian, 2013). In the present study, agglomeration was calculated using the LQ, which defines the prominence of an industry in a given region (Crawley et al., 2013).

The LQ can be expressed as follows:

$$LQ_i = \frac{e_i / E_i}{e / E}$$

If the result of the above ratio is $LQ_i < 1$ then the concentration of employees in HKIS firms in this selected region is relatively low. In other words, $LQ_i < 1$ implies fewer concentration of employees work in a given sector (HKIS in this paper) compared with other regions (Morrissey, 2016; Çelik et al., 2019). If the result of the above ratio is $LQ_i = 1$, then there is an equal concentration of people working in HKIS activities among the regions. If the result of the above ratio is $LQ_i > 1$, then the concentration of HKIS employees in this region is relatively high (Cromley & Hanink, 2012; Karakayacı, 2010; Munandar et al., 2017; Seçkin, 2015; Środa-Murawska, 2013).

An LQ value of 1.25 is generally accepted as the threshold for local or regional specialization (Mans et al., 2008; Tian, 2013; Nowakowska-Grunt et al., 2014). If $LQ_1 > 1.25$, then regional specialization is considered, based on the number of HKIS employees (Środa-Murawska, 2013; Morrissey, 2016; Çelik et al., 2019). To investigate the agglomeration of HKIS firms and regional specialization, $LQ_i > 1$ (agglomeration) and (specialization) were used in this study for the concentration value and cut-off value for the regional specialization level, respectively.

Before applying the LQ method, the Chi-square test was used to examine the degree of correlation between the spatial location of different sectors and employment power. The Chi-square test is widely used to analyze whether there is a relationship between two or more groups of variables (Akyol & Akbulut, 2017) and/or whether two or more independently selected samples originate from the same group (Duran, 2016). In addition, continuous (numerical) variables specified using measurements can be turned into categorical variables by characterizing them as lower or higher than some reference, to a certain degree (Ak, 2019).

Herein, this study aimed to determine whether there was a significant relationship between years and changes in urban employment. Accordingly, two hypotheses were proposed:

1. Null Hypothesis (H0): There is no association between the spatial location (city or region) and the employment strength of different sectors.
2. Alternative Hypothesis (H1): There is an association between the spatial location and the employment strength of different sectors.

Table 2 was prepared to test these hypotheses, showing the spatial location of HKIS sectors and their relationship with employment.

Table 2 The Relationship Between Spatial Location of Sectors and Employment (The table was prepared based on (Mprotsis et al., 2022))

	NACE 59	NACE 60	NACE 61	NACE 62	NACE 63	NACE 72	TOTAL
ANK-2019	1,570	950	3,691	16,257	5,780	3,384	31,632
IST-2019	18,880	7,202	1,1761	60,057	11,841	2,535	112,276
IZM-2019	524	100	1,723	5,565	2,802	1,308	12,022
ANK-2020	1,191	1,025	4,694	17,994	2,927	4,123	31,954
IST-2020	16,944	7,867	13,424	68,911	11,082	3,112	121,340
IZM-2020	667	94	2,084	6,674	828	1,311	11,658
ANK-2021	1,232	1,069	5,912	20,398	3,150	4,359	36,120
IST-2021	15,187	8,894	13,194	84,556	13,229	2,947	138,007
IZM-2021	390	183	2,252	8,181	778	1,362	13,146
TOTAL	56,585	27,384	58,735	288,593	52,417	24,441	508,155

The numbers of employees in HKIS sectors in Ankara, Istanbul, and Izmir in 2019, 2020, and 2021 obtained using the Chi-square test are presented in Table 2.

From the analyses, the Chi-square value was 39862.168, the degrees of freedom were 40, the p-value was 0, and Yates' Chi-square value was 39862.168. Overall, the result was significant at $p < .05$. $X^2(40, N = 508155) = 39862.168$, $p = 0$. Based on this, hypothesis 0 was rejected and hypothesis 1 was accepted. Therefore, there was a relationship between the spatial location of different sectors and employment power.

4. Study Area

The COVID-19 pandemic started to spread across the world in November 2019. The first COVID-19 case in Türkiye emerged in March 2020. The data of this study were evaluated over three years using the data published by the SSI between 2019 and 2021. The data for 2019 show the agglomeration before COVID-19. Since the data for 2019 indicate the conditions before the COVID-19 outbreak, they were analyzed as control data for comparison. Then, the data for 2020 contain the period between March and June, when full lockdowns and curfews were imposed, and the period after June, when the effects of the controlled social life and renormalization on the HKIS agglomeration were investigated. Finally, 2021 was examined as the period after COVID-19.

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In this study, calculations were made considering NUTS-3 regions. Ankara, Istanbul, and Izmir are Türkiye's three largest metropolises, and their provincial borders include both NUTS-2 and NUTS-3 regions. Figure 1 shows the locations of Ankara, Istanbul, and Izmir in Türkiye.

Figure 1 Locations of Ankara, Istanbul, and Izmir in Türkiye

According to data from the Turkish Statistical Institute (TURKSTAT), Türkiye's population in 2022 was 79,613,279, with 5,782,285 people living in Ankara, 15,907,951 in Istanbul, and 4,462,056 in Izmir. Of Türkiye's population in 2022, 32.84% lived in Ankara, Istanbul, and Izmir. According to the data on the distribution of SSI 4/a workplaces and compulsory insured persons by activity group and province, there were 1,239,615 actively insured persons in Ankara, 4,485,393 in Istanbul, and 1,010,798 in Izmir. Considering that there were 16,169,679 active insured persons in Türkiye in 2021, the share of active insured persons in the three metropolitan cities was 41.65%. Ankara, Istanbul, and Izmir were selected as the sample areas because approximately one out of every three people live in Ankara, Istanbul, and Izmir and approximately 4 out of every 10 actively insured people live in these three metropolitan cities.

In the context of the data published by TURKSTAT, the shares of Istanbul, Ankara, and Izmir in the gross domestic product from information and communication services were 87.26% in 2019, 87.46% in 2020, and 87.81% in 2021.

5. Results and Discussion

Table 3 shows that a total of 217,616 people were working in HKIS sectors in Türkiye before the COVID-19 pandemic. There were 112,276 people working in HKIS companies in Istanbul, 31,632 in Ankara, and 12,022 in Izmir. Of the total HKIS employees in Türkiye, 71.65% were working in Ankara, Istanbul, and Izmir. Computer programming and consultancy accounted for the majority of the employment activities. Of the HKIS employees employed in Ankara, Istanbul, and Izmir, 89.46% worked in motion picture, video, and television program production, sound recording, and music publishing, 84.61% in programming and broadcasting, 81.3% in computer programming, consultancy, and related activities, 64.71% in telecommunications, 52.59% in scientific research and development activities, and 47.04% in information service activities.

Table 3 Number of Employees in HKIS in Ankara, Istanbul, and Izmir (2019)

NACE CODE	HIGH-TECH KNOWLEDGE- INTENSIVE SERVICES	ANKARA	ISTANBUL	IZMIR	TÜRKİYE TOTAL	HKIS employment rate of the three cities in Türkiye (%)
59	Motion picture, video, and television program production, sound recording and music publishing, Video and television program production activities	1,570	18,880	524	23,444	89.46
60	Programming and broadcasting activities	950	7,202	100	9,753	84.61
61	Telecommunications	3,691	11,761	1,723	26,541	64.71
62	Computer programming, consultancy, and related activities	16,257	60,057	5,565	100,718	81.30
63	Information service activities	5,780	11,841	2,802	43,419	47.04
72	Scientific research and development	3,384	2,535	1,308	13,741	52.59
Total		31,632	112,276	12,022	217,616	71.65

Table 4 shows the HKIS LQ results in Ankara, Istanbul, and Izmir. In 2019, there was a concentration in the computer programming and consultancy sector in Ankara, and agglomeration at the regional specialization level in scientific research and development activities. In Istanbul, there was agglomeration at the regional specialization level in motion picture, video, and television program production, sound recording, music publishing, video and television program production sector and programming and broadcasting activities and concentration in the programming and broadcasting sector. In Izmir, there was a concentration in telecommunications, computer programming, consulting, and information service activities and an agglomeration at the regional specialization level in scientific research and development activities.

Table 4 LQ Value of High-Tech Knowledge-Intensive Services in 2019

NACE CODE	HIGH-TECH KNOWLEDGE-INTENSIVE SERVICES	ANKARA	ISTANBUL	IZMİR
59	Motion picture, video, and television program production, sound recording, and music publishing Video and television program production activities	0.46	1.56	0.40
60	Programming and broadcasting activities	0.67	1.43	0.19
61	Telecommunications	0.96	0.86	1.18
62	Computer programming, consultancy, and related activities	1.11	1.16	1.00
63	Information service activities	0.92	0.53	1.17
72	Scientific research and development	1.69	0.36	1.72

The 2019 LQ data are illustrated in Figure 2. The dominance of Istanbul in motion picture, video, and television program production, sound recording, and music publishing activities, and programming and broadcasting activities, and the dominance of Ankara and Izmir in scientific research and development activities are observed. The three cities were almost equal in computer programming, consultancy, and related activities.

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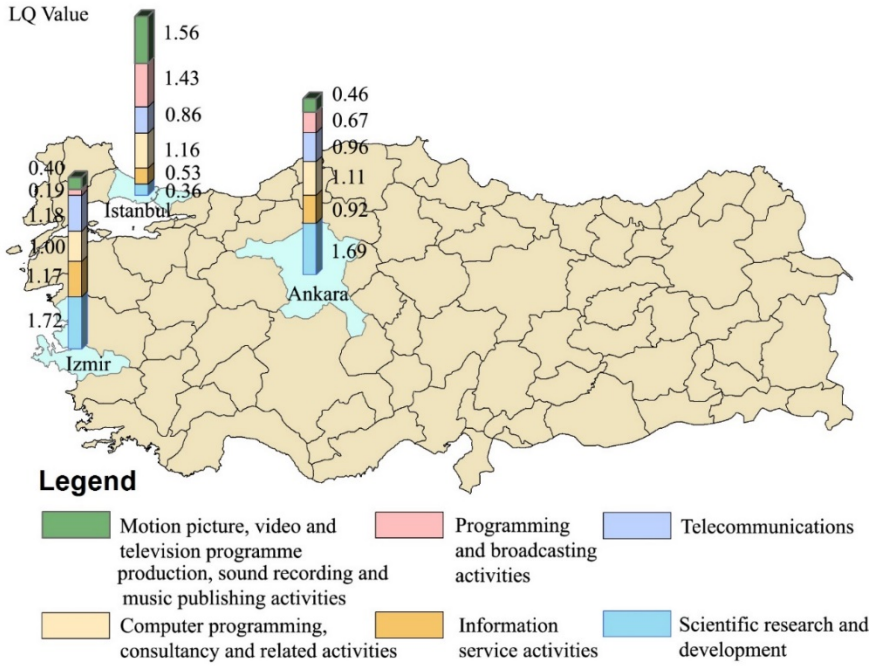

Figure 2 LQ map of HKIS activities in Ankara, Istanbul, and Izmir (2019)

After COVID-19 was defined as a pandemic by the World Health Organization in March 2020, measures to prevent it from spreading began to be implemented in many countries. The measures implemented in Türkiye, such as stay-at-home calls, distance education and work, and curfews, affected all sectors, including HKIS. HKIS activities have been directly and indirectly negatively affected by these restrictions while working to ensure that its customers adapt to pandemic conditions. According to SSI data on the distribution of workplaces covered by the 4/a category and compulsory insured persons by activity group and provinces, while 217,616 people were working in HKIS activities in 2019, the number of employees in HKIS activities decreased to 208,800 by the end of 2020 (Table 5), a 4.05% decrease in HKIS employment compared with the previous year. Although there was a decrease in total employment in Türkiye in 2020 during which COVID-19 measures were implemented, there was an increase of 1.02% in Ankara and 8.07% in Istanbul. In Izmir, a decrease of 3.01% in HKIS employment was recorded. However, when the combined proportions of the three provinces in Türkiye are examined, there was an increase of 1.6% in motion picture, video, and television program production, sound recording, and music publishing, video and television program production services, 1.67% in programming and broadcasting activities, 4.78% in telecommunication services, 0.81% in computer programming and consultancy activities, 31.56% in information service activities, and 1.44% in scientific research and development activities. After the COVID-19 pandemic, HKIS firms' desire to be located in metropolitan areas, agglomeration, and clustering has increased.

Table 5 Number of Employees in HKIS in Ankara, Istanbul, and Izmir (2020)

NACE CODE	HIGH-TECH KNOWLEDGE-INTENSIVE SERVICES	ANKARA	ISTANBUL	IZMIR	TÜRKİYE TOTAL	HKIS employment rate of the three cities in Türkiye (%)
59	Motion picture, video, and television program production, sound recording, and music publishing, Video and television program production activities	1,191	16,944	667	20,647	91.06
60	Programming and broadcasting activities	1,025	7,867	96	10,417	86.28
61	Telecommunications	4,694	13,424	2,084	29,071	69.49
62	Computer programming, consultancy, and related activities	17,994	68,911	6,674	113,970	82.11
63	Information service activities	2,927	11,082	828	18,877	78.60
72	Scientific research and development	4,123	3,112	1,311	15,818	54.03
Total		31,954	121,340	11,660	208,800	79.00

Table 6 shows the LQ values for the HKIS sub-sectors of Ankara, Istanbul, and Izmir in 2020. When the LQ data for 2020 are compared with the LQ data for 2019, unlike the previous year, concentration started in the telecommunications sector and information service activities in Ankara, in information service activities in Istanbul and Izmir, and there was concentration at the level of regional specialization in telecommunication services, while the concentration in information service activities decreased below the value of 1. It can be argued that the COVID-19 pandemic and measures to prevent the spread of the disease caused HKIS concentration and agglomeration in the metropolitan areas.

Table 6 LQ Value of High-Tech Knowledge-Intensive Services in 2020

NACE CODE	HIGH-TECH KNOWLEDGE-INTENSIVE SERVICES	ANKARA	ISTANBUL	IZMİR
59	Motion picture, video, and television program production, sound recording, and music publishing Video and television program production activities	0.38	1.41	0.58
60	Programming and broadcasting activities	0.64	1.30	0.17
61	Telecommunications	1.06	0.79	1.28
62	Computer programming, consultancy, and related activities	1.03	1.04	1.05
63	Information service activities	1.01	1.01	0.79
72	Scientific research and development	1.70	0.34	1.48

Figure 3 illustrates the LQ data for 2020. Istanbul continued to dominate in motion picture, video, and television program production, sound recording, music publishing, and programming and broadcasting activities, whereas Ankara and Izmir continued to dominate in scientific research and development activities. The three cities continued to have equivalent structures in computer programming, consultancy, and related activities. Comparing Figures 2 and 3, in 2020, when COVID-19 measures were implemented, information service activities started to be concentrated in Ankara and Istanbul compared with before the COVID-19 measures were applied.

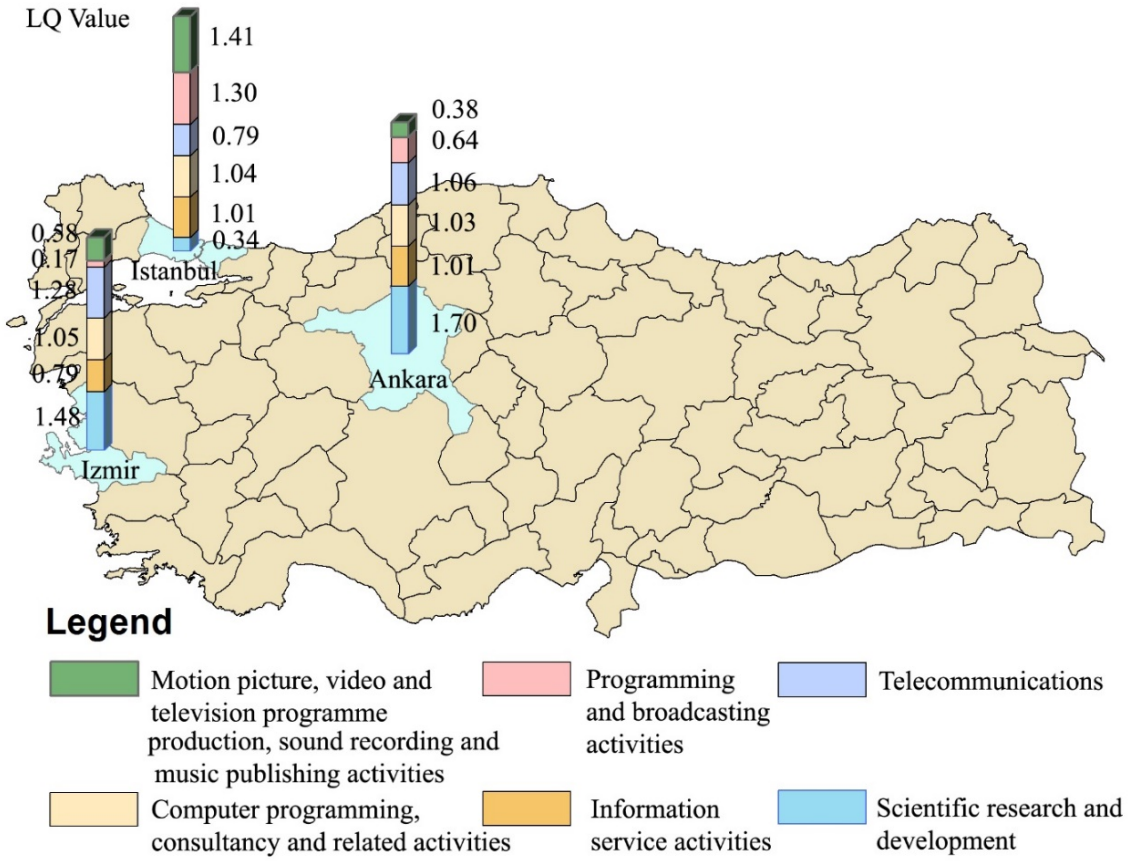

Figure 3 LQ map of HKIS activities in Ankara, Istanbul, and Izmir (2020)

The renormalization period caused a positive movement in terms of employment in 2021, owing to the lifting of bans and measures. There was a 14% increase in HKIS employment in 2021. Although there was a general decrease in employment in all HKIS sectors compared with 2020, the trend of agglomeration in metropolitan areas continued after 2020.

Table 7 shows the number of employees in HKIS activities in Ankara, Istanbul, and Izmir in 2021. HKIS employment in Ankara, Istanbul, and Izmir decreased by 0.32% compared with 2020 and accounted for 78.68% of the total HKIS employment in Türkiye. In 2021, compared with 2020, Ankara, Istanbul, and Izmir experienced a decrease of 1.58% in motion picture, video, and television program production, sound recording, and music publishing, video and television program production activities, 0.64% in programming and broadcasting activities, 1.02% in telecommunication activities, 0.05% in computer programming and consultancy activities, and 1.67% in information service activities. Compared with 2020, there was an increase of 0.03% in scientific research and development activities in Ankara, Istanbul, and Izmir in 2021.

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Table 7 Number of Employees in HKIS in Ankara, Istanbul, and Izmir (2021)

NACE CODE	HIGH-TECH KNOWLEDGE-INTENSIVE SERVICES	ANKARA	ISTANBUL	IZMIR	TÜRKİYE TOTAL	HKIS employment rate of the three cities in Türkiye (%)
59	Motion picture, video, and television program production, sound recording, and music publishing, Video and television program production activities	1,232	15,187	390	18,786	89.48
60	Programming and broadcasting activities	1,069	8,894	183	11,847	85.64
61	Telecommunications	5,912	13,194	2,252	31,192	68.47
62	Computer programming, consultancy, and related activities	20,398	84,556	8,181	137,868	82.06
63	Information service activities	3,150	13,229	778	22,303	76.93
72	Scientific research and development	4,359	2,947	1,362	16,034	54.06
Total		36,120	138,007	13,146	238,030	78.68

Table 8 shows the HKIS LQ values of Ankara, Istanbul, and Izmir in 2021. Compared with 2020, the HKIS trends continued in Ankara, Istanbul, and Izmir in 2021. Comparing Tables 8 and 6, there was agglomeration at the regional specialization level in telecommunication services in Ankara, but the level of concentration in computer programming, consulting, and information service activities decreased and fell below the concentration limit. Compared with 2020, there was no change in Istanbul and Izmir, and the agglomeration and clustering trend continued in the same way.

Table 8 LQ Value of High-Tech Knowledge-Intensive Services in 2021

NACE CODE	HIGH-TECH KNOWLEDGE-INTENSIVE SERVICES	ANKARA	ISTANBUL	IZMIR
59	Motion picture, video, and television program production, sound recording, and music publishing Video and television program production activities	0.43	1.39	0.38
60	Programming and broadcasting activities	0.59	1.29	0.28
61	Telecommunications	1.25	0.73	1.31
62	Computer programming, consultancy, and related activities	0.98	1.06	1.07
63	Information service activities	0.93	1.02	0.63
72	Scientific research and development	1.79	0.32	1.54

Figure 4 illustrates the 2021 LQ data. Istanbul's dominance continued in motion picture, video, and television program production, sound recording, music publishing, and programming and broadcasting activities, and Ankara and Izmir's dominance continued in scientific research and development activities. In the telecommunications sector, the agglomeration was maintained in Ankara and Izmir before COVID-19 and after COVID-19 measures. Istanbul and Izmir continued to

be concentrated on computer programming, consultancy, and related activities. Comparing Figures 4 and 3, information service activities continued to be concentrated in Istanbul after 2020.

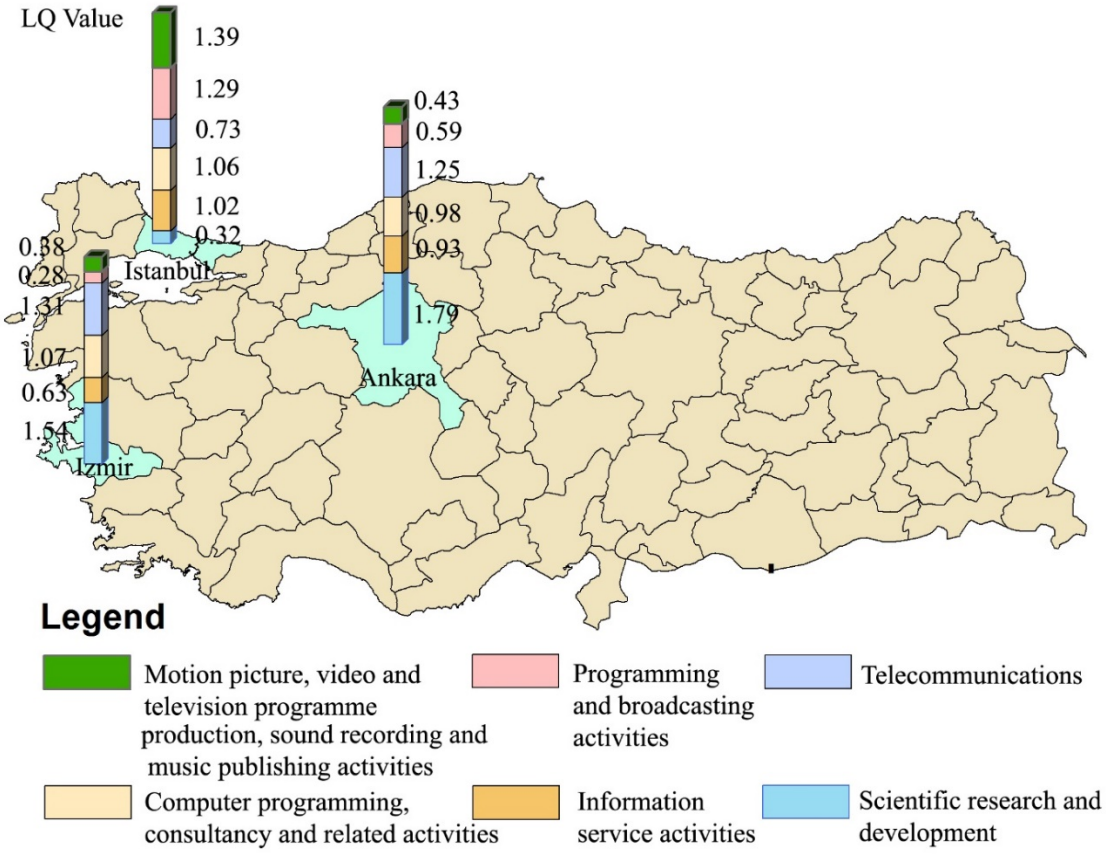

Figure 4 LQ map of HKIS activities in Ankara, Istanbul, and Izmir (2021)

6. Conclusion

This study investigated the changes in the spatial agglomeration of HKIS before the COVID-19 pandemic, during the implementation of measures to prevent its spread, and after the COVID-19 pandemic, specifically in Ankara, Istanbul, and Izmir.

There was agglomeration at the concentration level LQ > 1 in Izmir in the telecommunications sector in 2019. In 2020, COVID-19 pandemic measures caused agglomeration at the regional specialization level LQ > 1.25 in Izmir and agglomeration at the concentration level in Ankara. After the COVID-19 measures were implemented, Ankara and Izmir experienced agglomeration at the regional specialization level in the telecommunications sector. During and after the COVID-19 measures period, the telecommunications sector agglomerated at the regional specialization level in Ankara and Izmir. Owing to the COVID-19 measures, in 2020, unlike in 2019, the concentration in Izmir fell below LQ < 1 in the information service activities sector; in Ankara and Istanbul NUTS-3 regions, it exceeded LQ > 1, showing a change in agglomeration at the concentration level. In 2021, only information service activities resulted in an agglomeration at the concentration level in Istanbul, with the value of LQ > 1. The agglomeration in information service activities in Izmir before COVID-19 tended to concentrate in Istanbul after COVID-19 measures were implemented. Although all three cities experienced a concentration level of agglomeration in computer programming and consulting activities before the COVID-19 measures were implemented, in 2020, there was no change during the period of COVID-19 measures and the concentration level of agglomeration was maintained in these cities. However, in 2020, when COVID-19 measures were implemented, there was a decrease in the concentration levels of agglomeration in Ankara and Istanbul and an increase in Izmir compared with the period before COVID-19 measures were implemented. It can be argued

that COVID-19 measures caused a change in the trend of agglomeration in computer programming and consultancy activities toward Istanbul and Izmir.

After the COVID-19 measures were removed, the LQ level in Ankara fell below 1 in 2021, and the agglomeration trend in Istanbul and Izmir, which was caused by the impact of COVID-19, continued. The trend of agglomeration at the regional specialization level in motion picture production, sound recording, music publishing, and programming and broadcasting activities before COVID-19 measures continued during the COVID-19 measures period (2020) and the renormalization period (2021). COVID-19 measures did not change the agglomeration of these two sectors at the regional specialization level in Istanbul but caused a decrease in their LQ levels. The agglomeration of scientific research and development activities was at the level of regional specialization in Ankara and Izmir in 2019 before the COVID-19 pandemic; however, in 2020, when COVID-19 measures were implemented, this led to an increase in the LQ value in Ankara and a decrease in Izmir, but agglomeration at the regional specialization level was found to continue in both cities. With the renormalization period in 2021, there was an increase in the LQ value in scientific research and development activities in Ankara and an increase in Izmir compared with 2020, while the LQ value was lower than that in 2019. Moreover, COVID-19 further increased the agglomeration in scientific research and development activities in Ankara and decreased the agglomeration in Izmir compared with 2019 but caused the agglomeration trend to continue at the regional specialization level in both cities.

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The proportion of HKIS employees in Ankara, Istanbul, and Izmir compared with all of Türkiye was 71.65% in 2019; however, this rate increased to 79% in 2020, the period when the COVID-19 measures were implemented. COVID-19 measures may have caused less labor force loss in metropolitan cities where clustering is observed, especially in Ankara, Istanbul, and Izmir, compared with other cities. In 2021, the post-measures period, the share of HKIS employees in Türkiye for the three cities was 78.68%, decreasing by 0.32% because of HKIS investments in other cities. In addition, it was concluded that the HKIS agglomeration trend increased in Ankara, Istanbul, and Izmir compared with before the COVID-19 pandemic.

The literature review discussed in this study reports that HKIS activities mainly tend to agglomerate in metropolitan cities. The study showed that HKIS continued to agglomerate in the three metropolitan cities during and after the COVID-19 pandemic period. At this point, it can be argued that positive externalities are effective in reducing production costs through the agglomeration of HKIS in a city. In addition, economies of scope and scale may continue to agglomerate in cities because of competitiveness, variety, and improvement of specialization.

The literature review in this study also emphasizes that LQ provides only statistical data, not information about spatial differences besides issues such as the quality of firms and employees or sectoral connections and competition. The concentration information of HKIS in Istanbul, Izmir, and Ankara was obtained in this study that investigated the effect of COVID-19 on the concentration of HKIS sub-sectors. According to the results of this study, detailed future research is required on the competitiveness levels of firms, production, market, and sectoral relations. Future studies should also examine why HKIS activities are concentrated in these regions to develop strategies for HKIS sub-sectors. The literature review revealed that HKIS were directly and indirectly affected by COVID-19. However, it can be argued that the ability of HKIS companies to use technological infrastructure and have the qualified labor force potential reduced the level of impact resulting from the COVID-19 pandemic.

The COVID-19 pandemic and safety measures implemented to mitigate it have affected HKIS agglomeration. However, it was observed that the pandemic did not cause a major change in the concentration level of HKIS in the short term. In addition, the pandemic shifted the locations where HKIS activities were located. COVID-19 also caused changes in the sectoral agglomeration among HKIS sub-sectors. Trends for the 2020 and 2021 data indicate that the economic environment after the COVID-19 pandemic may continue to have an impact on service activities in the future. HKIS

activities are prone to be located mostly in big cities for various reasons such as spatial proximity with customers, production, industrial units, and infrastructure. This study, which also examined the changes in HKIS spatial agglomeration before, during, and after the COVID-19 measures concluded that they did not affect agglomeration trends in Ankara, Istanbul, and Izmir. The literature review emphasizes the tendency to work outside of the major metropolitan areas during and after the COVID-19 pandemic. Based on the findings of this study, HKIS concentration may continue in metropolitan areas. HKIS firms which were also affected by the pandemic and its measures can most likely choose places in metropolitan areas in the future and use the positive effects of agglomeration.

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Resume

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Investigation of the relationship between physical activity and park for some parks by SOPARC method in the case of Konya city (Karatay), Türkiye

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Abstract

In a rapidly evolving world, technological advancements have brought significant convenience to individuals. However, these developments have increasingly led to a sedentary lifestyle. The need for individuals to regain their natural right to move freely has become more pronounced. Parks, as the largest urban areas facilitating physical activity, play a critical role in addressing this need. This study examines the physical activity levels of park users in three parks in Konya, Türkiye. It also evaluates the park areas and features that enable physical activity. The research identifies the factors that either deter or encourage individuals from utilizing parks and recreational areas for physical activity. In addition, the aim was to calculate how much energy was expended by physical activity in these parks. According to the research findings, the parks have a large number of visitors. The majority of park users are female and the adult age group, while the senior age group prefers parks less. Despite the presence of visitors, inactivity is prevalent in these parks. There are large differences between the number of people in the target areas. While picnic areas are usually densely used, few people who used were observed in sports fields and walking paths. Pearson Chi-Square analysis was used to examine the differences between parks, target areas and periods, park users, and activity levels. The results indicated that among all target areas, picnic areas exhibited the lowest levels of physical activity. Based on these findings, the study offers design recommendations aimed at promoting higher levels of physical activity in parks.

Keywords: health, park, physical activity, quality of life, recreation

1. Introduction

Rapid change, which started with the Industrial Revolution and has spread to every field, leads to radical transformations from social institutions to cultural structures and lifestyles (Aykın, 2018). The human body needs to move constantly due to its innate characteristics (Zorba & Saygın, 2007). However, these transformations have imposed limitations on physical mobility. The fact that a person lives with so little movement also brings with it some health problems. These problems include slowing down the circulatory and respiratory systems, increased cardiovascular diseases, obesity, excessive changes in the digestive system, decreased joint movement limits and the formation of calcifications, decreased function in organs, and bone diseases (Bulut, 2013; Karaküçük; 1999; Tunay, 2008; Zorba & Saygın, 2007). A sedentary lifestyle also affects the quality of life, which expresses the feeling that life is going completely well. The concept of quality of life, in addition to representing the ability to do daily activities, also refers to the satisfaction that it provides from life and personal well-being (Genç et al., 2011). In widespread psychology, quality of life is called the conscious cognitive satisfaction value that someone has from his life (Rejeski & Mihalko, 2001). The search for a qualified life is one of the greatest struggles of mankind from birth to death (Vatansever et al., 2015). Today, living with improved quality of life has become as important as living longer (Akyol et al., 2008). In societies formed by sedentary and low-quality of

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life, the sustainability of human health is under threat, but it also imposes additional burdens on the economies of countries (Aykın, 2018).

Maintaining individual health, and hence public health, with a fun, low-cost, and highly efficient acquisition such as physical activity habits can also be used as an effective tool to reduce health expenditures, which are increasingly costly and have a large share in national budgets (Akyol et al., 2008; Bek, 2008). Many people are not physically active enough (McKenzie et al., 2006). In a study conducted in Turkey in 2013; In terms of physical activity in leisure time, 23% of men have adequate, 22% moderate and 55% low level of physical activity, these rates are 13%, 18% and 69% respectively for women. The proportion of men and women who engage in adequate and moderate physical activity decreases as age increases (Ünal et al., 2013). According to The World Health Organization (WHO), approximately 25% of adults and 81% of adolescents do not engage in enough physical activity. These rates are estimated to have increased with the measures taken due to the COVID-19 pandemic (Guthold et al., 2018, 2020; Şahin, 2022; WHO, 2022).

Physical activity is a basic human function. It is an important part of a healthy lifestyle for people of all ages. To be healthy and vigorous, physical activity is as important as eating, drinking, and sleeping (Ar, 2015; McKenzie et al., 2006; Zorba & Saygın, 2007). Regular physical activity has been shown to reduce morbidity and mortality by building and maintaining healthy bones, muscles, and joints, as well as reducing heart disease, diabetes, high blood pressure, colon cancer, depression/anxiety, and weight gain (HHS, 1996). WHO defines health as "a state of physical, mental and social well-being as a whole, not just protection from disease and harm". According to the age we live in, it can be defined as emotional, spiritual, intellectual, social, occupational, and physical well-being (McKenzie et al., 2006; Zorba & Saygın, 2007). The main purpose of physical activity for health is to prevent or slow down organic and physical disorders caused by a sedentary life, to increase physiological capacity, which is the basis of physical health, and to maintain physical fitness and health for many years. The effects of physical activity on health can be examined under three main headings as physical health, mental-social health, and its effects on future life (Bek, 2008; Demirel et al., 2014; Zorba & Saygın, 2007).

The ability of the public to freely engage in the phenomenon of movement, which is their natural right, and expanding opportunities to increase physical activity is a promising tool for addressing sedentary behavior associated with various chronic diseases (Cohen et al., 2007; Kılbaş, 1994). It has been proven by scientific research that the physical environment has a stimulating or inhibitory effect on individuals' ability to engage in an adequate level of physical activity (Berrigan & McKinno, 2008; Çubukçu et al., 2010; Humpel et al., 2002; Romero, 2005; Saelens et al., 2003; Taylor et al., 2006; Wells et al., 2007). Given the growing consensus that the environment plays a key role in promoting energy expenditure, a healthy and safely planned built or structured environment positively affects the determinants of health (Akyol et al., 2008; Kiraz, 2015). Understanding these determinants is important for developing effective interventions to increase physical activity levels in the population (Ball et al., 2001).

Many studies on health and green spaces advocate the positive effects of green spaces on health (Akdoğan et al., 2021; Ayan et al., 2018; Cleland et al., 2008; Küçükali et al., 2016; Lovasi et al., 2008; McCurdy et al., 2010; Rappe et al., 2006; Takano et al., 2002). Parks within green spaces, particularly, have been identified as significant community resources to promote disease prevention through the enhancement of physical activity (Bedimo-Rung et al., 2005; Cohen et al., 2016; Shores & West, 2008). Parks are an important component of healthy communities and provide a low-cost environment for community members to access and engage in physical activity (Cohen et al., 2019; Librett et al., 2007; Rhodes et al., 2017; Sallis et al., 2012).

Parks have an important role in providing environments for urban populations to be physically active, as they provide equal opportunities to facilitate physical activity to a wide range of users from different age, ethnocultural, and socioeconomic groups (Arifwidodo, 2020). People often use park and recreation services in a way that includes physical activities and contributes to their

physical health. Parks are also one of the most important elements of communication between society and individuals. In other words, parks can play a role in facilitating physical activity. Parks also provide opportunities for people to engage in sedentary behavior. Information about who uses public parks and what they do there can explain the current and potential contribution of parks to physical activity (Cohen et al., 2007; Emür & Onsekiz, 2007; Evenson et al., 2013; Floyd et al., 2008a; Godbey et al., 2010).

Park-based physical activity levels and visitor numbers are associated with park characteristics such as park proximity-accessibility (Abercrombie et al., 2008; Grahn, 1994; Han et al., 2013; Maroko et al., 2009; Roemmich et al., 2006; Schipperijn et al., 2013), size (Abercrombie et al., 2008; Ellaway et al., 2005), safety (Addy et al., 2004; Babey et al., 2005; Gümüş et al., 2017), aesthetics, facility quality, and type of exercise equipment in the park (Jansson et al., 2019). Apart from these, park usage is also a reflection of individual preferences such as age, exercise habits, and race/ethnicity. Other important features include the land use in the surrounding area and the availability of organized events that attract people to the park (Cohen et al., 2007).

This study is important in determining the positive effects of the relationship between parks and physical activity on urban quality of life and contributing to the design of future parks in this regard. Three parks were selected: Aşkar Höyüğü Park, Muhsin Yazıcıoğlu Park and Adalet Park. In the study method, parks in the same region were selected due to simultaneous observation conditions, and the reason for choosing more than one park number is to be able to make comparisons thanks to different findings and to increase the number of people observed. The aim of the research is to systematically investigate the physical activity measures of park users in Aşkar Höyüğü Park, Muhsin Yazıcıoğlu Park, and Adalet Park as examples, and evaluate the spaces and facilities within the parks that enable physical activity. The factors that limit users from accessing or influencing their choice of parks and recreational areas for physical activity have been determined. Within the scope of the study, it was calculated how much energy was spent by physical activity in parks. In light of the findings obtained, suggestions were made to contribute to the planning and design of existing and future parks by providing qualified and necessary data, increasing the service level of physical activity areas, and creating new recreational areas to support physical activity.

2. Methods and Materials

2.1. Material

The main materials of the research were determined as Adalet Park, Muhsin Yazıcıoğlu Park, and Aşkar Höyüğü Park located in the Karatay district of Konya province of Turkey (Fig. 1). Adalet Park was built in 2007. With an area of 78,000 m^2, the park includes a miniature of the Bosphorus Bridge and Mevlana Museum, a 4,600 m^2 artificial lake for boating, a 713 m^2 waterfall restaurant, a 93 m^2 waterfall, a walking path, sports fields, lighting elements, pergolas, children's playgrounds, and fitness equipment. Muhsin Yazıcıoğlu Park; built in 2014. With an area of 58,000 m^2, the park is located between Karfet and Fetihkent housing estates and is built on a mound with a history of approximately 6000 years. It is located just behind the newly built Sports and Congress Center. Most of the lighting system is provided by solar energy. It consists of small hills. It includes large grass areas, sports fields, fitness equipment, children's playgrounds, pergolas and ornamental pools. Aşkar Höyüğü Park: With an area of 47,000 m^2, the park is located between Adana Ring Road and Fevzi Çakmak Neighborhood, Başak Street, Akhüyük and Karkent Housing Complexes. It consists of small hills. Built-in 2012, the park includes an ornamental pool, sports fields, fitness equipment, lighting elements, walking paths, pergolas, and seating elements.

The materials of the study consisted of SOPARC (System for Observing Play and Recreation in Communities) forms, camera, satellite images, and literature. AutoCAD, Photoshop, SPSS 22.0 programs, and Office Software were used for data collection and evaluation.

Figure 1 The locations of the parks within the scope of the research in Konya province((Google Earth, 2019), 1. Aşkar Höyüğü Park (Anonymous1, 2014), 2. Muhsin Yazıcıoğlu Park (Anonymous2, 2014), 3. Adalet Park (Anonymous3, 2017))

2.2. Method

Relationships between physical activity and parks were revealed through literature research. The parks selected as the study material and the regions where the study will be carried out for each park are defined. These zones are functionally selected from the units located in 3 parks; a sports field, a children's playground, a picnic area, and a walking path. As a method, SOPARC was chosen, which will be carried out based on observations in 3 parks.

SOPARC is designed to obtain direct information about park use about the intersecting characteristics of parks and their users. It provides an assessment of park users' physical activity levels, gender, activity modes/types, age, and ethnic groups. Additionally, it provides information on individual park activity areas such as accessibility, usability, supervision, and organization. The validity of the activity codes used by SOPARC was established through heart rate monitoring. Direct observations are made at designated target areas that represent all standard locations that may offer opportunities for park users to be physically active (McKenzie et al., 2006; McKenzie et al., 1991).

SOPARC implementation; SOPARC observations were conducted throughout the day, including specific times in the morning, noon, afternoon, and evening (7:30; 11:30; 15:30; 18:30). Observations started in June and ended in July. For each park, observations were made for one week (7 days) and 4 hours per day. In total, 28 hours of observations were made in 1 week. On rainy days, observations were not made for that day and were made up later.

Observation materials were prepared before going to the park and were available in the park at least 20 minutes ago. SOPARC is based on systematic and periodic surveys with instant time sampling techniques, in which individuals and contextual factors are established within predetermined target areas located in parks. During the screening, the activity of each individual is coded as (walking, or vigorous), and sedentary (i.e., lying down, sitting, or standing). Separate screenings are conducted for men and female and the age groups of the participants are estimated. The accessibility of the area, the availability of space, the presence of supervision and equipment, and the presence and classification of organized activities were carried out with simultaneous entries throughout the day. Summary counts, the number of participants by gender, types, and levels of activity, and estimated age and gender groups were defined. The method allows for comparisons of physical activity levels in the same environment between different environments or at different times dec. Energy expenditure estimates (Kcal/kg/min) for the target area of the park can be calculated based on pre-approved constants for each activity level. To estimate the

kilocalories/kg expended, the number of people counted in the stationary, walking, and very active categories are multiplied by the constants 0.051kcal/kg/min, 0.096kcal/kg/min, and 0.144kcal/kg/min, respectively. Kilocalories/kg in each category can be summed to provide a measure of the total kilocalories/kg spent by park users in a given area. These values can be interpreted as the number of kilocalories per kg of body weight per minute spent in each area during the observed day (McKenzie et al., 2006). The energy expenditure calculations within the scope of the research were carried out over the more valid and widely used metabolic equivalent of task (MET). However, if desired, it is possible to obtain data based on the unit of kcal / kg/min using the constants given above.

Energy expenditure is calculated as MET. 1 MET is the amount of energy that a person burns per minute at rest and corresponds to 1.25 calories. Following the previous studies, 1.5, 3, and 6 MET values were given to park users observed in sedentary, walking, or vigorous activity, respectively (Suau et al., 2012).

3. Results and Findings

3.1. Features of Park Users

Observers made a total of 84 visits to the parks (21 days 4 visits/day). A total of 21,255 people were observed in the parks. 14.750 (69.3%) of the observed people are female users and 6505 (30.7%) are male users. Overall, more female users than males were seen at the parks. 28 visits were made separately for 3 parks (7 days 4 visits/day). During the observations made in Aşkar Höyüğü Park, 6952 people were observed. Female users constitute approximately 72% of the total number of people observed. During the observations made in Muhsin Yazıcıoğlu Park, 3451 people were observed. Female users make up about 64% of the total number of people observed. In the observations made in Adalet Park, 10,852 people were observed. In Adalet Park, where the most users are observed, the number of female users is higher than the number of male users. Female users constitute about 70% of the total number of people observed.

Age distribution was divided into four groups as children (0-12 years old), young (13-20 years old), adults (21-59 years old) and senior (60 and over years old). It is seen that the highest amount of users is in the adult group with 9283 people. It was observed that adults (43.6%) used the parks more than children (31.4%), young people (19.3%) and the elderly (5.7%). The number of elderly users in the parks is quite small. It is seen that the majority of the Aşkar Höyüğü Park users are adults in the age distribution. Children, young and seniors come respectively. The elderly age group makes up 6% of the park users, which is quite low. It is seen that the majority of Muhsin Yazıcıoğlu Park users are children and adults in the age distribution. Young and senior people come, respectively. In Muhsin Yazıcıoğlu Park, the elderly users are very few, making up 5.3% of the park users. According to the age distribution of Adalet Park users, it is seen that adults make up the majority. Children, young and seniors come respectively. The same is true in Adalet Park. Elderly users constitute 5.6% of park users (Table 1).

Table 1 Features of Park Users

User Features		PARKS TOTAL	AHP	MYP	AP
	Number of users	21255	6952	3451	10852
Gender	**Female**	14750	4956	2228	7566
	Male	6505	1996	1223	3286
Age	**Child**	6661	2488	**1428**	2745
	Young	4081	1078	556	2447
	Adult	**9283**	**2959**	1282	**5042**
	Seniors	1230	427	185	618

AHP; Aşkar Höyüğü Park, MYP; Muhsin Yazıcıoğlu Park, AP; Adalet Park

3.2. Terms of Target Areas

In the observations made in 3 parks, the conditions of the target areas in the parks are given in Fig. 2 3 parks are accessible (88%) and usable (84%), but are empty at some times. Specially in the

morning and at noon, the user could not be observed in some areas. In terms of security, the control (56%) is insufficient especially in the morning and evening periods. Urban equipment elements (76%) and rarely organized efficiency (1%) were provided. It is dark (15%) due to the lack of equipment and its non-use; therefore, access is rarely restricted. Considering the parks, Muhsin Yazıcıoğlu Park has deficiencies in terms of usability (wet, windy, etc.). While Aşkar Höyüğü Park and Muhsin Yazıcıoğlu Park are inadequate in terms of supervision, Adalet Park is supervised. There is a lack of equipment with fountains, lights, and trash cans in Adalet Park. While very few organized events were held in Aşkar Höyüğü and Muhsin Yazıcıoğlu Parks, no organized events were held in Adalet Park. In three parks it is dark in the evening. Rarely, in some periods, some target fields are empty.

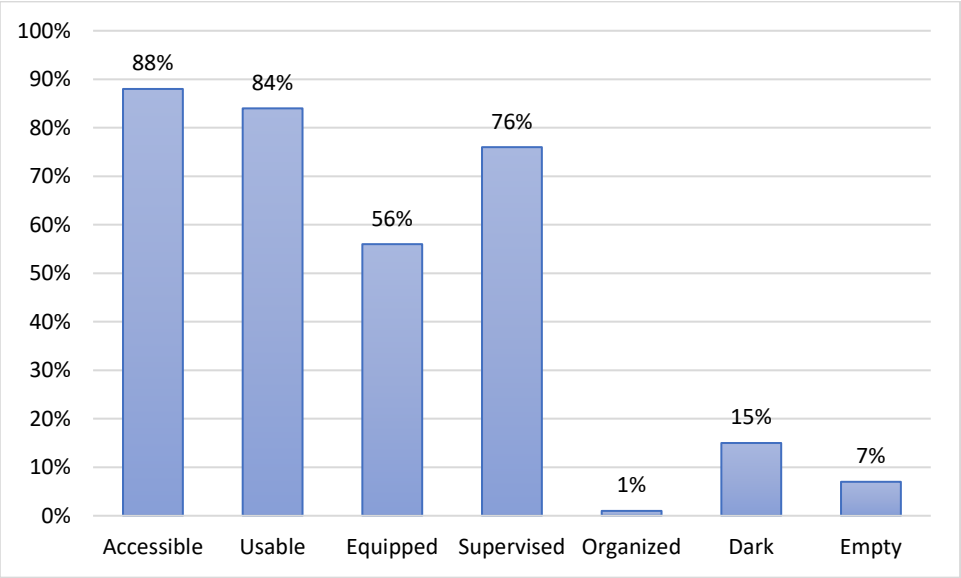

Figure 2 The conditions of the target areas of the three parks

3.3. Periods

The distribution of the people observed in the 3 parks according to the periods is given in Figure 3. The parks were observed in four periods: morning, noon, afternoon and evening (7:30; 11:30; 15:30; 18:30). Looking at the distribution of the 3 parks according to periods, more park users were observed in the afternoons (35.9%). Periods were observed in the afternoons (28.1%), evenings (25.6%) and mornings (10.4%), respectively. According to observations, park users do not visit parks in the morning periods. The reason for the intensity of the number of users in the park in the afternoon is the decrease in the noon temperature and the escape to green areas in the city where the temperature is felt less. The period when all age groups have the most users is in the afternoon. When viewed by gender, it is also afternoon during the peak period of male and female users.

Looking at the distribution of each park by period, it was observed that more park users in the Aşkar Höyüğü Park and the Adalet Park in the afternoon, noon, evening, and morning time intervals. The number of users observed in Muhsin Yazıcıoğlu Park in these time intervals changed as evenings, afternoons, noon, and mornings. The number of users in the morning period of Aşkar Höyüğü Park constitutes 9.3% of the total number of users, the number of users in the morning period of Muhsin Yazıcıoğlu Park constitutes 11.3% of the total number of users and the number of users in the morning period of Adalet Park constitutes 16.6% of the total number of users.

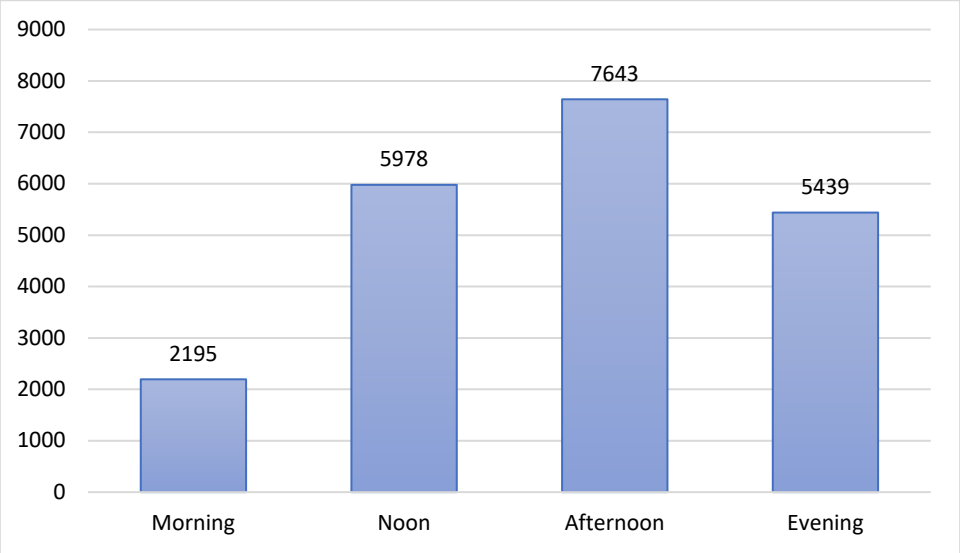

Figure 3 Distribution of park users by periods

The average number of people observed in the parks on weekdays and weekends is given in Fig. 4. The average number of users observed at the weekend (58%) of the parks is higher than the average number of users observed during the week (32%). This ratio is almost equal in Muhsin Yazıcıoğlu Park. Aşkar Höyüğü Park has 44% of users on weekdays and 56% on weekends. Muhsin Yazıcıoğlu Park has %50,4 of users on weekdays and 49.6% on weekends. Adalet Park has %38 users on weekdays and 62% on weekends. There are significant differences in the average number of users on weekdays and weekends in Adalet Park; users come in large groups on weekends.

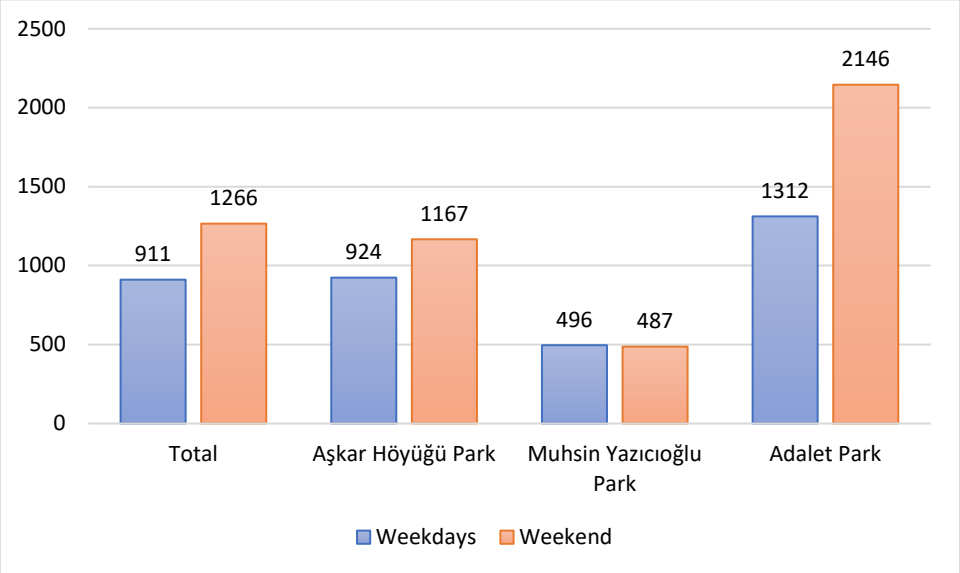

Figure 4 The average number of observed people on weekdays and weekends

3.4. Number of People Observed in Target Areas

Users were observed according to four target areas as picnic, children's playground, walking path and sports area. The number of people observed in the target areas is given in Figure 5. The ranking of parks according to the number of users in the target areas is picnic (77.7%), children's playground (16%), sports field (3.2%) and walking path (3.1%).

In Aşkar Höyüğü and Muhsin Yazıcıoğlu Parks, the ranking according to the number of users in the target areas is in the form of picnic, children's playground, sports field and walking path. This ranking is in the form of a picnic, a children's playground, a walking path, and a sports field in the Adalet park. The use of the walking path in Adalet Park is more than the sports field.

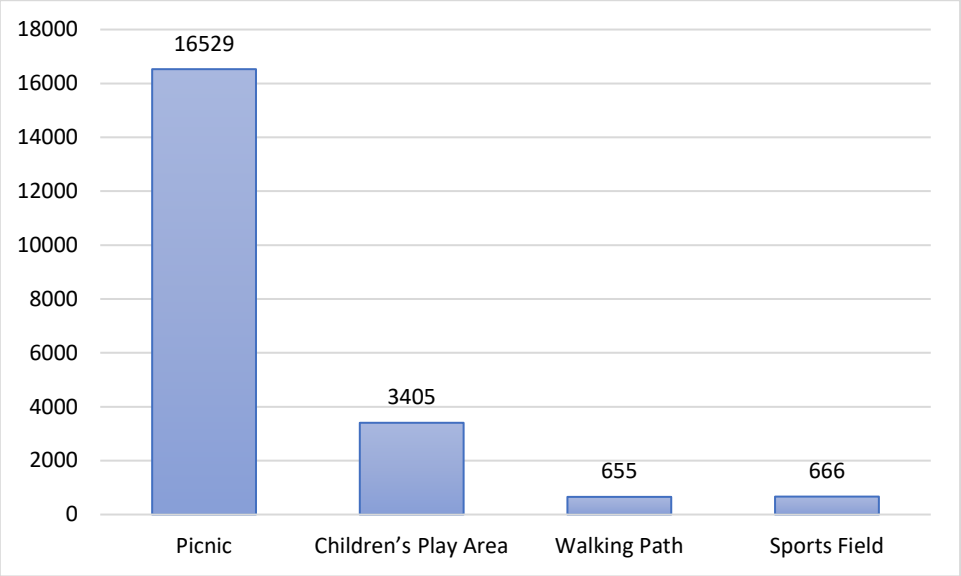

Figure 5 Number of people observed in target areas

3.5. Activity Statuses

Users are classified according to the activity statuses they do in the parks. Accordingly, 23 activity statuses were determined in the parks. 3 the activity status of the observed people in the park is given in Figure 6. Looking at the parks in general, picnic (39%) is the most common activity. Other activities are sitting (33%) and climbing/sliding (9%). The least performed activity was reading (0.04%).

When looking at the general structure of the parks in Aşkar Höyüğü Park and Muhsin Yazıcıoğlu Park, the most common activity is sitting (38%-32%). Other activities are picnicking (36%-29.4%) and climbing/sliding (7.9%-15.2%). The least performed activity is reading (0.04%- 0.05%). In addition, running is one of the least performed activities in Muhsin Yazıcıoğlu Park (0.08%).

When examining the activity status of observed individuals in Adalet Park, the most common activity is picnicking (41.2%). Other activities include sitting (29.7%) and climbing/sliding (8.1%). The least performed activities are reading (0.04%) and cycling (0.04%).

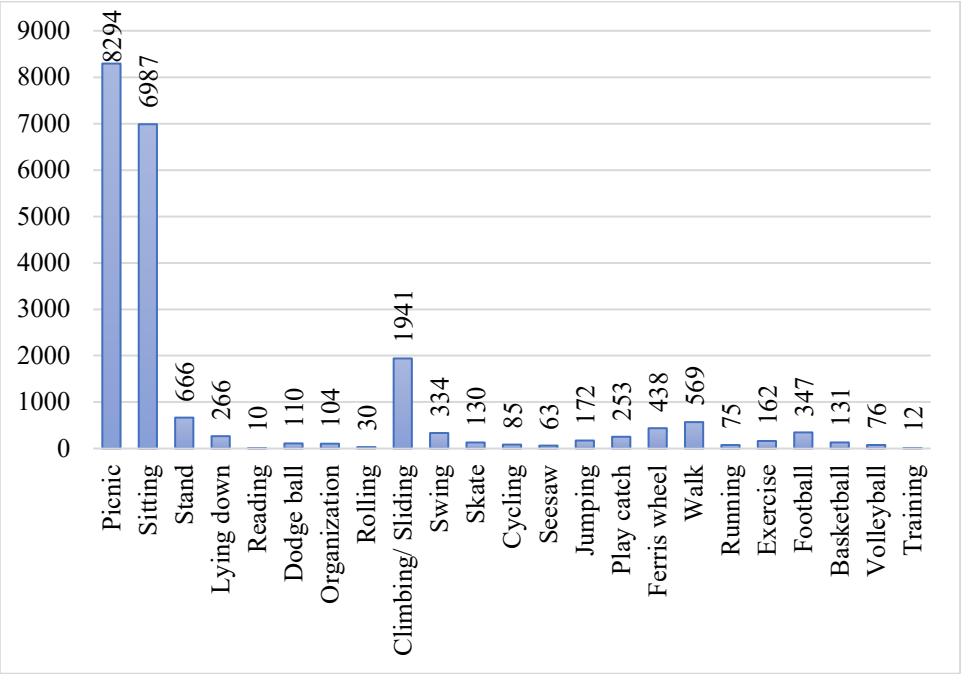

Figure 6 Total activity status of the three parks

3.6. Activity Levels and Energy Expenditure

Users were classified into three groups according to their energy levels in the parks: sedentary, walking, and vigorous. The activity levels of the parks are given in Figure 7. Looking at the 3 parks in general, inactivity is dominant but vigorous activity level is very low (sedentary 77%, walking 18.5%, vigorous 4.5%). According to observations, men are generally more physically active than female. Overall, men are three times more active than female in vigorous physical activity (3% vs. 9%). They are almost twice as active at the walking level of activity (15% vs. 26.5%).

The level of inactivity is quite high in Aşkar Höyüğü and Adalet Parks. It is lower in Muhsin Yazıcıoğlu Park compared to the others. The vigorous level is very low in Adalet Park. The park with the highest level of vigorous activity is Aşkar Höyüğü Park.

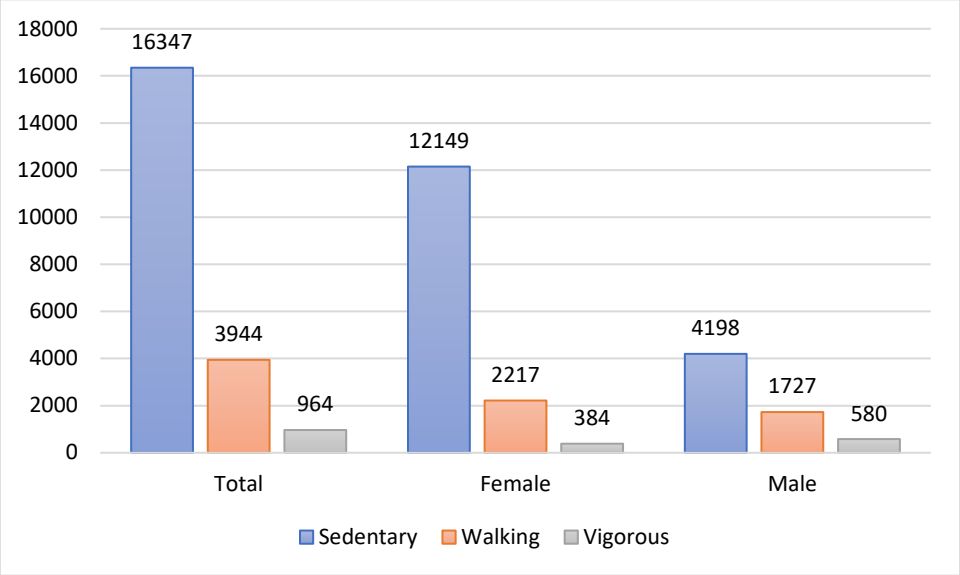

Figure 7 The distribution of activity levels in parks according to gender

The average METs of the 3 parks considered within the scope of the research were calculated and, accordingly, the METs were determined for each park. According to the findings, the METs are 2.18 for Muhsin Yazıcıoğlu Park, 2.02 for Aşkar Höyüğü Park, and 1.88 for Adalet Park (Table 2). According to this result, although the METs of each park are close to each other, it has been determined that the most effective park as a MET is Muhsin Yazıcıoğlu Park. The unit m^2 area METs were calculated over the parking areas. Accordingly, it was found to be 0.30 for Aşkar Höyüğü Park, 0.26 for Adalet Park, and 0.13 for Muhsin Yazıcıoğlu Park. The reason why the MET, which falls to m^2 in Muhsin Yazıcıoğlu Park, is low is that the number of users is small compared to the park size.

Table 2 METs According to Parks

	Number of users	Average number of users each day	Park Size (m^2)	MET per m^2	Total MET	METs per capita
AHP						
Female	4956	708			9178,5	1,85
Male	1996	285,1			4932	2,47
Total	6952	993,1	47.000	0,3	14110,5	2,02
MYP						
Female	2228	318,2			4416	1,98
Male	1223	174,7			3126	2,55
Total	3451	493	58.000	0,13	7542	2,18
AP						
Female	7566	1080			13584	1,79
Male	3286	469,4			6900	2,09
Total	10852	1550	78.000	0,26	20484	1,88

AHP; Aşkar Höyüğü Park, MYP; Muhsin Yazıcıoğlu Park, AP; Adalet Park, MET; Metabolic Equivalent of Task

In the scope of the research, average METs were calculated based on the target areas of the three parks, and accordingly, METs were determined for each target area in each park. According to the findings, the METs per person vary in target areas, but in all three parks, the lowest MET is observed in the picnic area. In Aşkar Höyüğü Park, the most effective area in terms of METs based on target areas is the children's play-ground with 4.17 METs. In Muhsin Yazıcıoğlu Park, the most effective area is the sports area with 3.79 METs, and in Adalet Park, it is the walking path with 3.49 METs (Table 3). METs per square meter were calculated for the parks based on target areas.

Table 3 METs According to Target Areas in the Parks

	Number of users	Average number of users each day	Park Size (m^2)	MET per m^2	Total MET	METs per capita
AHP						
Picnic	5530	790	39660	0,21	8403	1,51
Children's Play Area	1005	143,5	620	6,76	4195,5	4,17
Walking Path	151	21,5	2120	0,23	507	3,35
Sports Field	266	38	3000	0,33	1005	3,77
MYP						
Picnic	2273	324,7	54600	0,06	3477	1,51
Children's Play Area	869	124,1	600	4,98	2988	3,43
Walking Path	131	18,7	1700	0,23	402	3,06
Sports Field	178	25,4	910	0,74	675	3,79
AP						
Picnic	8726	1246,5	63500	0,21	13633,5	1,56
Children's Play Area	1531	218,7	1700	2,81	4785	3,12
Walking Path	373	53,7	4000	0,32	1305	3,49
Sports Field	222	31,7	1200	0,63	760,5	3,42

AHP; Aşkar Höyüğü Park, MYP; Muhsin Yazıcıoğlu Park, AP; Adalet Park, MET; Metabolic Equivalent of Task

The average METs were calculated for the three periods considered in the scope of the research, and accordingly, METs were determined for each period in each park. According to the findings, METs per person vary across the periods, but in all three parks, the lowest MET is observed during the afternoon period. In Aşkar Höyüğü Park, the most effective period in terms of METs is the morning period with 2.38 METs. In Muhsin Yazıcıoğlu Park and Adalet Park, the most effective periods are the evening periods with 2.32 and 2.08 METs respectively (Table 4).

Table 4 METs According to Periods in the Parks

	Number of users	Average number of users each day	Total MET	METs per capita
AHP				
Morning	653	93,2	1558,5	2,38
Noon	2003	286,1	3820,5	1,9
Afternoon	2653	379	5223	1,96
Evening	1643	234,7	3508,5	2,13
MYP				
Morning	393	56,1	796,5	2,02
Noon	836	119,4	1663,5	1,98
Afternoon	973	139	2179,5	2,23
Evening	1249	178,4	2902,5	2,32
AP				
Morning	1149	164,1	2203,5	1,91
Noon	3139	448,4	5554,5	1,76
Afternoon	4017	573,8	7423,5	1,84
Evening	2547	363,8	5302,5	2,08

AHP; Aşkar Höyüğü Park, MYP; Muhsin Yazıcıoğlu Park, AP; Adalet Park, MET; Metabolic Equivalent of Task

3.7. The Relationships Between Physical Activity, Parks, and Park Users

Pearson Chi-Square analysis was performed according to the number, gender, and age characteristics of the park users observed and identified in the 3 parks within the scope of the research, and it was determined whether there was a difference between the demographic characteristics of the users in terms of parks. According to the find-ings, no statistically significant difference was detected in terms of the number of users and gender characteristics across the parks. However, when looking at the ages of the users, a statistically significant difference was

found among users in the child age group (p=0.038) (Table 5). While the number of child users in Aşkar Höyüğü Park and Muhsin Yazıcıoğlu Park are close to each other, the number of child users in Adalet Park is low. Since Adalet Park is larger than the other parks and has the characteristics of an urban park, the playgrounds in it are more comprehensive and larger than the other two parks. However, it is striking that the number of child users in this park is lower than in the other parks.

Table 5 Comparison of Users' Demographic Characteristics Across Parks

User Features	PARKS	Pearson Chi-Square	P Value
	Number of users	261,583	0,358
Gender	**Female**	219,124	0,253
	Male	156,927	0,292
Age	**Child**	190,985	**0,038***
	Young	126,697	0,196
	Adult	190,935	0,074
	Senior	64,622	0,385

****P<0,01, *P<0,05**

Pearson Chi-Square analysis was performed according to the number, gender and age characteristics of the park users observed and identified in 4 target areas in each of the 3 parks within the scope of the research, and it was investigated whether there was a difference in user characteristics between the parks (Table 6). According to the findings, statistically significant differences were found in the number of users, gender and age (p=0.000). The number of users in target areas is higher in picnic areas than in other target areas. Female are in the majority in the picnic area, but in the minority in the sports area. Children are in the majority in the children's playground, but in the minority on the walking path.

Table 6 Comparison of Target Areas in Terms of Demographic Characteristics of Their Users

User Features	TARGET AREA	Pearson Chi-Square	P Value
	Number of users	577,166	**0,000****
Gender	**Female**	528,105	**0,000****
	Male	426,404	**0,000****
Age	**Child**	551,224	**0,000****
	Young	285,411	**0,000****
	Adult	389,921	**0,000****
	Senior	293,145	**0,000****

****P<0,01, *P<0,05**

Observations and determinations were made regarding the number, gender, and age characteristics of park users during the periods in the three parks covered in the study. A Pearson Chi-Square analysis was conducted to investigate whether there was a difference in user characteristics across parks. According to the findings, there was no statistical difference in the number of users according to the periods (Table 7). However, a statistically significant difference was found in the number of male participants according to gender (p= 0.001). Male users were observed in small numbers during the morning period. When examined by age, a statistically significant difference was found among young park users (p= 0.032). The young age group was observed nearly 4 times more during the afternoon period than the morning period.

Table 7 Comparison of Users' Demographic Characteristics Across Periods

User Features	PERIOD	Pearson Chi-Square	P Value
	Total number of users	423,614	0,065
Gender	**Female**	331,736	0,179
	Male	290,544	**0,001****
Age	**Number of Child**	238,171	0,466
	Number of Young	206,915	**0,032***
	Number of Adult	258,330	0,282
	Number of Senior	97,866	0,345

****P<0,01, *P<0,05**

3.8. Relationships Between Parks and Activity Levels

Observations and determinations were made regarding the activity levels of park users in the three parks covered in the study. A Pearson Chi-Square analysis was conducted to investigate whether there was a difference in activity levels across parks (Table 8). According to the findings, no statistically significant difference was detected in terms of activity levels across parks. In all 3 parks, inactivity prevails and the level of vigorous is very low.

Table 8 Comparison of Users' Activity Levels According to Parks

	Activity Levels	Pearson Chi-Square	P Value
PARKS	**Sedentary**	180,647	0,126
	Walking	116,353	0,473
	Vigorous	57,463	0,165

****P<0,01, *P<0,05**

Observations and determinations were made regarding the activity levels of park users in the target areas of the three parks covered in the study. A Pearson Chi-Square analysis was conducted to investigate whether there was a difference in activity levels across parks (Table 9). According to the findings, there were statistically significant differences (p=0.000) in the activity levels of target areas and park users. The activity level in the picnic area is generally sedentary while walking and vigorous activity levels dominate in other areas.

Table 9 Comparison of Users' Activity Levels According to Target Areas

	Activity Levels	Pearson Chi-Square	P Value
TARGET AREAS	**Sedentary**	390,847	**0,000****
	Walking	417,269	**0,000****
	Vigorous	191,540	**0,000****

****P<0,01, *P<0,05**

Pearson Chi-Square analysis was performed according to the activity levels of park users observed and determined in the periods in the 3 parks within the scope of the research, and it was determined whether there was a difference in the activity levels between the parks (Table 10). According to the findings, no statistically significant difference was detected between activity levels and periods.

Table 10 Comparison of Users' Activity Levels According to Target Areas

	Activity Levels	Pearson Chi-Square	P Value
PERIODS	**Sedentary**	250,138	0,313
	Walking	201,730	0,074
	Vigorous	84,630	0,147

****P<0,01, *P<0,05**

4. Discussion

The research on physical activity has expanded in recent years to examine the environmental influences that either enhance or restrict opportunities for individuals to be active (Kaczynski & Henderson, 2007). Environmental determinants of health have received increasing attention in the literature, but there is little empirical research in this area (Giles-Corti & Donovan, 2002). Parks have long served to provide the community with spaces for entertainment and relaxation. They are designed to enhance community livability and offer recreational opportunities for individual health benefits (Hamilton, 2011). Parks contribute to physical activity, but it is difficult to measure activities and the variables associated with them. Because the field contexts change, and the number and characteristics of users are quite variable. SOPARC is a reliable and applicable tool for evaluating physical activity and related contextual data in a community setting (McKenzie et al., 2006). Parks are valuable community resources that can play an important role in the fight against rising rates of obesity and chronic disease in youth across the country. A better understanding of the ways in which these environments are associated with physical activity among children can inform future research and environmental and policy changes that can improve the health and well-being of future generations (Besenyi, 2011).

Although observations regarding many public parks suggest that men visit parks more frequently than female (Shores & West, 2008), our study reveals the opposite. Our research results show that females' interest in parks is higher than males', offering a new perspective that contradicts previous observations. When analyzed in terms of age group, it shows that it is not sufficiently used by adults and the elderly and that most people using the park are sedentary (Cohen et al., 2013; Cohen et al., 2010; Cohen et al., 2007; Cohen et al., 2006; Floyd et al., 2011; Floyd et al., 2008a; Kaczynski & Mowen, 2011). The elderly was the age group that used the park the least (Shores & West, 2008), which was also supported in our study. However, adults and children were observed more frequently than youth or the elderly. These findings provide significant clues into the park usage habits of different age groups. The low park usage rates among elderly individuals highlight the necessity of designing accessible and appealing spaces specifically tailored to this demographic. According to findings, the higher frequency of park usage observed among adults and children underscores the importance of planning spaces and activities that cater to the needs of these groups. The observed disparities between youth and the elderly further emphasize the need for more inclusive approaches in the design and management of parks. In a nutshell, the equitable development of parks to support all segments of society can play a critical role in promoting individual and public health.

Increased physical activity levels in adults and the elderly have positive effects on different aspects of quality of life. An increase is observed in areas such as physical functions, ability to assume roles, pain perception and social interaction (Vatansever et al., 2015). In a study by Cohen et al. (2007), the presence of senior centers in park facilities was associated with an increase in the number of elderly people observed in the park. This suggests that senior people may need customized programs or incentives to use park spaces.

While increasing and developing park areas are likely to increase their use, the greatest gains in serving more people may come from increasing the number of events and activities planned and organized in parks. The presence of events in the park, including sporting competitions and other attractions, appears to be the strongest association between park use and community-level physical activity. Achieving this goal will require the recruitment and training of more staff, including coaches, activity supervisors and event planners (Cohen et al., 2010; Cohen et al., 2007). Adult supervision provided during times of organized park activities can have a meaningful impact on children's activities in the park throughout their educational process (Leek et al., 2011). However, some studies report that there are negative relationships between organized park activities and the activity levels of adults and children (Floyd et al., 2008b). This indicates the importance of the structure of the events and their alignment with the needs of the participants.

Increased proximity to parkland is associated with physical activity (Kaczynski & Mowen, 2011). The park area made the increase in physical activity among young people reasonable (Epstein et al., 2006). Social factors and design features should be considered to encourage higher levels of park-based physical activity among children and young people (Floyd et al., 2011). Nearness alone is not enough; accessibility and safety of parks are also key to promoting physical activity, especially among young people. Well-designed parks with diverse recreational opportunities can encourage higher levels of engagement, while social factors such as community support can encourage long-term participation in physical activity.

The most influential relationships in the number of park users are found between the size of the park and the number of organized activities observed. However, neighborhood population density, neighborhood poverty levels, perceptions of park safety, and the existence of a park advisory board were not associated with park use. While low perceptions of safety are seen as a factor that restricts parking use, there is no trend that high perceptions of safety facilitate parking use (Cohen et al., 2010). Perceptions of safety can influence the use of recreation areas (McKenzie et al., 2006). It shows that perceiving a park as safe may not facilitate its use (Cohen et al., 2010). Although it is neutral in this respect in some studies, it has been found to affect parking usage, especially in the morning hours in the study (Cohen et al., 2016; Cohen et al., 2007; Cohen et al., 2006).

The number of people observed in the morning periods is lower than in other periods (Shores & West, 2008). As in the studies of Shores and West (2008), more people were observed in the afternoon period in the two parks. However, at Muhsin Yazıcıoğlu Park, in line with the study by (Cohen et al., 2006), a greater number of individuals were observed during the evening period.

While children were more in the playground and females were more in the walking path (Cohen et al., 2006), in our study females were more in the picnic area. This finding suggests that females' preferences for park usage may vary depending on the design and amenities provided in different areas. Additionally, it is plausible that picnic areas have become more attractive to females due to their capacity to fulfill social interaction and recreational needs.

The majority of activities in the park consist of sitting. In both males and females, the predominant activity level is sedentary. These findings are similar to the reports obtained from previous studies (Cohen et al., 2006) utilizing observational methods.

Energy expenditure also varied according to activity areas. Sedentary behavior and lower levels of energy expenditure were associated with picnic areas (Floyd et al., 2008a). The target areas with playgrounds are the areas with the highest activity levels among park visitors (Shores & West, 2008). While many types of park use, both active and passive, combine to provide a range of social, economic, and psychological benefits through leisure experiences, the prevalence of sedentary activity in park settings suggests that there may be more opportunities to promote physically active park use (Bedimo-Rung et al., 2005; Floyd et al., 2008a). This highlights the need for park designs that encourage more active engagement, particularly in areas like picnic spaces where sedentary behaviors are more common. By incorporating more dynamic features and structured activities, parks could better support physical activity and enhance overall health outcomes for visitors.

5. Conclusion

Parks play a critical role in facilitating physical activity in communities, they not only provide facilities with planned and supervised activities, but also provide places for people to carry out recreational activities, even if they are sedentary after arriving there.

The sustainable increase in the quality of life through physical activity, which has positive effects on health, necessitates investment in these areas. Understanding the current situation can assist in directing investments in a more informed manner. For this reason, the scientific studies carried out on this issue will have a guiding quality.

In this study, the relationship between physical activity and park for 3 parks was investigated by the SOPARC method in the case of Konya City (Karatay), Turkey. During the 21 days of observations, a total of 28 observations were made in 12 target areas. The observations consisted of 4 periods on 1 day (morning, noon, afternoon, evening). A total of 21255 people were observed in 3 parks. The park target area conditions, demographic characteristics of park users, activity status, and energy levels were recorded in the SOPARC forms. In the final part of the study, the collected data was organized, and the energy expenditure and METs spent in the parks were calculated. The data were compared statistically with Pearson Chi-Square analysis.

- When the demographic characteristics of park users are considered, it is seen that female users are relatively more than male users. While the majority of park users are in the adult age group, the elderly age group prefers parks less. When viewed according to the parks, the situation is the same in Aşkar Höyüğü Park and Adalet Park. However, the majority of park users in Muhsin Yazıcıoğlu Park are children's age group.
- In terms of target area conditions, access was generally achieved. Although sometimes there are problems with usability due to wind and wetness, it is generally usable. While Adalet Park is supervised, Aşkar Höyüğü Park and Muhsin Yazıcıoğlu Park are not supervised in the morning and evening periods. While Aşkar Höyüğü Park and Muhsin Yazıcıoğlu Park are sufficient in terms of equipment, the lack of fountains and garbage cans in Adalet Park creates a lack of equipment. Too few organized events were held. In all 3 parks, it is dark

during the evening periods due to whether the lighting element is not used or due to lack of lighting elements. The number of users in the walking path and sports areas was low, especially in the mornings and at noon.

- The number of people in periods was observed most often in the afternoon. Few people were observed during the morning periods and could not be observed from time to time. However, the highest number of people in Muhsin Yazıcıoğlu Park was observed in the evenings. In total 3 parks have more users on average on the weekend. When looked at by park, the average number of people coming to Muhsin Yazıcıoğlu Park on weekdays and weekends is almost equal and even more on weekdays.
- There are large differences in the number of people in target areas. While picnic areas are usually observed intensively by people, sports fields and walking paths are observed very little compared to the picnic area.
- Picnic, sitting and climbing/sliding are the top 3 activities, while reading is the least common activity. The situation is the same in 3 parks.
- When the parks are analyzed in general and the 3 parks are analyzed separately, inactivity is dominant in the activity levels of the people. The level of vigorous activity is very low.
- METs were calculated according to parks, target areas, and periods. According to the parks, Muhsin Yazıcıoğlu Park has the highest MET value. METs per unit m^2 area were calculated based on parking areas. The highest METs per m^2 are in Aşkar Höyüğü Park and the lowest in Muhsin Yazıcıoğlu Park. The reason for the low MET per m^2 in Muhsin Yazıcıoğlu Park is the low number of users compared to the size of the park. When looking at the target areas, the area where the MET is the lowest is the picnic area. According to the target areas in Aşkar Höyüğü Park, the most effective place of MET is the children's playground, the most effective place in Muhsin Yazıcıoğlu Park is the sports area, and the most effective place in Adalet Park is the walking path. In terms of periods, the lowest MET is at noon in all 3 parks, but the effective periods are different. The most effective period in Aşkar Höyüğü Park is in the morning, while the most effective period in Muhsin Yazıcıoğlu Park and Adalet Park is in the evening.
- Using Pearson Chi-Square analysis, differences between the park, target areas and periods, and park users were examined. When looking at the park and demographic characteristics, no difference was detected, but a significant difference was detected in the child age group ($p = 0.038$). There are few children in the Adalet Park. Within the scope of the research, statistically significant differences were found in the number of users, gender, and age ($p=0.000$) in the target areas. When demographic characteristics were analyzed according to periods, no difference was detected in the number of users, but a significant difference was detected in male users ($p = 0.001$). When looked at by age group, significant differences were detected in the younger age group ($p = 0.032$). Male users and younger age group users were observed in very small numbers in the morning period.
- Using Pearson Chi-Square analysis, differences between parks, target areas, periods, and activity levels were examined. No difference could be detected between parks and activity levels. The three parks are dominated by sedentary, walking, and vigorous activity levels, respectively. When looking at the target areas, statistically significant differences ($p = 0.000$) were detected. The picnic target area is dominated by inactivity, while the other target areas are dominated by walking and vigorous activity levels. According to the findings, no difference was detected in the activity levels in the periods.

Today, society's lack of sufficient knowledge about physical activity, and inadequate perception of the importance of physical activity for health, and lack of sufficient physical activity have become one of the reasons for the increase in obesity, sedentary life, and many diseases in society. Parks provide opportunities for people in cities to get away from busy urban life, satisfy their longing for nature, and engage in recreational activities. As a result of the observations and analyses, suggestions have been made that will contribute to the creation of new recreational areas that will

support physical activity and increase the service level of physical activity areas by providing qualified and necessary data for the planning and design of existing and future parks.

- The accessibility of the parks allows people to carry out their physical activities. Situations that prevent access must be eliminated. Walkways and circulation paths should be designed by the standards and should be connected without interruption.
- Reinforcement elements should be added to areas where lighting elements and fountains are insufficient.
- Supervision should be increased in the morning and evening hours in Aşkar Höyüğü Park and Muhsin Yazıcıoğlu Park.
- Park irrigation should be done during the hours when park users are not present because the wetting of seating elements and grass due to irrigation makes that area unusable.
- Organized events that will allow physical activity should be organized by park management and municipalities. Encourage people to participate in organized activities such as cycling, collective walking, and outdoor fitness. Platforms for aerobics should be placed in certain areas. Fitness equipment should be in a certain area, designed in different sizes, and appeal to all age groups. Achieving this goal will require the recruitment and training of more staff, including coaches, activity controllers, and event planners.
- Sports fields should be designed by standards. Tribunes or seating areas should be created around the field for those who come to watch sports activities. Sports fields should be diversified by creating areas suitable for baseball and tetherball activities, which are not widely practiced in Turkey. It is forbidden to enter most parks with bicycles due to the risk of accidents. To prevent this, bicycle paths must be built by standards separate from pedestrian circulation in the park.
- Children are our future, the most suitable areas where they can be healthy individuals and perform physical activities are children's playgrounds. As a result of observations made in parks, children's play groups, especially climbing/sliding, should be developed. Children's playgrounds should be separated according to age groups. The area for young children should be designed to be more eye-catching, and colorful, with animal figures etc. Since sandboxes help children's mental development and develop their imagination, sandboxes of different shapes should be included in parks. Areas should be created where they can spend time with their parents. The age limit of 13 should be removed for playgroups in parks, and play groups not only for children but also for adults should be created and placed in parks. Larger slides, Ferris wheels, and swings should be built. Competitive game elements that increase arm, and leg movements and balance should also be used.
- To attract elderly users to the parks, special design areas of the parks need to be created. A short-distance, flat, non-slippery walking path supported by handrails and fitness equipment that requires light strength should be designed.
- Chess aimed at improving intelligence and play elements that require manipulative play skills should also be added to the parks. Seating areas should be provided for spectators for chess/checkers activities. Large grass areas should be created for picnic areas. Areas that can meet the needs of every person should be designed in parks. When designing areas, standards should be adhered to, and their surfaces and dimensions should be suitable for human ergonomics.
- To increase the reading rate in the parks, mini libraries should be created, mass reading days, and under-tree reading events should be held.

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Resume

Esra Sivri İçöz began her undergraduate studies at the Faculty of Agriculture, Department of Landscape Architecture, Selcuk University, in 2013, and graduated with the title of Landscape Architect in 2017. In the same year, she commenced her Master's program at Selcuk University, Department of Landscape Architecture. Between 2019-2020, her thesis work was supported by BAP and she worked as an intern at Selcuk University, Department of Landscape Architecture. She received the title of Master of Landscape Architect in 2020. In 2020, she started her doctoral studies at Selcuk University, Faculty of Science, Landscape Architecture Department. Her doctoral studies are still going on. She has publications on various topics related to the physical and psychological effects of landscape areas.

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Towards sustainable cities: Evaluating the distribution and functionality of green spaces in Atakum

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Abstract

The rapid increase in urbanization has led to a concentration of population and buildings, resulting in reduced green spaces and disrupted ecological balance. This trend negatively affects the well-being and quality of life in cities. Designing green spaces according to planning standards and protecting these areas is crucial for the sustainability of urban environments and the preservation of livable spaces for future generations. In light of these challenges, it is vital to preserve and expand green spaces for both environmental and social reasons. This study aims to evaluate the spatial distribution, size, and adequacy of existing green spaces in 16 neighborhoods of Atakum, a district in Samsun that has recently undergone intense urbanization. It also assesses the accessibility of these spaces using Geographic Information Systems (GIS). The analysis of urban green spaces in Atakum was conducted through spatial and buffer zone analyses using the Spatial Analyst tool in ARCGIS 10.7, revealing the current situation of these vital areas. The findings highlight the significance of green spaces in ensuring livable and sustainable urban development, especially in rapidly urbanizing areas. The research identifies substantial disparities in the distribution and accessibility of open and green spaces in Atakum, indicating an urgent need for improved urban planning. Using GIS analysis, the study compares the availability of green spaces against the World Health Organization's recommended standard of 10 m² per person. Results show that many neighborhoods fall short of this benchmark, a situation exacerbated by rapid urbanization and population growth. This deficit adversely impacts residents' physical and mental well-being, as adequate green space is essential for public health, social cohesion, and environmental sustainability. Additionally, the analysis reveals that existing green spaces primarily serve recreational purposes and lack multifunctionality, limiting their usability for diverse community needs. To address these deficiencies, the study recommends a multi-faceted urban planning approach, emphasizing the equitable distribution of green spaces, the design of multifunctional areas, and robust community engagement in the planning process. It also stresses the need for stronger legal frameworks to preserve and create green spaces, advocating for the integration of research and data analysis to inform evidence-based policies. In conclusion, this research contributes to understanding how urban green spaces can enhance livability, particularly in the context of climate resilience. The findings underscore the importance of strategic planning in fostering sustainable and inclusive urban environments in Atakum, offering valuable insights for future urban studies in similar contexts.

Keywords: equity in green space distribution, open and green spaces, urban planning, multifunctional areas, urbanization

1. Introduction

Open and green spaces not only enhance the quality of life in cities but also play a critical role in the ecological and environmental sustainability of urban areas. The size, accessibility, function, and spatial organization of these spaces are crucial elements in urban planning. The design and planning of open and green spaces vary in content, size, and function across countries and cities.

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These variations are influenced by natural features such as topography, soil capability, vegetation, climate conditions, the population served, and the characteristics of the settlement (Ersoy, 2015).

Urban open and green spaces include a range of areas such as parks, gardens, playgrounds, sports fields, forests, cemeteries, conservation zones, and medians along roads. Green spaces are designed for various purposes, including acting as buffer zones to protect natural resources and historical artifacts, and to prevent unplanned urban sprawl. On a neighborhood scale, one of the key benefits of green spaces is their contribution to human health. Their ecological functions significantly aid in air purification by balancing gases that cause air pollution and producing oxygen. Moreover, green spaces offer opportunities for residents to improve their mental and physical well-being through sports and recreational activities. Socially, they promote social relationships and enhance community solidarity (Ersoy, 2015). Green spaces serve a wide array of purposes, including nature conservation, recreation, ecology, land organization, aesthetics, and fostering social interactions (Bilgili, 2009). Given these benefits, the development of green spaces is integral to the healthy functioning of the urban ecosystem. However, for these areas to be truly effective, they must meet criteria of accessibility, sufficiency, and integration.

The primary factors determining the adequacy and accessibility of urban open and green spaces are their size and spatial distribution. Today, rising population densities and unplanned urban development are contributing to problems such as the reduction of green spaces, the loss of their functionality and productivity, and their insufficient proximity to residential areas. This situation has a significant impact on the quality of life for urban residents. This study aims to analyze the current status of open and green spaces in the Atakum district of Samsun, particularly regarding accessibility, sufficiency, and integration. Additionally, areas within the district that require improvement will be identified and discussed.

The intense urbanization in the Atakum district over the past 20 years has led to a rapid population increase, significantly raising the demand for infrastructure and urban amenities. This growing demand has placed immense pressure on existing green spaces, making sustainable planning and preservation of these areas a necessity. The protection of open and green spaces is not only crucial for improving urban life quality but also for maintaining ecological balance. Therefore, the planning and management of such areas should be regarded as essential components of urban development. This is the primary reason for selecting Atakum as the study area. The district consists of 57 neighborhoods, with this study focusing on 16 neighborhoods to assess urban life quality.

Open and green spaces are vital elements of urban life that enhance living standards by preserving the natural environment, improving environmental quality, and providing areas for recreation and social interaction. These spaces have been defined from various perspectives by experts across different disciplines. According to the Planned Areas Zoning Regulation, published in the Official Gazette (Resmi Gazete) on July 3, 2017 (issue no. 30113), green spaces are defined as "the total of playgrounds, children's parks, recreational areas, picnic and entertainment zones, as well as recreational and activity areas allocated for public use (including metropolitan-scale fairs, botanical and zoological gardens, and regional parks)." Keleş (1980) defined open spaces in the *Urban Sciences Dictionary of Terms* as "urban sections left in their natural state or allocated for agricultural or non-residential recreational purposes, outside of constructed areas where people conduct their daily lives." He further described green spaces as "parks, tree-lined roads, and similar public areas arranged by municipalities in cities and towns for activities such as resting, walking, and children's play, which help soften the city's concrete appearance." Although it is theoretically possible to distinguish between open and green spaces, in practice, the line between them is often blurred. Therefore, it may be more practical to evaluate these spaces collectively as "open and green spaces," which helps avoid confusion and fosters a more holistic understanding.

Open and green spaces play a crucial role in restoring the disrupted balance between nature and people in cities, improving urban living conditions. In addition to shaping the identity and

character of cities, these spaces offer high potential for recreational activities. They are open-air areas that provide urban residents with opportunities to enjoy their environment, rest, engage in sports, and socialize, all while contributing to the city's unique identity (Thompson, 2002). Moreover, these spaces contribute not only to the aesthetic and physical appeal of cities but also to the regulation of the microclimate and the organization of pedestrian and vehicle traffic. They positively influence social interactions, helping to strengthen social bonds, while also raising awareness of nature and the environment (Gül & Küçük, 2001).

In the literature, urban green spaces are generally classified based on their purpose, ownership, function, and location. According to ownership, they are grouped into three main categories: public spaces, semi-private spaces, and private spaces (Gezer et al., 2009). Public spaces include areas like city and neighborhood parks, urban forests, groves, cemeteries, botanical gardens, fairgrounds, exhibition areas, road medians, sports fields, zoos, picnic spots, and national parks. Semi-private spaces, which are not accessible to all residents and may be limited to specific groups or require a fee, include school grounds, military zones, public institution properties, factory sites, campuses, racetracks, and golf clubs. Private spaces, on the other hand, are for the exclusive use of their owners or residents and include residential gardens, terrace and rooftop gardens, facility gardens, and urban agricultural gardens (Gül et al., 2020).

Functionally, green spaces are divided into two categories: active and passive. Active green spaces, such as parks, children's playgrounds, and sports fields, are designed for public use and recreation (Official Gazette (Resmi Gazete), November 2, 1985, No. 29030). Passive green spaces, which include noise barriers, erosion-preventing buffer zones, and medians, play a significant role in improving environmental conditions and organizing urban spaces (Kaya, 2022). Both types of green spaces are essential for enhancing urban life and preserving the natural environment. In terms of hierarchical organization, green spaces are classified into five groups: residential area playgrounds, neighborhood parks, district parks, sector parks, and city parks (Ersoy, 2015). These classifications help cities meet green space needs and manage them effectively.

Green spaces significantly influence urban life quality and must adhere to certain standards in terms of quantity and accessibility. The process of organizing green spaces and setting quantitative standards began in England in the 1800s. Today, ensuring access to green spaces is essential for meeting social needs, particularly in densely populated cities (Gül et al., 2020). Green space planning and policies are central to sustainable urban life, contributing to both public well-being and environmental sustainability.

Urban green spaces have a profound impact on the health and quality of life of city residents. International organizations like the United Nations and the World Health Organization (WHO) have established guidelines for the ideal and minimum amount of green space per person (WHO, 2017). While these standards vary across countries, they serve as benchmarks for cities worldwide. The United Nations recommends 30 m^2 per person, the European Union suggests 26 m^2, and the United States recommends 18 m^2 (Şenik & Uzun, 2022). The WHO suggests an ideal of 50 m^2 of green space per person, with a minimum of 9 m^2 acceptable in urban areas (Badiu et al., 2016; WHO, 2017). Some cities have set even higher standards, such as 40 m^2 in London and 48.5 m^2 in Los Angeles (Gül et al., 2020). These benchmarks are considered essential for fostering a healthy urban environment. However, current regulations in Turkey fall short of these international standards and do not fully meet the green space needs of Turkish cities.

Legal regulations, zoning plans, and ordinances in Turkey dictate the allocation of green space to improve urban life and create sustainable environments (Önder & Polat, 2012). Historically, the amount of green space per person was first proposed at 4 m^2 in 1933 under the Law on Construction Roads (Official Gazette (Resmi Gazete), June 21, 1933, No. 2433). However, this was revised with the Zoning Law of 1956, which set a minimum of 7 m^2 per person. In 1975, the Metropolitan Area Master Plan proposed 9.25 m^2 per person. Further updates in 1999 increased the requirement to 10 m^2 per person in urban areas (Official Gazette (Resmi Gazete), September 1, 1999, No. 23804)

(Table 1). However, green space standards in Turkey have seen little improvement since 1999, and current standards still do not reflect population density variations (Özdede et. al., 2021). Considering the importance of green spaces, this issue warrants urgent review and updating.

Table 1 Legal Regulations Regarding Open and Green Spaces in Turkey

Law	Total (m²/person)
Green Spaces under the Law on Construction Roads, No. 2290	4.00
Zoning Law, No. 6875/1605 (July 6, 1956)	7.00
Metropolitan Area Master Plan (Dec. 22, 1975)	9.25
Zoning Law, No. 3194 (Nov. 2, 1985)	7.00
Zoning Law, No. 3194 Amendment (Sept. 1, 1999)	10.00

By comparing international best practices and green space standards, Turkish urban planners can identify areas for improvement, develop more sustainable policies, and address the shortcomings in green space accessibility. These international approaches can serve as valuable guides in overcoming the challenges faced by Turkish cities.

Green space standards in Turkey are generally determined through a quantitative approach based on the amount of green space per capita. However, a purely quantitative approach is not sufficient; it is equally important to consider the city's physical characteristics (such as climate, topography, location, etc.), socio-cultural factors, economic conditions, and usage frequency (Eminağaoğlu & Yavuz, 2010).

As stated in Appendix 2 of the Regulation on Spatial Plans (MEURT, 2014: Türkiye Cumhuriyeti Çevre ve Şehircilik Bakanlığı- Ministry of Environment and Urbanization of the Republic of Türkiye), open and green spaces are classified into various types, with specific standards set for the amount per capita (Table 2). This appendix serves as an important guide for the planning of open and green spaces in cities. By determining the size and types of these areas, it mandates the preservation and proper planning of such spaces to improve urban livability standards and ensure environmental sustainability.

Table 2 Green Spaces and Their Standards According to the MPYY (MPYY: Regulation on Spatial Plans) (Source: Resmi Gazete, 2014) (Appendix-2 Table)

Open green spaces	Standard (m²/person)
In district-level planning	Children's playground
Park	
Square	
Neighborhood sports field	
Botanical park	
Picnic area	
Recreation area	
In provincial-level planning	Zoo
City forest	
Areas to be afforested	
Fairgrounds, festivals, and carnival areas	
Hippodrome	

Accessibility is a key factor that determines the frequency of use of open and green spaces and enhances the well-being of users. To improve the quality of urban life, it is crucial for all residential areas to have accessible open and green spaces at different hierarchical levels. This context emphasizes the importance of planning where green spaces will be located in cities and highlights the critical significance of the concept of 'accessibility' (Schipperijn et al., 2010). Strategically planning green spaces allows city residents to be in closer contact with nature, thereby improving their quality of life. Therefore, prioritizing accessible and sustainable green spaces in urban planning is essential.

Standards for accessibility to open and green spaces vary from country to country, just as they do for quantitative standards. According to the European Commission's Urban Audit report, users should be within a maximum walking distance of 15 minutes from green spaces. These distances vary according to the types of green spaces: for example, it should take no more than 10 minutes to reach children's playgrounds, no more than 20 minutes to reach neighborhood parks, and no more than 30 minutes to reach city parks. As a general rule, all users should have access to green spaces within 300 meters (approximately a 5-minute walk) from their homes (Gül et al., 2020).

Access to open and green spaces in cities can be evaluated using various analyses conducted with Geographic Information Systems (GIS). GIS-based accessibility analyses include Buffer analysis, which creates a buffer around an area to assess accessibility; Network analysis, which evaluates the accessibility of services in a particular area; Kernel Density analysis, which shows the distribution of density; and New Closest Facility analysis, which identifies the nearest service point (Tango & Topçu, 2021).

Accessibility refers to the ease with which open and green spaces can be reached on foot, via public transport, or by other means of transportation (Ergin et al., 2020). Effective service radii encompass the areas served by these spaces and the population living in those areas. The effective service radii vary depending on the type, size, and location of the open green spaces within the urban fabric (Table 3).

Table 3 Standards for Open and Green Spaces (Source: Tülek & Mirici, 2019 ; Ersoy, 2015)

Parks	Effective Service Area Radius (m)	Population Served	Ideal Size (acres)
Children's Playground	200-600	Neighborhood	8-16
Sports Area	2000	Entire city	40-60
Neighborhood Park	500-1500	3,500-5,000 people	20-40
District Park	1000-2500	15,000-30,000 people	160-400
City Park	1000-10,000	Entire city	40-800
Regional Park	25,000-100,000	Region	2000-4000
National Park	Entire country	Country	Variable

Moreover, the MPYY in our country also contains provisions regarding walking distances. The Regulation on Spatial Plans, which was published in the Official Gazette (Resmi Gazete) on June 14, 2014, Issue No. 29030, and came into effect, specifies a walking distance of 500 meters for children's playgrounds, play areas, and open neighborhood sports fields. In the buffer analysis conducted for green spaces, the 500-meter radius circles defined in the regulation were used for analysis (Regulation on Spatial Plans, Article 12/2; MEURT, 2014).

2. Material and Method

As of the end of 2022, Samsun province, with a population of 1,368,488, ranks 16th in Turkey. The province has a total of 17 districts, with its central districts being Atakum, İlkadım, Canik, and Tekkeköy. Due to rapid development in recent years, Samsun has become a province where construction has increased, and its urban boundaries have expanded. This transformation has also brought attention to Atakum, which is part of the study area, as its urban structure has expanded (Atakum Municipality, 2023). Atakum, which gained district status in 2008, is one of the fastest-growing districts in terms of population in Samsun. While its population was 107,953 in 2008, it rose to 245,328 by 2023 (TÜİK, 2024). The district, which was primarily a coastal settlement with secondary residences in the early 2000s, has spread inland (southward) in recent years due to population growth, becoming a densely built area. The district, which consists of 56 neighborhoods, includes 16 neighborhoods within the study area (Figure 1).

Figure 1 Study area (Source: Prepared by the author using Google Earth Pro, 2024)

The populations and densities of the neighborhoods subject to the study are provided in Table 4. When examining the table, it is observed that the neighborhoods with the highest population densities are Cumhuriyet, Yenimahalle, Mimarsinan, and Mevlana.

Table 4 Neighborhood Populations and Densities (People/ha) (Source: Population data from index (2024), area data calculated by the author using vector data obtained from Atakum Municipality and GIS) (Atakum Municipality, 2023)

Neighborhood Name	Population (people)	Area (ha)	Gross Density (people/ha)
Atatepe	3659	131.5	27.8
Balaç	3041	174.2	17.4
Büyükkolpınar	3191	184.4	17.3
Cumhuriyet	27845	148.3	187.7
Çobanlı	2317	74.9	30.9
Denizevleri	3584	78.1	45.8
Esenevler	20315	148.4	136.8
Güzelyalı	4253	78.4	54.2
İstiklal	11237	154.5	72.7
Körfez	20672	639.6	32.3
Küçükkolpınar	8690	99.5	87.3
Mevlana	17111	153	111.8
Mimarsinan	23797	160.2	148.5
Yenimahalle**	57301	365	156.9
Yeşildere	3532	138.1	25.5
Total	**210545**	**2728.1**	**77.17**

Note: Due to the large size and high population of Yenimahalle neighborhood, it was divided by Samsun Governorship's approval (dated 05.10.2023, number 67651) under Article 9 of the Municipal Law No. 5393, and the area east of Ali Gaffar Okkan Street was named Atakent Neighborhood. Since demographic data for the study could not be found for these two neighborhoods separately, Yenimahalle's boundaries before the decision were used (Atakum Municipality, 2023).

The data for this study were collected from both primary and secondary sources. Primary data were gathered through informative interviews with officials from the Atakum Municipality's Urban Planning Department. The main sources of secondary data include books, articles, and theses.

The study focused on evaluating and analyzing the open and green spaces in the built-up areas of Atakum district, Samsun province, using geographic information systems (GIS) methods. Aerial photographs and maps of the area were used as materials.

The research conducted in the built-up region of Atakum district followed a method comprising four stages. The steps of the method used in the study are shown in Figure 2.

-Identifying the location of urban green spaces using satellite images and digital data obtained from relevant institutions.

-Conducting a literature review to establish the conceptual framework and determine appropriate standards in terms of accessibility and adequacy.

-Creating quantitative and spatial data on open and green spaces, calculating service areas, and mapping them (buffer zone analysis – spatial analyses) using ArcGIS 10.7 software.

-Evaluating the spatial adequacy and accessibility of open and green spaces.

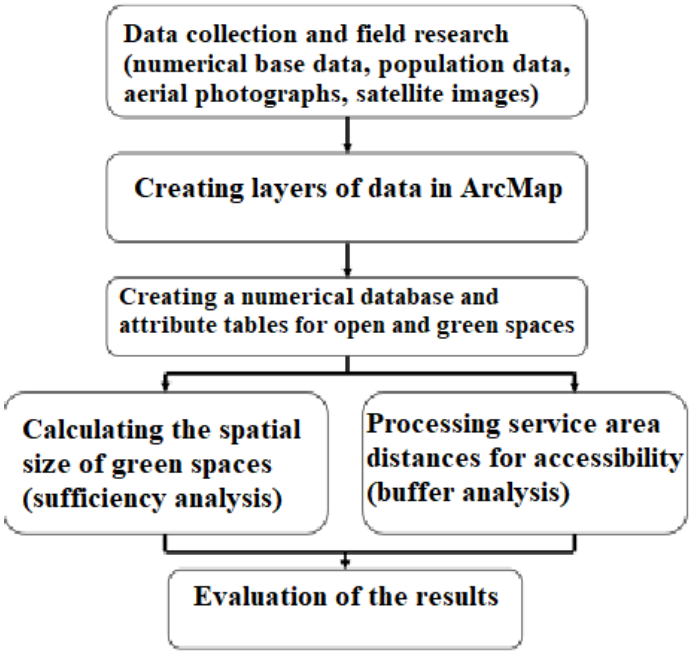

Figure 2 Methodology diagram

In the study, open and green spaces located in 16 neighborhoods were analyzed, focusing on the extent to which neighborhood parks meet population needs, the adequacy of recreational areas such as children's playgrounds and outdoor sports facilities, and the amount and accessibility of existing open and green spaces in consideration of neighborhood population sizes. Both parks serving all residents and children's playgrounds were included in the evaluation. The adequacy analysis was conducted by calculating the green space per capita based on the neighborhood populations, while the accessibility analysis was carried out using buffer zone analysis to map the

service area of green spaces based on walking distances. The processes carried out using the buffer analysis technique were performed in a simple and intuitive manner, as fewer data sets were used. In this technique, factors such as the topography of the region and road availability were not considered when determining distances.

Parks and children's playgrounds were digitized using GIS with satellite images and updated maps. Information on the size and type of green spaces was processed into the program as attribute tables. Demographic data, including the population of each neighborhood, were obtained from TÜİK to calculate the green space per capita. GIS (ArcGIS 10.7) was used to assess service areas through buffer zone analysis.

3. Results

In the study, open and green spaces were identified in 16 neighborhoods of Atakum district. In this context, open and green spaces in the 16 neighborhoods within the sample area were digitized using ArcGIS 10.7 software and processed as current status data. According to the findings, the total amount of open and green space is 958,361 m², and the amount of active green space is 563,568 m². As for passive green spaces, the area contains 296,041 m² of medians, and 9,700 m² of open squares (Figure 3). Semi-private (schoolyards, military zones, areas belonging to public institutions, factory sites, campuses, racetracks, and golf-tennis clubs) and private green spaces (residential and site gardens, agricultural lands) were not included in the study.

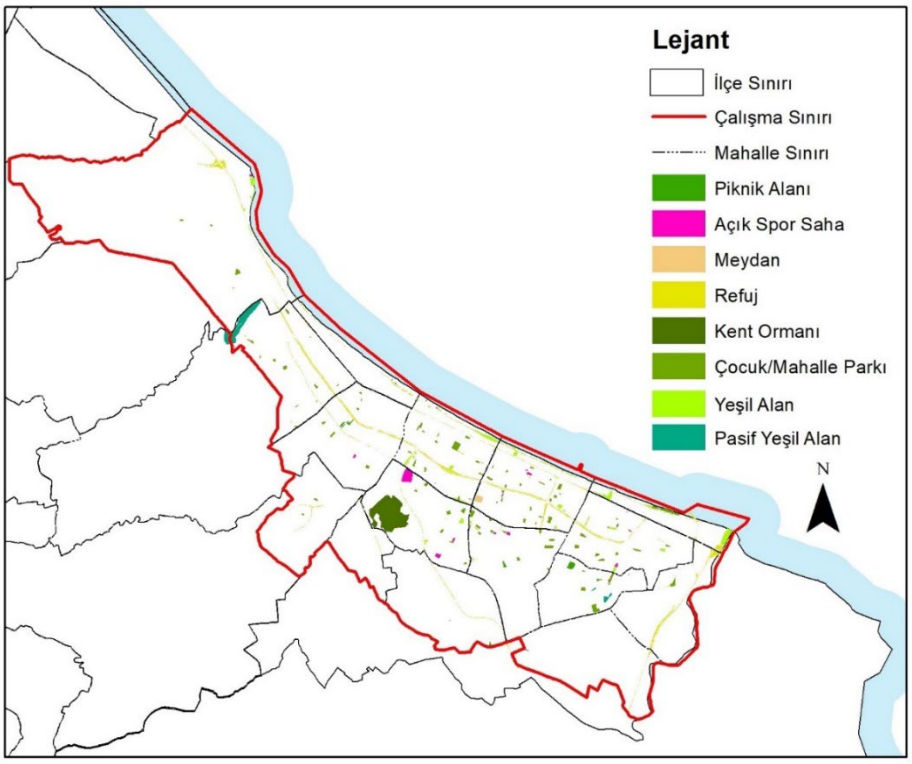

Figure 3 Analysis of the current open and green spaces in the study area (Source: Prepared by the author using ArcGIS 10.7)

As a result of the examination, it was found that İstiklal neighborhood has the highest amount of open and green space. The reason for this is the presence of a 195,345 m² urban forest within the neighborhood boundaries. On the other hand, there are no active green spaces in Büyükkolpınar and Çobanlı neighborhoods. The green spaces in these neighborhoods consist only of road medians. These areas are still in the development phase, with existing structures primarily consisting of detached houses or residential complexes. While there are children's playgrounds within the residential complexes, there are no public active green spaces.

The amount of green space per capita was calculated by dividing the total amount of green space in each neighborhood by the population of that neighborhood. In this way, the compliance of open and green spaces with the standards outlined in the regulations and their spatial adequacy was determined. If this ratio does not fall below 10 m² per capita according to the relevant legal regulations, the area is considered sufficient. Figure 4 is a thematic map showing the neighborhoods where the ratio of open and green space per capita is above and below 10 m². It was determined that all neighborhoods, except for Denizevleri, İstiklal, and Yeşildere, fall below the open and green space standard (Table 5).

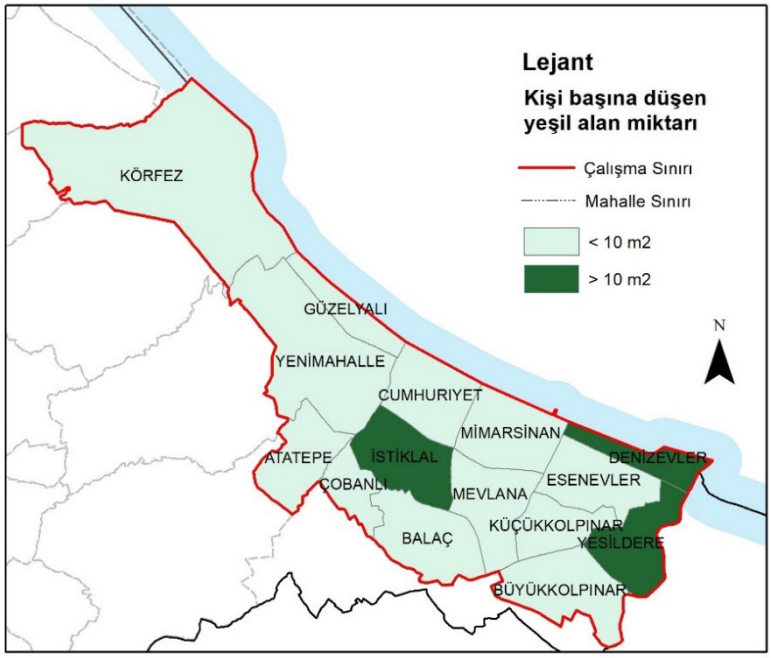

Figure 4 Per capita green space by neighborhood (Source: Prepared by the author using ArcGIS 10.7)

It is observed that İstiklal Neighborhood has the highest amount of open and green space per capita, with 22.10 m². This high ratio is largely due to the urban forest within the neighborhood boundaries, making its green space ratio significantly higher than other neighborhoods. Additionally, Denizevleri (20.09 m²/person) and Yeşildere (11.85 m²/person) are among the other neighborhoods where the amount of green space per capita is above the standard. All remaining neighborhoods fall below 5 m² per person, far below the standard.

Table 5 Green Space Amount and Per Capita Green Space by Neighborhood (Source: Prepared by the author using ArcGIS 10.7 based on index population data)

Neighborhood	Population (people)	Open and Green Space (m²)	Green Space Per Capita (m²)
Atatepe	3659	6785	1.85
Balaç	3041	9967	3.27
Büyükkolpınar	3191	13085	4.10
Cumhuriyet	27845	96915	3.48
Çobanlı	2317	5621	2.42
Denizevleri	3584	72023	20.09
Esenevler	20315	47168	2.32
Güzelyalı	4253	22935	5.39
İstiklal	11237	248342	22.10
Körfez	20672	54025	2.61
Küçükkolpınar	8690	37810	4.35
Mevlana	17111	41424	2.42
Mimarsinan	23797	95295	4.00
Yenimahalle	57301	165084	2.88
Yeşildere	3532	41882	11.85
TOTAL	**210545**	**958361**	**4.55**

When evaluating the adequacy of open and green spaces, several key factors must be considered. First, the size and distribution of the area should be examined. While the total amount of green space in a city may be sufficient, if these areas are not evenly distributed, access to green spaces may be limited for city residents. Therefore, the adequacy of green spaces is not only about quantity but also accessibility. Furthermore, it is important that open and green spaces serve different purposes. Spaces catering to various users are positively evaluated in terms of adequacy. In the study area, children's playgrounds are the most common, and these areas also include open sports areas and rest areas.

To assess the accessibility of open and green spaces, a buffer zone analysis based on distance was applied. A metric radius distance was used to measure the distance, determining how accessible green spaces are for users. The service areas consist of publicly accessible areas serving the local population. Accessibility to open and green spaces in the study area was evaluated using the buffer analysis in ArcGIS 10.7. The distance standards were applied according to the radius distances defined in the regulations. According to the regulations, a walking distance of 500 meters was used to determine the service areas for children's parks, playgrounds, and open neighborhood sports areas. Since the urban forest and picnic areas have an impact beyond the neighborhood scale, the multiple buffer option was used for these areas, selecting distances of 1000m, 1500m, 2000m, and 2500m for the urban forest, and 1000m, 2000m, and 3000m for the picnic area service area. The results of the analysis are presented in Figures 5a, 5b, 5c, and 5d.

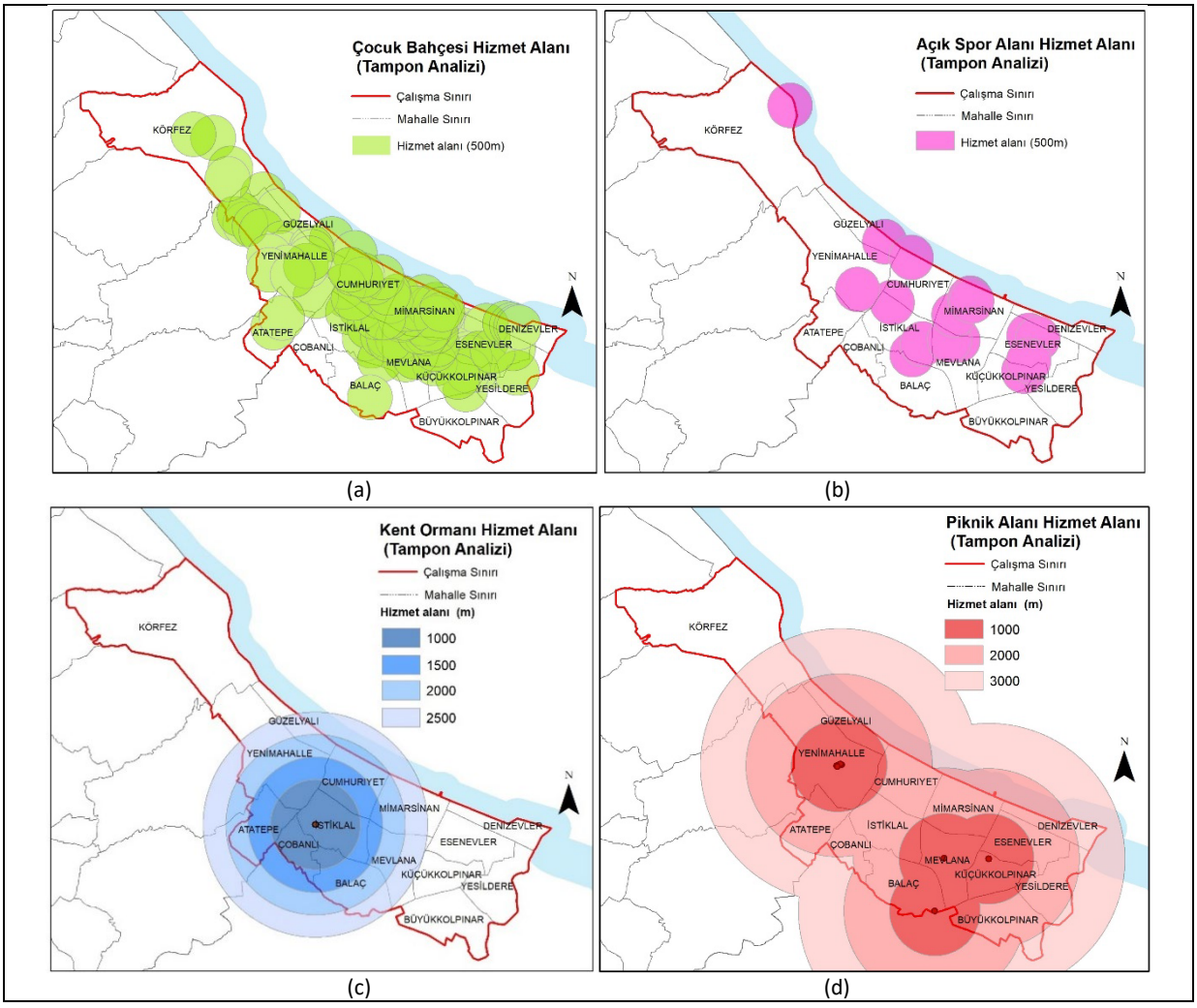

Figure (5a) Children's park service area; **(5b)** Open sports area service area; **(5c)** urban forest service area; **(5d)** Picnic area service area (Source: Prepared by the author using ArcGIS 10.7)

In our country, when calculating per capita green space in adequacy analyses, areas that are not actively used by urban residents, such as road medians (refüj) and passive green spaces, are typically included. However, in this study, the adequacy analysis within the scope of the accessibility analysis was conducted solely based on actively used green spaces. The accessibility criteria also encompass aspects such as access for individuals with disabilities, safety—particularly for women and children—proximity to public transportation, and usability by people from various demographic groups. These issues were not included in the study as the study area is large and the scope is at a higher scale.

According to the analysis results, while children's parks remain within the accessible service areas at the neighborhood scale, open sports areas are found to be inaccessible in Körfez, Yenimahalle, Atatepe, Çobanlı, Balaç, Büyükkolpınar, and Yeşildere neighborhoods.

4. Discussion

In this study, the current situation of open and green spaces in the Atakum district was examined in terms of accessibility and adequacy, and their services to urban residents were evaluated. The research findings provide important insights, both positive and negative.

When examining the accessibility of open and green spaces by neighborhoods, it was determined that these areas are not adequately distributed in surrounding neighborhoods, and significant challenges in access may arise. The per capita ratios of open and green spaces are below both the standards recommended by the World Health Organization and those specified in our country's relevant regulations. The research results indicate that, due to rapid urbanization and population growth in the region, the existing green spaces are insufficient, and the local population cannot fully benefit from these areas. The lack of adequate open and green spaces negatively impacts both physical and mental health. It is necessary to increase legal and economic incentives for the protection of existing open and green spaces in the study area and to create new ones.

This study investigates the current state of open and green spaces in the Atakum district, focusing on their accessibility and adequacy, as well as the services they provide to urban residents. The findings reveal significant insights regarding the spatial distribution and availability of these essential resources.

Access to green spaces has been linked to numerous health benefits, including reduced stress levels, increased physical activity, and improved overall quality of life (Kuo, 2015). Furthermore, these spaces are crucial for biodiversity, providing habitats for various species and contributing to ecological resilience (Gómez-Baggethun & Barton, 2013). However, the analysis conducted in this study indicates that many neighborhoods in Atakum fall short of the recommended standard of 10 m^2 of green space per person, which is a guideline set forth by both the World Health Organization and local regulations. This shortfall not only limits residents' access to essential recreational and restorative environments but also reflects the broader challenges posed by rapid urbanization.

The analysis indicates that open and green spaces are not uniformly distributed across neighborhoods, leading to accessibility challenges for residents. Urban green spaces are crucial for enhancing the quality of life, promoting physical activity, and ensuring social interaction among community members (Wolch et. al., 2014). However, in Atakum, many neighborhoods experience a lack of accessible green areas, particularly in densely populated zones.

Research shows that neighborhoods with poor access to green spaces can contribute to social inequality and adverse health outcomes (Beyer et al., 2014). The results of this study align with these findings, revealing that many residents, especially in areas like Körfez and Yenimahalle, face significant barriers to accessing recreational spaces. Addressing these disparities is essential for fostering equitable health benefits across diverse socio-demographic groups.

Moreover, the per capita ratios of open and green spaces in Atakum fall below both the World Health Organization (WHO) recommendations and national regulations. The WHO suggests a

minimum of 9 m² of green space per person to promote physical and mental well-being (WHO, 2017). However, our findings indicate that most neighborhoods have significantly lower ratios, underscoring the insufficiency of existing green areas.

The scarcity of adequate open and green spaces has been linked to a decline in residents' physical and mental health. Research has consistently shown that access to green spaces can reduce stress, enhance mood, and encourage physical activity (Mitchell & Popham, 2008; Niemelä et al., 2010; Jennings et al., 2012; Hartig et al., 2014). The lack of sufficient green spaces in Atakum may therefore contribute to higher rates of chronic diseases and mental health issues among residents.

The rapid urbanization and population growth in Atakum have exacerbated the issue of inadequate green spaces. As cities expand, green areas often face encroachment from development, leading to their degradation or disappearance. This phenomenon is evident in Atakum, where urban sprawl has resulted in the loss of accessible open spaces. The findings indicate that existing green spaces are underutilized, primarily due to their insufficient quantity and accessibility, limiting their potential benefits for the community.

Recommendations for Improvement; To address these challenges, it is imperative to enhance the protection of existing open and green spaces while simultaneously investing in the creation of new ones. Urban planning policies should prioritize the integration of green infrastructure into development projects, ensuring that new housing and commercial areas include accessible green spaces (Tzoulas et al., 2007). Additionally, the implementation of legal and economic incentives to preserve existing green areas is crucial. Initiatives such as public-private partnerships could facilitate the development of community parks and recreational facilities, improving overall accessibility and fostering community engagement.

In conclusion, the study highlights the critical need for strategic planning and policy interventions to ensure adequate and equitable access to open and green spaces in Atakum. By prioritizing green space development and protection, urban planners and policymakers can significantly enhance the quality of life for residents, promote public health, and contribute to sustainable urban development.

5. Conclusion

One of the greatest needs of cities is effective planning to ensure the balanced distribution of open and green spaces throughout the urban area. It should not be forgotten that these areas not only add aesthetic value but also support the physical and mental health of all segments of society, strengthen social ties, and promote environmental sustainability.

It is crucial to have green spaces that individuals from different age groups and socio-economic levels can easily access. Additionally, these areas should be planned to serve multiple purposes, such as sports activities, recreation, cultural events, and education, rather than just functioning as parks. Open and green spaces of varying hierarchies (such as neighborhood parks, community parks, city parks, and regional parks) provide various user groups with opportunities for physical activity as well as socialization.

This study highlights the current state of open and green spaces in the urban settlement of Atakum and the importance of these areas in urban life. The analyses show that most neighborhoods are inadequate in terms of active green spaces and that the standard of 10 m² of green space per person, as specified in legal regulations, has not been met. Although the accessibility of existing green spaces may seem sufficient, an examination of their sizes reveals that their capacity to serve the surrounding population is quite limited.

Numerous studies in the literature exist on the importance of urban open and green spaces for cities. However, there is currently no study focused on this issue specifically in the province of

Samsun or the district of Atakum. Therefore, this study stands out as one of the first to evaluate the adequacy of open and green spaces in Atakum, serving as an important reference.

The findings of this study hold significant importance for urban planning and management. To create sustainable cities, the existence of urban open and green spaces and their spatially appropriate planning and design are critical elements that must be considered.

6. Recommendations

The findings of this study underscore the pressing need for effective urban planning that ensures the balanced distribution of open and green spaces throughout Atakum. Such spaces are not merely aesthetic enhancements; they play a pivotal role in promoting the physical and mental health of the community, enhancing social cohesion, and fostering environmental sustainability. As urban areas continue to grow, the importance of accessible green spaces becomes even more critical in addressing various public health concerns, such as urban heat islands, air pollution, and mental well-being.

In light of these findings, it is recommended that urban planners and policymakers take a multi-faceted approach to address the deficiencies in green space provision:

Prioritize Equitable Distribution: Planning efforts should focus on ensuring equitable access to green spaces across all neighborhoods, particularly those that are currently underserved. Implementing policies that prioritize the development of parks and green corridors in high-density areas can alleviate accessibility issues.

Multifunctional Spaces: Green spaces should be designed to serve multiple purposes, catering to various community needs, such as recreation, sports, cultural events, and education. For instance, integrating community gardens, playgrounds, and open-air classrooms can enhance the utility of these areas, making them more inclusive and beneficial for diverse demographics.

Community Engagement: Involve local residents in the planning and design processes of green spaces to ensure that these areas meet the specific needs and preferences of the community. Participatory approaches can enhance community ownership and stewardship of green spaces, leading to better maintenance and utilization.

Strengthen Legal Frameworks: The establishment and enforcement of regulations that promote the preservation and creation of green spaces is vital. Local governments should consider implementing green space preservation ordinances and providing incentives for developers to include public green spaces in new developments.

Integrate Research and Data Analysis: Future studies should continue to explore the relationship between urban green spaces and public health outcomes, as well as their socio-economic impacts. This research can inform evidence-based policies and contribute to the growing body of literature that underscores the importance of urban greenery in enhancing livability (Gianfredi et al., 2021).

Climate Resilience: As cities face the challenges of climate change, urban green spaces can serve as critical components of climate adaptation strategies. Green areas can mitigate urban heat effects, manage stormwater, and enhance urban biodiversity, contributing to the overall resilience of urban ecosystems (Van Doorn & McPherson, 2018).

In conclusion, this study highlights the current inadequacies in open and green space provision in Atakum and emphasizes the need for strategic urban planning to foster sustainable, healthy, and inclusive urban environments. By prioritizing the development and equitable distribution of green spaces, city planners can significantly enhance the quality of life for residents and contribute to the overall resilience and sustainability of urban areas.

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A reading of "place attachment" in spatial perception: The case of KTU department of architecture

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Abstract

The concept of space, the fundamental object of architecture, is perceived through sensory experiences, with prior spatial experiences playing a significant role in this process. Cultural diversity leads to variations in the spatial behavior of societies in different geographies, meaning that individuals experiencing the same structure may connect space, meaning, and place in diverse ways. This research builds upon Edward Relph's Place and Placelessness, which examines the phenomenological dis-course on "how places are experienced and how they change." It focuses on the concept of "place attachment," defined as the emotional, cognitive, and behavioral bond formed at the intersection of the experiencing body and the experienced space. The Architecture Department at KTU, recognized for its accessibility and its role in training students proficient in architectural terminology and skilled in designing future spaces, has been selected as the focus of this study. The research aimed to derive semantic interpretations of the physical, emotional, and social dimensions of place, following the three categories Relph used in his analysis of place. A semi-structured interview technique with predetermined open-ended questions was employed, and participants were asked to create memory maps based on the building plan. Data analysis provided insights into how users perceived the study area, identifying spaces where a sense of attachment was strong. Conversely, areas perceived as "non-places," evoking a sense of being "out of place," were highlighted. Suggestions were offered for improving such negative spaces and guiding future research.

Keywords: Edward Relph, place, place attachment, space, spatial perception

1. Introduction

Like Humans maintain an inseparable relationship with the natural and artificial environments in which they live. Individuals are both influenced by the dialogue they establish with their experienced environment and act as agents affecting that environment and other users. The field of environmental psychology, which has been a subject of discussion since the 1960s, focuses on this dynamic interaction (Steg et el., 2015). Space, a central concept within environmental psychology, plays a significant role in shaping human memories. The interaction between individuals and the spaces they occupy, as well as with other users within those spaces, encompasses various dimensions, including emotional states and spatial behaviors at both individual and social levels (Yaşaroğlu, 2017).Therefore, it is crucial to understand and define the interactions between the experiencing body, the experienced space, and other users within the confines of that space.

Kurt Lewin (1936), one of the pioneers in exploring this relationship, analyzed the connection between place and person from the perspective of psychological personality foundations, emphasizing how physical space shapes user behavior. During the 1970s, multiple scientific disciplines sought to evaluate these behaviors and the outcomes arising at the body-space interface. As time progressed, these studies generated extensive discourse on topics such as sense of place (Relph, 1976; Tuan, 1977; Steele, 1981; Jorgensen & Stedman, 2001), place attachment (Hidalgo & Hernández, 2001), place identity (Proshansky, 1978; Twigger-Ross & Uzzell, 1996), and

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community attachment (Trentelman, 2009). However, this growing body of work has introduced challenges in distinguishing similarities and differences among these concepts due to their conceptual diversity.

For instance, Lalli (1992) describes place attachment as a component of place identity, whereas Brown and Werner (1985) use the terms attachment and identity interchangeably. Nonetheless, place attachment remains a fundamental concept in studies examining how individuals interact with places and develop emotional connections to them (Altman & Low, 1992; Brown et al., 2003; Giuliani, 2003; Manzo & Perkins, 2006; Knez, 2005; Kyle et al., 2005).Drawing on this body of research, place attachment, grounded in bodily experiences of space, is understood as a multifaceted phenomenon.

The phenomenon of space, which has been the primary subject and output of the architectural discipline throughout human history, has been approached in various ways over time. To fully comprehend the concept of space, the experiencing body must first occupy a central position within the boundaries that define it. At this juncture, it is crucial to highlight the contributions of Merleau-Ponty cite, who introduced the concept of the "body-subject" through his phenomenological exploration of bodily perception, incorporating the notions of "experience" and "sensation" within the subject-object binary.

Ponty (1962) asserts that 'the body is both subject and object,' highlighting that while the body belongs to an individual, it is simultaneously perceived as a cultural object by the experiencing self. Within this framework, the experiencing body functions as a medium through which space is interpreted, facilitating a dialogue with both natural and constructed/artificial environments. As Ponty (1962) further states, "Without my body, there would be no space for me," highlighting the essential role of the body in establishing a connection with the environment. Regardless of the conditions under which space is perceived through bodily experience, a sense of place or concept of place is always present (Relph, 1976). Drawing on the perspectives of Ponty and Relph, the formation of the concept of place can be defined as emerging from the interaction between the body and space.

The existence of place has been a central topic of philosophical and scientific inquiry, explored through diverse disciplines and methodologies. Edward Relph's Place and Placelessness (1976) draws on Carl Sauer's focus on cultural landscapes, Donald W. Meinig's studies of spatial perception, and Yi-Fu Tuan's concept of "topophilia." Philosophers like Edmund Husserl and Martin Heidegger explored lived experience and Dasein (being-in-the-world), while Maurice Merleau-Ponty emphasized the embodied perception of space. Christian Norberg-Schulz applied these ideas to architecture, examining how spaces acquire meaning. Relph synthesizes these perspectives to highlight the profound significance of place in human life. Relph (1976) underscores the significance of understanding how space is experienced by the body. The objective of phenomenology, as an interpretative study of human experience, is to elucidate aspects of experience that are known but often overlooked in daily life (Seamon, 2000).

According to Relph (1976), without uncovering the essence of a space, it becomes challenging for the body to infer why that space is meaningful or meaningless. In this context, he emphasizes the body's identification with place, asserting that places are *"important centers of our immediate experience of the world."* The phenomenon of perception arises from the dialogue at the subject-object interface, facilitated through direct bodily experiences, sensory interactions, and the subsequent activation of consciousness. Ponty (2005), indicates that perception is not merely a sum of data provided by individual senses but rather a deeper and more holistic experience emerging from the interaction and integration of these senses. This perspective emphasizes that perception is not a mechanical process but a dynamic one in which the individual participates fully—physically, mentally, and emotionally. A deeper understanding of experienced space is achieved by decoding the sensory and emotional intensity, as well as the atmosphere, formed at the intersection of the experiencing body and the experienced space.

Relph (1976), a prominent figure in the conceptualization of space, argues that space is not merely a void, a plane, or a container encompassing a specific area. Instead, he contends that the way space is experienced by its users should be a central focus. Relph (1976, p. 9) defines spatial experience as the continuity between direct experience and abstract thought. Furthermore, he posits that space and society are inherently interlinked, as space is both socially constructed and shaped by the relationship between the experiencer and the experienced. This perspective integrates mental conceptions of existence with the physical dimensions of defined boundaries.

Numerous studies (Relph, 1976; Tuan, 1977; Steele, 1981; Jorgensen & Stedman, 2001) have examined the concept of "place," which emerged from discussions about space and parallels the notion of social space or socially produced space introduced by the French philosopher Henri Lefebvre (1991).

According to Cresswell (2004, p. 75), *place* refers to locations that individuals engage with and ascribe meaning to. Through the communication established between people and the spaces they experience, and the meanings attributed to these spaces, the concept of *space* transforms into the concept of *place* (Usta, 2020). Augé (2017, p. 45) describes this transformation within the context of space and place as *"supermodernity."* Architect Norberg-Schulz (1971), who approaches the concept of place from a phenomenological perspective, highlights the *spirit of place* and asserts that the concept of place arises from the human need to establish a connection with the environment. Similarly, Relph (1976), in his seminal workplace *and Placelessness,* distinguishes the concept of place within academic discourse, associating it with subjectivity and experience.

From this perspective, places are conceptualized as both a mode of thought and a state of being, grounded in user behaviors. Relph (1976) underscores the significance of the relationship between place and human experience, arguing that places are not merely defined by human activities but also function as spaces of security and identity for their users. His discourse is informed by Heidegger's (1927) existentialist concepts of *dasein* (being-in-the-world) and *dwelling* (residence). Consequently, Relph contends that place possesses an experiential quality, embodying a state of attachment essential to human existence and experience.

Given the experiential nature of places, they can also be characterized as tools for intergenerational communication (Ar, 2021). This highlights the role of place not only as a physical and functional environment but also as a medium for preserving and transmitting human experience across generations.

Relph (1976) established a conceptual relationship between *space* and *place*, which has often been treated as separate concepts in academic studies. According to Relph, what makes space unique is the dynamic relationship between action and intention, which evolves based on human experience. In this context, he argues that space and place are dialectically structured within human environmental experience. This is because spaces cannot be understood independently of the contexts in which they exist (Seamon & Sowers, 2008).

Relph (1976), in his comprehensive study of the transformation of space into place, emphasizes people's attachment to and identification with place. He defines *place identity*—closely related to the concept of place attachment—as *"the permanent sameness and unity of that [place] that distinguishes it from others"* (Relph, 1976, p. 45). Furthermore, he highlights the importance of place as a center of direct experiences (Relph, 1976, p. 141). He argues that the intensity of intention, formed by the meaning and experiences shared between the body and space, lies at the core of both attachment to and identification with place (Seamon & Sowers, 2008).

Places are composed of three interconnected dimensions that collectively give meaning to them: *physical, personal, and social dimensions, along with their respective functions* (Relph, 1976; Canter, 1977; Stokols & Shumaker, 1981; Stedman, 2003; Smaldone et al., 2005). The interplay between these dimensions fosters attachment to a place. Establishing a connection with a place is a multifaceted process, emerging through the bodily experience of the place. This process depends on the formal, functional, and semantic dimensions of the space (Özgen, 2020). Within these

dimensions, the interaction of spatial behaviors, emotions, beliefs, and knowledge plays a significant role (Altman & Low, 1992; Chow & Healey, 2008).

The concept of identity also holds a pivotal role in fostering a sense of attachment through interaction with place, as identity is integral to the essence of place (Relph, 1976; Yuen, 2005; Sharifi & Yamagata, 2016). Place identity thus emerges as a crucial element in understanding the deeper connections individuals form with their environments.

In numerous studies, the concept of attachment has been closely linked to place identity, defined as *"a substructure of one's self-identity in a broad sense, consisting of one's cognition about the physical world in which one lives"* (Proshansky et al., 1983, p. 59). The body, which experiences place through its unique personal identity, interprets and makes sense of it in distinct ways. Consequently, as personal identity evolves over time, the meaning attributed to space may also change. This interdependence suggests a reciprocal relationship between personal identity and the identity of place, which itself is a component of space.

The concept of place identity, as a facet of personal identity, plays a crucial role in the development of place attachment. Lefebvre (1969, p. 26) posits that identity is instrumental in an individual's interaction with time, space, and the entities within their environment. Beyond the physical attributes of a place, place identity is also reinforced by its social context (Twigger-Ross & Uzzell, 1996). Proshansky (1978; 1983, p. 57) describes place identity as a profound emotional connection users develop with their environment, framing it as the socialization of the self within the physical world. As both users and places undergo changes over time, new self-definitions continually emerge. Place identity, therefore, is shaped by how the physical characteristics of experienced space are internalized by the perceiving body (Relph, 1976).

In examining the relationship between place identity and place attachment, distinguishing clear boundaries between the two concepts remains challenging. Scholars have proposed various approaches to this relationship. Some argue that the two terms are synonymous (Brown & Werner, 1985), while others see attachment as a subset of identity (Lalli, 1992), or conversely, identity as a subset of attachment (Kyle et al., 2005). Others suggest that both concepts are dimensions of a broader framework (Jorgensen & Stedman, 2001) or that they represent distinct yet interrelated aspects of the human relationship with place (Hernández et al., 2007). Despite these differing perspectives, it is widely acknowledged that place identity and place attachment largely overlap (Brown et al., 2003). The key distinctions can be analyzed along two axes: the emotional bond arising from the interaction between body and space (place attachment) and the cognitive dimension that connects the self to the physical environment (place identification) (Rollero & De Piccoli, 2010). For instance, the duration of time spent in a place for emotional bonding versus the time required for cognitive identification illustrates points of divergence between these contexts.

Place attachment is commonly defined as *"an emotional connection with places"* (Hummon, 1992, p. 256), *"an individual's cognitive or emotional connection with a particular environment and setting"* (Altman & Low, 1992, p. 165), and *"a positive and affective bond or relationship between individuals and the environment they live in"* (Shumaker & Taylor, 1983, p. 233). Thus, place attachment can be understood as the bond established between individuals and their environment, place, or location. Research has consistently validated the role of social relationships in fostering emotional bonds with place (Fried, 2000; Moser et al., 2002; Pretty et al., 2003; Lewicka, 2005). From this perspective, place attachment emerges as the transition of meaning from the physical aspects of the environment to its social dimensions (Fried, 2000). In alignment with this idea, friendship and close interpersonal relationships formed within a shared space are identified as significant dimensions of place attachment (Pretty et al., 2003). A study by Mesch and Manor (1998) further demonstrated that stronger social relationships positively correlate with increased levels of place attachment.

The concept of place attachment can generally be defined as the emotional bond that arises during the *"moment"*—the process of experience—in which the relationship between the body and

space is realized. When space is viewed as a reflection of the body, changes in the meaning attributed to space can be expected as personal identity evolves over time. This is because the attachment to a place, formed through experience, is intrinsically connected to personal identity.

The concept of place attachment, which may vary based on identity, should be examined through different categories. In this context, studies on gender yield mixed findings. Some studies suggest that both genders exhibit similar levels of place attachment (Brown et al., 2003; Lewicka, 2005), while others indicate that women demonstrate a stronger emotional attachment (Hidalgo & Hernandez, 2001; Mesch & Manor, 1998). Consequently, there is no definitive conclusion about the relationship between place attachment and gender.

Age is another significant factor influencing place identity and place attachment (Ng et al., 2005; Pretty et al., 2003). This parameter is closely tied to the duration of time spent in a given place (Kasarda & Janowitz, 1974; Knez, 2005; Lewicka, 2005). A sense of belonging to a place emerges when an individual identifies with that place, indicating that time plays a crucial role in developing this feeling. Relph (1976) asserts that place attachment is directly linked to the length of time a person resides in a place and the personal interactions they engage in within that environment. However, other studies show that place attachment can also form through short-term interactions between the body and space (Bonaiuto et al., 1999; Harris et al., 1996).

A study examining the educational dimension of place attachment, conducted with a Polish sample group, found that higher levels of education negatively affect the formation of place attachment. This is attributed to the fact that highly educated individuals tend to be more geographically mobile and, as a result, less attached to specific places (Lewicka, 2005).

Studies that consider these various components separately have consistently demonstrated that place attachment is closely linked to identity. Within this context, the field research planned for this study will also focus on the relationship between identity and place attachment. The study aims to measure the place attachment of space users with varying identities and identify the parameters influencing this attachment.

2. Method

The study, centered on the concepts of place attachment and identity, deemed it appropriate to conduct fieldwork in a location where diverse identities coexist. To ensure meaningful and insightful results, it was considered essential to select participants capable of comprehending the study's subject and questions and providing well-informed responses. Accordingly, architecture students were chosen as the participant group, and the academic buildings on the university campus—where students spend the majority of their time—were identified as the study area. Place attachment refers to the emotional bond formed between the user and the place when the user needs and expectations are met in that environment. Additionally, the time spent in the space and the development of social relationships within it also contribute to the formation of this emotional bond. In this context, the study focuses on university education buildings, incorporating parameters such as cultural diversity, gender, and age.

The designer plays a crucial role in the formation of the sense of place attachment in the physical, behavioral and semantic dimensions of the designed spaces. This is because the designer is the first to experience and create the space. The formation of architectural identity is influenced by the architecture department building, the student-instructor and student-student relationships that occur within this building, and the concept of place attachment that emerges as a result.Therefore, architectural education buildings were considered as one of the important places where place attachment should be measured. In this context, the study area is defined as the education block of KTU Department of Architecture located in Trabzon city.

This study aims to identify specific areas within the KTU Department of Architecture building that participants perceive as significant places, fostering a sense of attachment. The reasons for the

lack of a sense of place in the remaining spaces were analyzed and the study was planned to be concluded by suggesting improvements for future research and for these spaces (Figure 1).

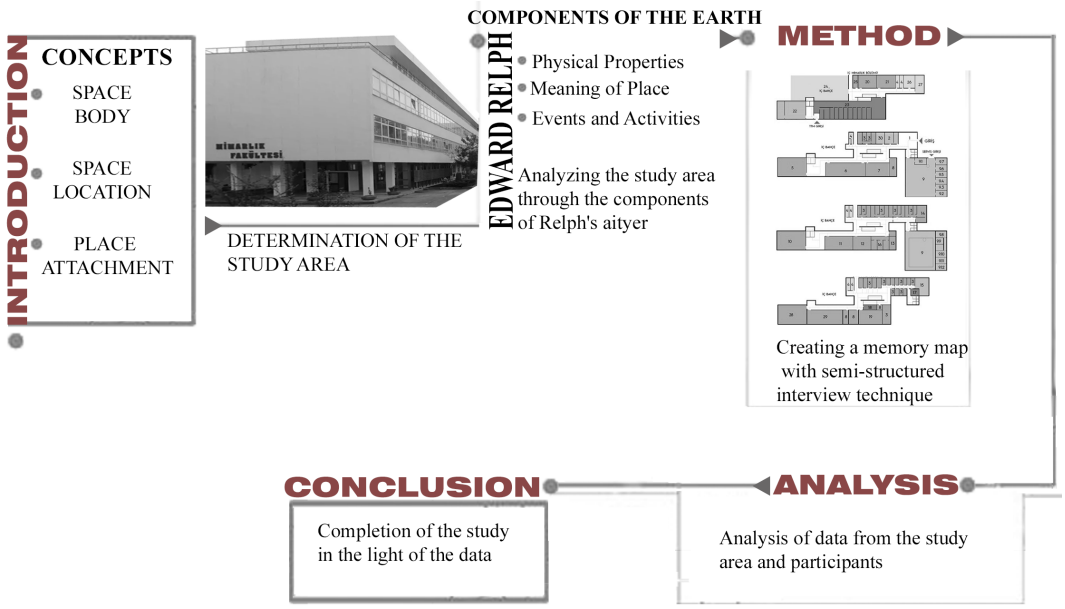


Figure 1 Flowchart of the study

Within the scope of the studies on place attachment; this study aims to test differences such as gender, age, residence time, education status in a single investigation. In this context, the sample group consisted of 1st and 4th year students of KTU Department of Architecture. Due to the age differences within the groups selected for the study, residence times may vary. For this reason, participants who lived in another province before university education and who had not resided in Trabzon except for the education period were preferred. Thus, the change in residence times within the group was controlled.

While Rubin and Babbie (2016) recommend working with three to ten participants in phenomenological studies, Charmaz (2011) states that at least ten participants should be studied (Baltacı, 2018). Therefore, the sample group was limited to a total of 12 volunteer participants, three girls and three boys from the 1st and 4th grades who did not originate from Trabzon. It was planned to ask open-ended questions about socio-demographic factors and the study area to the participants by obtaining the necessary institutional permissions. In the continuation of the study, a two-stage research method was implemented, in which participants were asked to create a memory map based on the questions provided. The relationship between space and place attachment was examined through participant interviews, utilizing narratives and mapping as complementary analytical tools. Although the school building serves diverse user groups, this study focused specifically on students who use the school as an educational space. The researchers sought to understand how this group perceives and interacts with the environment within their daily academic routines. The integration of interviews and mapping methods proved highly effective, with each method addressing the other's limitations and enriching the overall analysis.

In the study, data were obtained by using the interview technique which is one of the qualitative research methods. The interview provides the opportunity to access participants' experiences and perceptions regarding the subject being researched. Therefore, the aim was to collect data using a semi-structured interview technique with open-ended questions. Below are the explanations of the 'semi-structured interview' and 'memory maps' sections, which constitute the two stages of the study.

2.1. Semi-structured Interview

It consists of socio-demographic questions aimed at understanding the participant and questions related to the workspace aimed at interpreting the participant's use of areas within the

KTU Department of Architecture. People determine the environment they will live in with components such as culture, economic status and lifestyle. Therefore, the first goal is to identify socio-demographic characteristics of the participants. In this way, it can be analyzed how the participant's understanding of the environment and the physical characteristics of the place are in a relationship. Therefore, the rest of the study consists of questions aimed at deciphering the cognitive, emotional and behavioral elements that occur in the participants' communication with space. In this direction, the participants were asked questions such as "How would you express your connection with KTU Architecture Department Building in a sentence?", "At which point of the building do you feel connected to the place? Why?", "In what time periods do you use the university and why?". These questions are aimed at understanding which of the parameters that Relph considers as the three components of place are formed through whichone or which ones.

2.2. Memory Maps

It will be created by the participant marking and explaining the places that have meaning for him/her on the floor plans of the building selected as the study area. The points where the space transforms into a place can be identified through the mapping of the pointsat which the participants remember the sense of place in the space. In line with the analysis of the data obtained as a result of the study, it is planned to complete the study with the findings and then discussion and conclusion sections.

3. KTU Architecture Department Building

Karadeniz Technical University has a contemporary campus design as a result of a competition project won by Nihat Güner and Mustafa Polatoğlu in 1963 (Araz, 1990). In terms of its architectural configuration and physical characteristics, the Department of Architecture building is composed of two linear rectangular forms. The basic geometric form used is reflected in the organization of the interior spaces. The mass is designed in such a way that the functions belonging to academicians in the southern parts and students in the northern parts are located. There are 40 rooms in the south-facing section, and three design studios are located on each floor of the classrooms section. The solution of different functions in different areas provides student-academic separation. This separation is articulated with vertical circulation areas. The carrier red colored wall of the staircase designed at the focal point of the mass supports this hierarchical distinction in spatial terms (Figure 2).

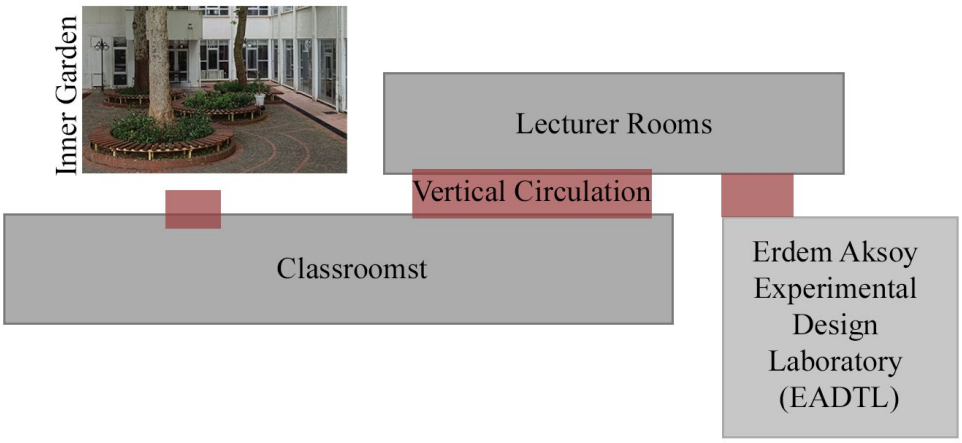


Figure 2 KTU Department of Architecture mass formation scheme

The semi-open area and foyer at the entrance of the department building serve as key meeting points for students. The foyer also functions as a "third space" (interaction area), hosting departmental events and activities. Additionally, the linear circulation corridors shaped by the building's mass are utilized as exhibition spaces. This design approach redefines the circulation areas of the Department of Architecture building, transforming them from mere transit zones into dynamic spaces for social interaction.At the time of its establishment, it was designed to

accommodate 300 students. In this context,classrooms of various sizes and different functions were designed. However, in order to meet the increasing quota over time; some classrooms were combined and almost all classrooms were organized to be used as studios. This situation caused some areas to be too deep (thin- long). Apart from these, there is the Erdem Aksoy Experimental Design Laboratory (EADTL), which is a mass and is used by all building users. This block with a gallery is generally used as a classroom for first year students. It is also the area where project submissions and seminars are held. There are three different staircases for the transition between floors. The first one is located to the left of the entrance area and is usually used by lecturers. The second is the staircase with a red wall located at the intersection of the masses. The third staircase is associated with the classroom block and is mostly used by students. This staircase overlooks the inner garden formed by the combination of the masses (Figure 3-4).

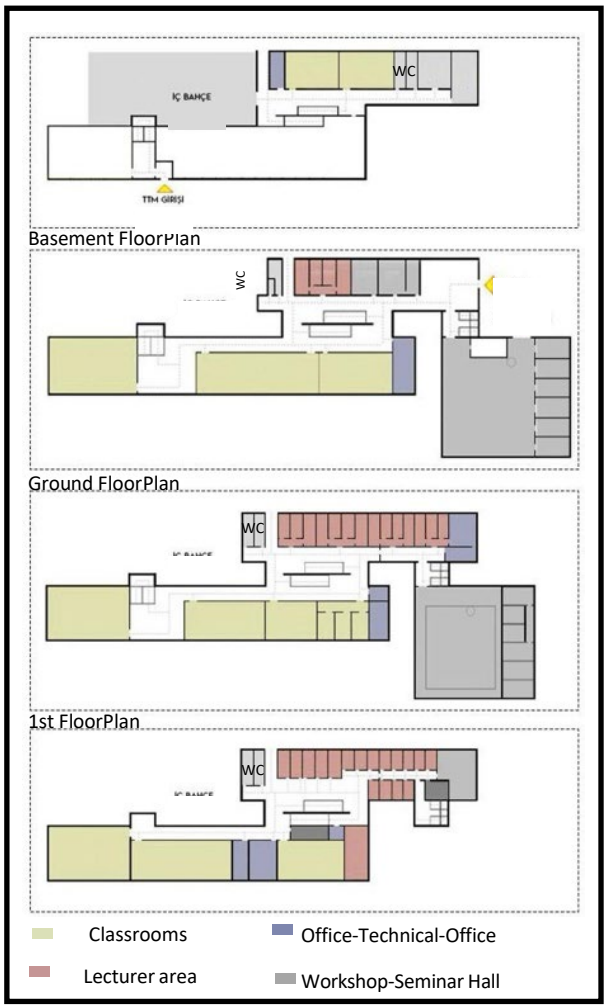


Figure 3 KTU Department of Architecture function diagram

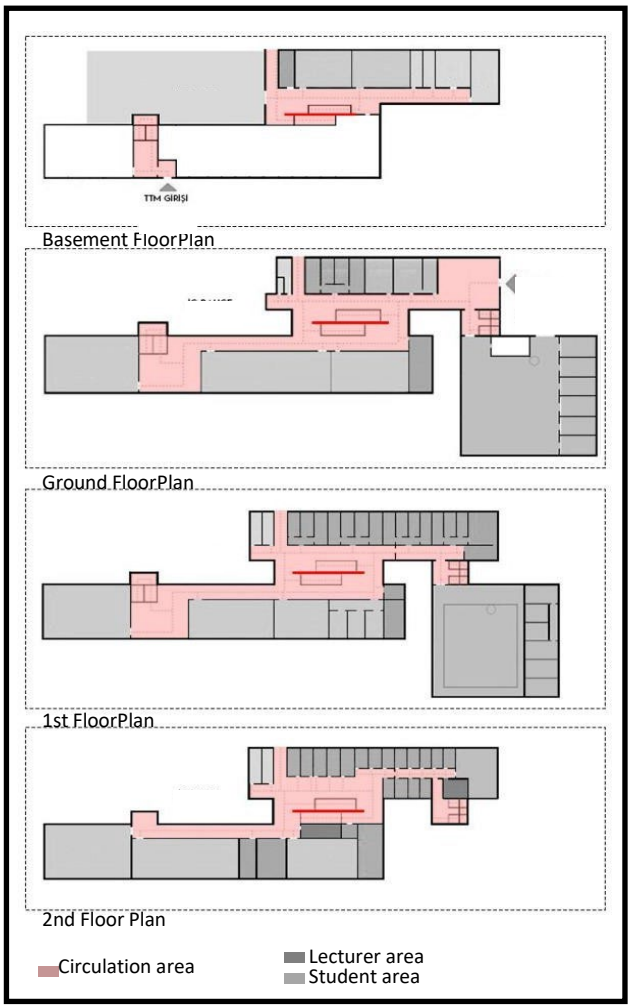


Figure 4 KTU Department of Architecture circulation diagram

The physical configuration of the study area has been created by considering the activities and activities carried out in the building. The EADTL, designed in connection with the entrance serves as a first-year classroom. In addition to this function, departmental activities such as seminars and workshops are organized. The building entrance area is used asan area where department-related activities are held. In addition, it has functions such as exhibition gathering and waiting area. The circulation line associated with the entrance hall turns into areas where activities such as socializing take place, as well as being transition and waiting spaces for users. Another space used as activity area is the inner garden. This space, which is related to the building, creates a landscape scene for those who look from the inside, while it becomes a resting area for those who are in the space. It is also used as a gathering and celebration area for various purposes (Figure 5).

Figure 5 Collage work created with photographs of KTU Department of Architecture

The workspace contains several interrelated meanings. The most obvious meaning is the hierarchical distinction that constitutes the physical existence of the building. However, in architectural education, the significance of the instructor-student dialogue, which develops differently from other disciplines, is reflected in the common areas of use. Circulation areas act as an instructor as well as being the spaces where the education between instructor and student continues. This education, which extends beyond studio work, demonstrates that architecture is more than just studio practice. Additionally, place is not a uniform or static experience for everyone; it carries a variety of meanings based on the diverse experiences of different users. In this context, the second phase of the study began to examine space using additional factors that influence the personal interests and experiences of these users.

4. Findings

Within the scope of the research, the aim is to reveal the relationship between the concept of place attachment and age, residence time and education status through the determined sample group. In this context, the data obtained within the scope of the study were analyzed in two separate groups as first grades and fourth grades. To observe the relationship between place attachment and gender, the interview data were further analyzed in subgroups of male and female students (Figure 6).

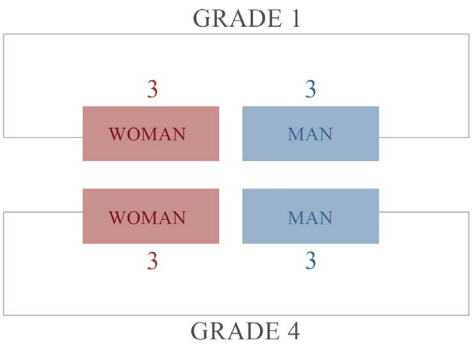


Figure 6 Diagram showing the distribution of participants

4.1. Analysis of Semi-structured Interview Data of First Year Students

In the first stage of the study, as a result of the socio-demographic questions directed to the students, the age of the participants, the cities they live in and what these cities mean to them were obtained (Figure 7). The participants, who are 18 and 19 years old, come from various cities. These cities host different cultures and their city scales are different from each other. However, to the question “What does the city you live in mean to you?” the participants gave common answers such

as "Peace, Feeling of home". In addition, concepts expressing positive emotions such as "Trust, Comfort, Happiness, Emotional connection, Life" were used. However, they do not use the same expressions for the city of Trabzon, where they are located for education. It can be inferred that the feeling of attachment is related to the duration of residence in the place where the participants were born and raised. Some of the participants also stated that their loyalty was not only due to the city but also to their close environment living in that city. In this case, it can be said that social relations are also effective in the development of the sense of commitment.

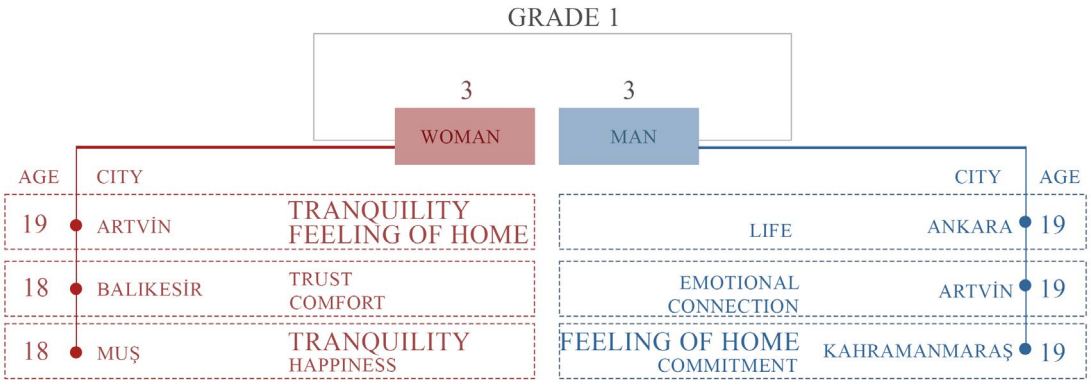


Figure 7 Diagram showing the meaning of age-city-city for first year students

As the study progresses, the participants were asked questions about the KTU Architecture Department building. These questions were asked to uncover what the building means to them, the spaces they feel connected to the place and the purposes of using the building. It was observed that the discourse related to the department building were generally associated with their dreams. A common answer from all participants regarding the place they felt most attached to was EADTL. Most of the participants stated that they gave this answer because they spent a lot of time in this place. In addition, the fact that it offers a large and free working space it offers fosters a sense of attachment for some users. For this reason, it is used by the participants to develop projects and study outside of class hours. A male student stated that he feels good in the inner garden, which is enclosed and has trees. Another male student said that he felt a sense of attachment to the place in the MA1 classroom because it was reminiscent of the old classroom system. Only one student in this participant group used the building for seminar activities other than studying (Figure 8).

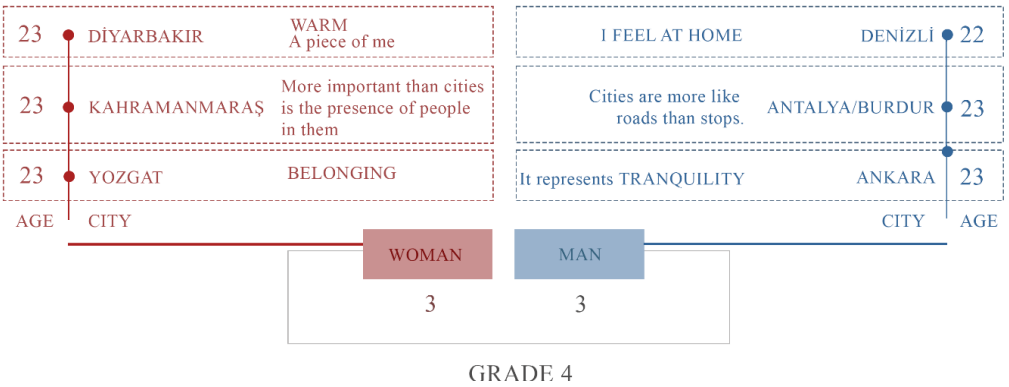


Figure 8 Expressions about KTU Architecture Department Building and the points felt depending on the location

4.2. Analysis of Semi-structured Interview Data of Fourth Grade Students

The participants, who are 22 and 23 years old, come from various cities with different scales and cultures. The participants responded to the question (What does the city you live in mean to you?) with answers such as "Peace, belonging, a part of me and the feeling of being at home". In addition, a participant from Kahramanmaras answered "The presence of people there is more important than the cities", while a participant from Antalya used the expression "The city I lived in was more like the road itself than the stop point" (Figure 9). The fact that these answers were received from

students who are completing their architectural education shows that the space can actually turn into a place with the presence of the people living there.

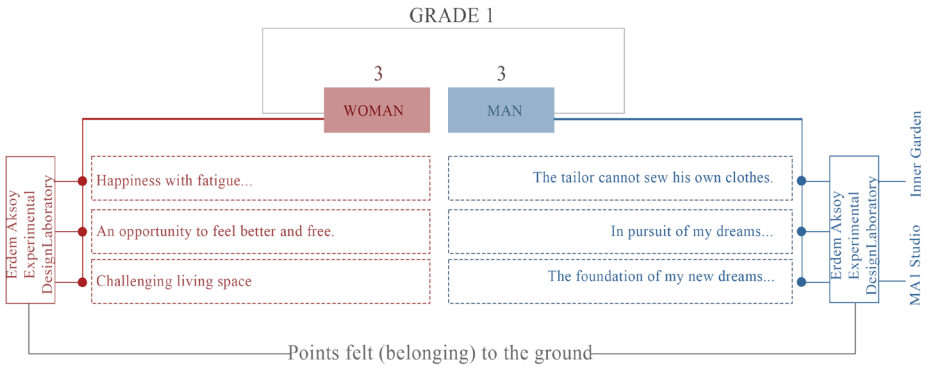


Figure 9 Expressions about the KTU Architecture Department Building and the places felt depending on the location

Thoughts about the department building were expressed with adopted sentences such as "My home in Trabzon", "My favourite place in Trabzon", "Heartfelt bond, peace", "My family, my home". When asked about the points of attachment to the place, places such as EADTL, red wall, inner garden, sitting area in the entrance canopy area, canteen, where they usually spend time to relax and socialise outside the class were given as common answers. Apart from these, individual responses such as corridors, student staircase, front of MA3 and an academic lecturer's room were also given (Figure 10). Compared to first year students, fourth year students were found to have more place attachment points.

This can be inferred to be an effect of the fact that they spent more time in the building. In this case, it can be inferred that the fact that they have spent more time in the building has an effect. Thus, it can be said that the transformation of space into place and the awareness of the components of the place experienced during this process progresses in proportion to the duration of architectural education and experience. Another noteworthy issue is that none of the classrooms is specified as a point of attachment to the place.

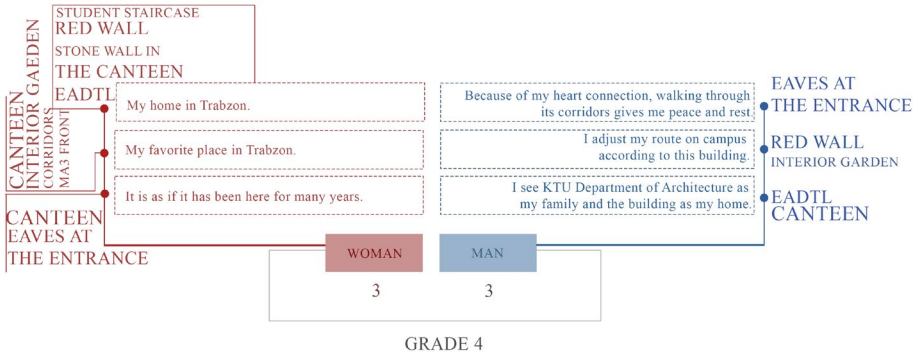


Figure 10 Expressions about KTU Architecture Department Building and the points felt depending on the location

4.3. Analysing the Memory Maps of First Year Students

The memory map data requested from the participants were processed on the building plans. Each of the indicated points represents a participant, and the opacity of the traces surrounding them was increased to provide a clear reading of place attachment. In this way, it was clearly seen in which situations and for what purpose the spaces of the building were used.It was noticed that the basement was almost never used by the participants. There was one indoor and one outdoor space used by two participants. The interior space was used once for an activity organized by an instructor within the scope of the course. The participant expresses this experience as a memory of having an active and fun time. The user who experienced the inner garden states that there is a sense of attachment to the place. In this case, the physical characteristics of the space (private

space created by architectural elements) and the presence of green landscape elements play a role (Figure 11).

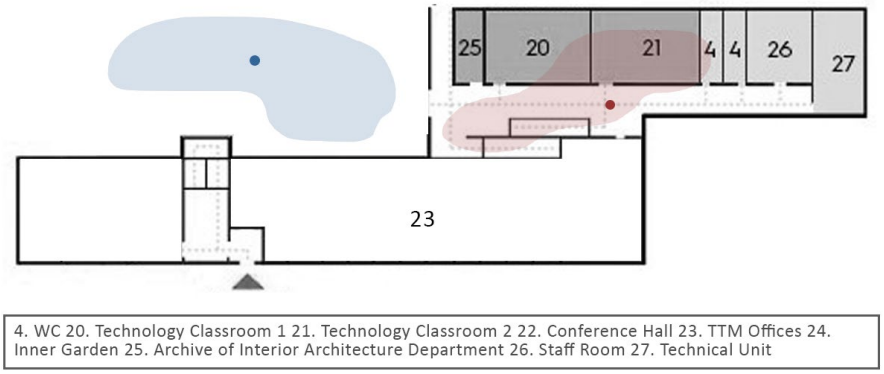


Figure 11 Basement floor plan memory points

When the ground floor data is analyzed; it is observed that it is used by all participants due to the fact that the building entrance is on this floor. The entrance hall and the benches in this space are used as waiting and socializing areas. One participant makes all phone calls in the building in this area due to the large entrance space. In this context, it has been observed that he has a command of the smallest detail in space. Two participants stated that they looked at the exhibited projects while using the circulation areas. EADTL is used by the participants within the scope of the course, as well as for studying outside of class hours. Their preference for this space is due to the fact that they feel spacious, cozy and therefore comfortable. However, one participant stated that the space was stuffy. The other classrooms used on the ground floor are MA1 and MA2 studios. They are used as teaching and working areas. In MA1, which is stated to be a long and narrow space, it is difficult to reach the sound and image from the back rows.

In addition to the studios, the large area in front of the MA2 studio, where the student staircase is located, is used by one participant to study. Half of the participants visit the lecturer's room 2308 on the ground floor for critiques (Figure 12).

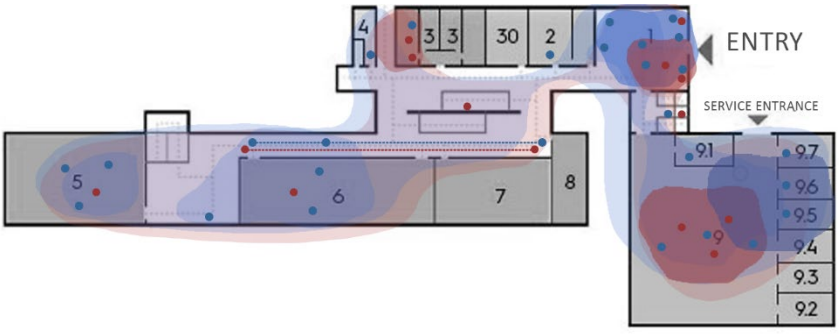
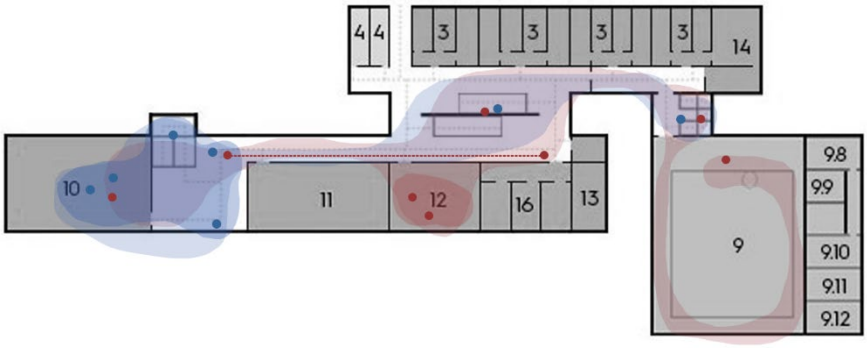


Figure 12 Ground floor plan memory points

The connection to the first floor is provided by the red-walled staircase, which is close to the entrance, and the student staircase in between. The staircase belonging to the educators is used for making measurements within the scope of the course and for project submission at the end of the semester. Apart from this; it was observed that it is not generally preferred by the participants, stating that it belongs to the educators.

The upper floor of the EADTL, where the final submissions are made, provides an opportunity to view the workspace on the ground floor through the gallery space. One participant described this space as a peaceful resting area. The long corridor belonging to the student block and the student staircase at the end of this corridor, which faces the inner gardenand is bright, are areas to

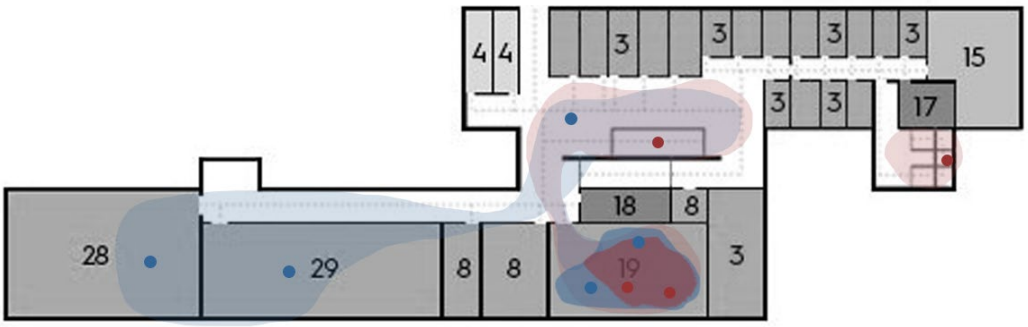
spend time for two participants. The wide and free hallway of the student staircase that merges with the corridor is also an area used by the participants to study. MA3 and MD2, the classrooms on this floor, offer students the opportunity to study and stay up during the deadline weeks (Figure 13).



3. Faculty Members' Rooms 4. WC 9. Erdem Aksoy Experimental Design Laboratory (9.8. Eastern Black Sea Archive 9.9. Building Science Lab-I 9.10. Graduate Archive 9.11. Dean's Office Archive 9.12. Museum) 10. MA3/Project Workshop 11. MD3/Classroom 12. MD2/Classroom 13. Department of Interior Architecture 14. Department of Architecture 16.Graduate Classrooms

Figure 13 First floor plan memory points

It is observed that the memory points formed in the second-floor spaces are low compared to the other floors due to less use of this floor. Özgönül Aksoy Computer Aided Design Laboratory (ÖABDTL) used within the scope of the course is one of these memory points. This space, in one participant's memory, is muffled and closed due to the high frequency and number of desks. Another participant stated that he had a pleasant time playinggames in this space between classes. The same participant states that the MD4 studio is spacious and large due to its balcony. In addition, he states that the exhibition stand created with Atatürk photographs on this floor causes a sense of attachment to the place at that point (Figure 14).

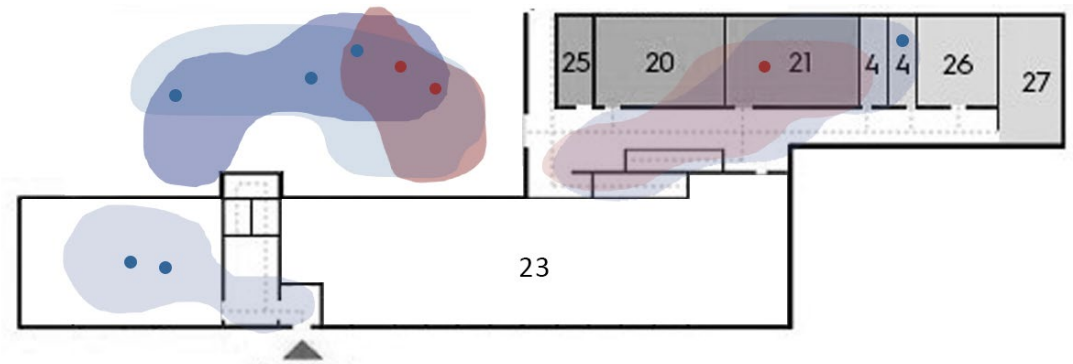


3. Faculty Members' Rooms 4. WC 8. Office/Technical Unit 15. Seminar Hall 17. Small Seminar Hall 18. Graduate Computer Aided Design Laboratory 19. Özgönül Aksoy Computer Aided Design Laboratory 28. MA4/ Interior Architecture Project Workshop 29. MD4/ Interior Architecture Classroom

Figure 14 Second floor plan memory points

4.4. Analysing the Memory Maps of Fourth Grade Students

When the basement floor plan is considered, the inner garden is identified by almost all users as a place where a sense of attachment to the place is awakened and memories are accumulated. This place, which is generally used for socializing, is also described as a private space. One participant mentioned the presence of green landscape elements and also mentioned komorebi (light seeping through the trees) and birdsong. He also states that it is a space that provides the opportunity to see people moving in the interior. The conference hall where the club meetings took place was marked as a memory point for two male participants. Apart from this, the technology classroom used within the scope of the course and the toilet, which was described as "isolated and scary", were mentioned as memory points on this floor (Figure 15).



4. WC 20. Technology Classroom 1 21. Technology Classroom 2 22. Conference Hall 23. TTM Offices
24. Inner Garden 25. Archive of Interior Architecture Department 26. Staff Room 27. Technical Unit

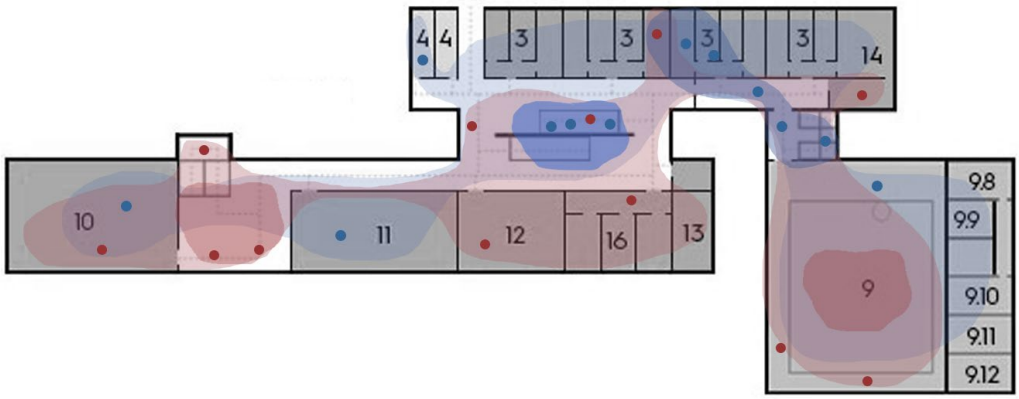
Figure 15 Basement floor plan memory points

When the ground floor data was analyzed; it was determined that the semi-open space in front of the building entrance was used for waiting, resting and socializing. This resting and socializing area continues with the entrance hall. A participant described this space, where events and activities such as exhibitions and socializing take place, as "Our warm space surrounded by wooden windows". In addition, physical features such as the wall with the inscription of the architecture department, the statue of Mimar Sinan and benches are also included in the memories. EADTL, which is connected to the entrance hall and is one of the points where the sense of attachment to the place is the most intense, is used by all participants as an event and activity area such as interviews, exhibitions, workshops. The only negative discourse about this space is the presence of the disturbing sound of the lighting elements. The staircase, which is stated to belong to the trainers, is generally not used by the participants. The staircase with red walls is mostly preferred for vertical circulation. The inviting staircase in the center of the horizontal circulation area is one of the points where a sense of attachment to the place is formed for all participants. MA2, one of the classrooms, was marked by only one participant as it was used for lectures. However, the student staircase floor hall in front of the MA2 classroom is a socializing space for the participants as well as a place where they can study. It is an area where they eat stressful and hurried meals, especially during the delivery weeks. The staircase, which is connected to this space, is used as a place where delivery photos are taken by a participant due to its physical characteristics. Another point on this floor where half of the participants felt connected to the place was identified as the room belonging to the lecturer numbered 2308 (Figure 16).

1. Entrance 2. Secretariat 3. Faculty Members' Rooms 4. WC 5. MA2/Project Workshop 6 . MA1/Project Workshop
7. MD1/Classroom 8. Office 9. Erdem Aksoy Experimental Design Laboratory (9.1. KTU Digital Design Research and Fabrication Unit 9.2. Building Knowledge Lab.-II 9.3. Faculty Warehouse 9.4. Sports 9.5. KTU Digital Design Research and Fabrication Unit 9.6. Commodity Storage 9.7. Archive) 30. Interior Architecture Department Secretariat

Figure 16 Ground floor plan memory points

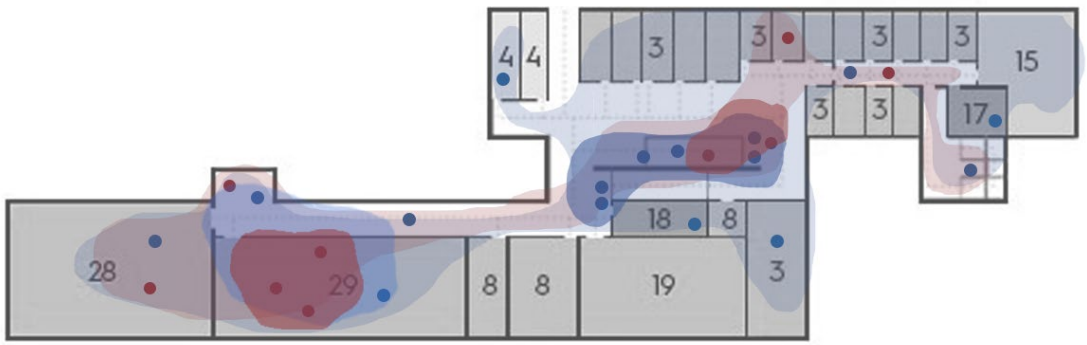
When the first floor plan memory maps were analyzed, it was observed that there was no sense of attachment to a common place for all participants. While the general communication with this floor is provided by the staircase with red walls, it is observed that most male participants use the instructor staircase during their visits to the instructor block. This staircase is also used for end-of-term project submissions. It is observed that half of the participants' memories of the gallery floor of EADTL are shaped by the deliveries that took place here. Classrooms such as MD2, MD3 and MA3 are remembered as they are used in this floor within the scope of the course (Figure 17).



3. Faculty Members' Rooms 4. WC 9. Erdem Aksoy Experimental Design Laboratory (9.8. Eastern Black Sea Archive 9.9. Building Science Lab-I 9.10. Graduate Archive 9.11. Dean's Office Archive 9.12. Museum) 10. MA3/Project Workshop 11. MD3/Classroom 12. MD2/Classroom 13. Department of Interior Architecture 14. Department of Architecture 16.Graduate Classrooms

Figure 17 First floor plan memory points

The memory points formed in the second-floor spaces are concentrated in the red-walled staircase and chess game areas. The chess area, which is formed by the extension of the red wall and used for socializing and resting, is considered as a private area by a participant. For this reason, telephone calls within the building are made at this point. The same participant stated that he uses the toilet on this floor because it is particularly clean. The corridorbelonging to the instructor rooms has become a quiet and tense memory point for a participant. MD4 is used as the final project classroom. For one participant, this studio felt unpleasant because it was small and impractical. The MA4 classroom became a memory pointfor one participant within the scope of the course, while for another person it felt alienbecause he had not used it before (Figure 18).



3. Faculty Members' Rooms 4. WC 8. Office/Technical Unit 15. Seminar Hall 17. Small Seminar Hall 18. Graduate Computer Aided Design Laboratory 19. Özgönül Aksoy Computer Aided Design Laboratory 28. MA4/ Interior Architecture Project Workshop 29. MD4/ Interior Architecture Classroom

Figure 18 Second floor plan memory points

5. Discussion

This study investigated the spatial attachment of students from the KTU Architecture Department and examined how their habits of space usage evolved during their education. Data were collected from first- and fourth-year students, who were selected as the sample group. Due to the intensive coursework in architectural education, the participants spent a significant amount of time in the building and described it with terms such as "feeling of home," "belonging," and "peace".

First-year students, who are in the early stages of their interaction with the KTU Architecture Department building, predominantly used the space for project development during and after class hours. The Experimental Design Laboratory (EADTL), where the primary course activities took place, emerged as the primary space to which first-year students felt strongly attached. This finding suggests that the duration of experience plays a significant role in the formation of place attachment. Furthermore, it was observed that the space's identity as a location where students could realize their dreams was more influential in creating a sense of attachment than the physical characteristics of the space itself. Notably, one participant from an Anatolian city likened the MA1 classroom to a traditional classroom layout and therefore preferred it for studying. This highlights how spaces that evoke personal or cultural associations can strengthen place attachment. Accordingly, the concept of place emerges as a key factor in place attachment, memory, and identity formation.

Fourth-year participants, who had spent more time in the building, developed a stronger sense of attachment to less frequently used and more specific areas within the building. This finding aligns with Relph's (1976) assertion that the duration of residence significantly influences the sense of place attachment. The physical features of the spaces mentioned by fourth-year students were particularly influential in shaping their attachment. This indicates that architectural education fosters cognitive awareness, which in turn enhances the emotional and intellectual connections that individuals establish with their environment.

The activities and events organized in the department building also played a pivotal role in shaping the students' sense of place attachment. First-year students predominantly associated the building with academic activities such as studying and project development. In contrast, fourth-year students perceived the space through a broader range of activities, including exhibitions, workshops, and social events. These diverse activities enriched students' attachment to and use of the space. Consequently, place attachment can be understood as the meaning derived from the transition of an experienced space from a physical dimension to a social one.

Architecture, as a multidisciplinary practice, provides its users with the opportunity to engage with spaces in varied and dynamic ways. The building in this study offered students the flexibility to use spaces for different purposes. For instance, the hall adjacent to the student staircase served as an independent workspace for some participants, while others used it for socializing and organizing events with friends, appreciating its spaciousness and physical features. Consistent with Relph's (1976) theory, the findings suggest that individuals develop a sense of place attachment by subjectivizing and personalizing their experiences in a space. The higher awareness of fourth-year students compared to first-year students highlights the contribution of architectural education to this process.

6. Conclusion

This study has demonstrated how architecture students' sense of attachment to spaces and their methods of using these spaces evolve over the course of their education. The findings underscore the following key points:

6.1. Role of Duration in Place Attachment

Extended time spent in a space enhances attachment, as it allows individuals to develop deeper connections and familiarity with the environment. Architectural education fosters cognitive awareness, which helps students appreciate the spatial and social nuances of their surroundings.

6.2. Impact of Social Activities

Events such as exhibitions, workshops, and social gatherings diversify students' interactions with the space and enrich their sense of attachment. Educational buildings should therefore be designed to facilitate such activities, creating an environment that fosters both academic and social engagement.

6.3. Designing for Flexibility and Emotional Engagement

Spaces that allow for multiple uses and foster positive associations contribute significantly to place attachment. However, mandatory spaces like classrooms often fail to evoke such emotional bonds, as they are primarily associated with functional and obligatory activities. Incorporating user-centered features into classroom design could transform these spaces into more engaging and meaningful environments.

In conclusion, this study provides valuable insights into how the design of educational buildings impacts students' academic and social experiences. By supporting both functional and emotional needs, these spaces can better serve their users and contribute to the holistic development of a sense of place attachment. Furthermore, the findings offer a foundation for future research into the relationship between architectural design and user experience in educational settings.

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Resume

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Declarations

Ethics approval and consent to participate

Ethics committee approval has been obtained.

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Flexible model proposals for post-disaster temporary housing in architectural design

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Abstract

Shelter is one of the most basic needs that emerged with the existence of humanity and is necessary for people to continue their lives. In addition to meeting physical needs, it also has social and cultural functions. Especially in the post-disaster process, it is essential to create temporary shelter units in the face of emerging problems. Since societies can be affected simultaneously in this process, needs must be met as quickly as possible. "Flexible container designs" are seen as a solution to this problem. Flexible container designs can provide significant advantages in meeting basic needs after a disaster and in terms of rapid intervention. The study aims to present flexible model suggestions that can be used to produce temporary shelter units. Because the production of temporary shelter units is essential in terms of flexibility due to reasons such as reusability, portability, limited design periods, etc. The study discusses the designs made by the students within the scope of the Structural System Information course of the Architecture Department of Gazi University Faculty of Architecture. The students were asked to produce solutions to problems such as the emergence of shelter needs for people after disasters, bringing containers to the need area, and serving different functions. The study reveals the value of the concepts of flexibility, portability, and modularity in the design of temporary shelter units through student designs; it emphasizes the importance of these concepts in design processes in both architectural education and architectural practices. The study will contribute to the development of innovative, flexible, and portable solutions.

Keywords: architectural education, container, earthquake, flexible designs, portable designs

1. Introduction

Since the early periods of history, people have needed shelter, a place to take refuge from the effects of nature. Along with changing and developing living conditions, shelters have also developed; social functions such as being comfortable, healthy, livable, sustainable, etc. have been assigned to spaces. A shelter should always protect the physical and mental health of its users and be able to meet the needs of its users (Tamer Uçar, 2015).

When people lose their homes and living spaces where they feel safe due to natural disasters, it both increases the impact of the adversities they experience and prolongs the time to return to their normal lives after the natural disaster (Abanoz & Vural, 2023). When the post-disaster needs are examined, it is of great importance in terms of disaster management to provide safe shelter spaces in order for disaster victims to reconstruct their living arrangements and routines. The need for shelter is one of the most critical problems to be met in the emergency phase after natural disasters.

Temporary shelter units are needed until permanent housing is completed (Ayanoğlu & Erbaş, 2023). Temporary shelter units are defined as units that meet the shelter needs in disasters,

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epidemics, earthquakes, etc., and are unsuitable for long-term use (Beyatlı, 2010). These units must be produced in a short time, be quickly installed, not require high costs, and be able to meet people's physical and social needs.

In the world and in our country, in the post-disaster sheltering process, Tent type, Mevlana houses, and prefabricated houses are used as temporary shelter units. Although they are cheap and easy-to-install systems at first glance, the traditional methods used today need to be revised in terms of allowing disaster-affected communities to stay in healthier and more comfortable places, to adapt to climatic conditions, and to meet user needs more quickly. Therefore, these systems need to be replaced by more advanced, innovative systems (Beyatlı, 2010).

When the words “container”, “shelter”, “temporary shelter” are searched in Web of Science, there are 1310 publications in the field of architecture and civil engineering in 2020 and after. The concepts that draw attention in the publications are as follows: adaptability, flexibility, foldability, kinematic compatibility, modularity, portability, sensitivity, sustainability, energy efficient, resilience. It is seen that these concepts support the same view (Clarivate, 2024).

At this point, the need for flexible, sustainable systems that can replace traditional structures and that can be quickly installed and dismantled clearly emerges. Flexible housing units play an important role in modern construction; they are supported in the face of a rapidly changing world. The increase in natural disasters and the decrease in environmental resources cause the need for flexible housing units that can be adapted to different needs. Temporary housing units are considered necessary for groups such as immigrants, refugees, homeless, etc., as well as natural disasters. The requirements for the units can be listed as durability, flexibility, mobility, sustainability, and comfort (Erdoğan Biter, 2023).

This study discusses the designs made by the students within the scope of the Structural System Information course of the Architecture Department of Gazi University Faculty of Architecture. The study focuses on the problems that lead people to seek new solutions in terms of meeting their basic needs and security as well as shelter needs. Students are expected to create durable, portable, sustainable, and innovative designs that consider the concepts of flexibility, portability, and modularity. The designed temporary shelter units undertake a critical mission with these concepts. This study will improve students' design skills through student designs and contribute to being more prepared for disaster risk. The study aims to reveal the value of flexibility, portability, and modularity in the design of temporary shelter units and to emphasize the importance of these concepts in the design processes in both architectural education and architectural practices. It is also thought to be a guide for newly designed shelter units.

2. Post-Disaster Temporary Housing Units: Container Design

Temporary shelter areas are basic shelter areas where the best possible living conditions are provided, which are pre-planned in order for the disaster victims to shelter for a temporary period of time after overcoming the initial chaos after the disaster, to be protected from climatic conditions and to live comfortably (Maral, 2016). There are many temporary shelter units: disaster units, prefabricated units, caravans, containers, trailers, etc. Within the scope of this study, container systems are focused on.

The container can be defined as a building element or unit positioned at a sufficient height from the ground level, has a simple and lightweight structure, is easy to transport and install, and has many different areas of use. Due to these features, container units are preferred in many areas (Kumaş, 2022). The use of containers in architecture is divided into two parts: the first is the use of a single cell (temporary shelter after a disaster), and the second is the use of mass (exhibition hall, fairground, etc.).

- Use in Emergency Situations: They can be used quickly in disaster situations such as earthquakes and floods. They can be used as emergency shelters to provide temporary accommodation for disaster victims or as emergency health centers.

- Transportation: The most common use of containers is maritime transportation. Standard containers are used to transport goods around the world on large ships. They are also used in land transportation, such as trains and trucks, allowing goods to be transported quickly and safely.
- Storage: Containers are also used to meet storage needs. Containers are preferred especially for temporary or long-term storage of products such as construction materials, furniture, clothing.
- Construction: In the construction industry, containers are used for purposes such as temporary offices, worker accommodation units, engineering offices and worker rest areas. When the nature of the work requires constant relocation, containers can be quickly moved and rearranged.
- Events and Fairs: Containers are used as temporary shops, food and beverage areas, toilets, ticket offices, etc. in events such as concerts, festivals, fairs, etc. It offers solutions to the needs of event areas with its portable and quickly installed structure.
- Housing and Hotels: In recent years, containers have become popular as environmentally friendly and sustainable housing alternatives. By bringing containers together, structures such as housing, hotels, and holiday villages can be built. Their fast installation and cost advantages make them preferred in this area.
- Agriculture: Containers are ideal for vertical farming applications. Especially in urban farming projects, containers can be used to create space-saving, efficient and sustainable farming areas.

Containers generally consist of a steel frame skeleton with wall panels, roof panels, and floor panels as carriers. They are of standard dimensions and are designed for transportation and storage purposes. Container design includes structural design (external dimensions of the container, internal volume), material selection, internal layout and functions, air conditioning and insulation, security and ease of use, and rapid assembly and disassembly (Niu, 2010).

Containers, which have many areas of use, are aimed to be used quickly, effectively and reliably within the scope of the study, especially in situations requiring emergency intervention after a disaster. Containers offer a solution to quickly resolve the sheltering problem that occurs after a disaster. Therefore, the fact that many countries, including Turkey, are under earthquake risk and the need to quickly resolve the sheltering problem that occurs after an earthquake also reveals the necessity of the containers' potential to provide urgent and effective assistance to earthquake victims.

Many different parameters should be taken into consideration in the design of post-disaster shelter units. In addition to providing the need for shelter, many other parameters such as the removal, storage and reuse of these units should be an important part of the design process (Vural Arslan & Gülay, 2023). International/national standards and guidelines provide guidance on shelter principles in particular. On a national level, "AFAD-Directive on the Establishment, Management and Operation of Temporary Accommodation Centers" (2015) and on an international level, "The Sphere Handbook-Humanitarian Charter and Minimum Standards" (2018) provided an important reference point for the study.

AFAD's Directive on the Establishment, Management and Operation of Temporary Accommodation Centers (2015) defines the principles for the location of accommodation centers, infrastructure requirements, security measures and provision of basic services (water, electricity, health, education, etc.). It aims to support rapid and effective response after a disaster. According to the Directive, it is important that temporary shelters are located in areas where they can be protected against hazards, taking into account the prevailing winds and water basins that may accumulate during the rainy season, and in a position suitable for capacity expansion in case the population increases. In addition, the standards for shelter units are as follows:

- The indoor area per person in shelter units should be 3.5-4.5 m^2.
- Containers should be 30 cm above the ground height.
- In hot and humid climates, air flow should be ensured and protected from direct sunlight.
- Optimum insulation should be provided in cold climates.
- Electricity should be available to all units and fire resistant materials should be used (AFAD, 2015).

The Sphere Handbook: Humanitarian Charter and Minimum Standards (2018) defines minimum standards in humanitarian processes. According to the Sphere project, shelter is more than four walls and a roof. The charter defines what people affected by disasters have a right to expect from humanitarian assistance and consists of four main chapters: water supply, santitation and hygiene promation, food security and nutrition, shelter and settlement, health services. All chapters are important in designing units that are equitable, fair, accessible, livable, culturally acceptable, accessible, healthy, flexible and safe for all. In particular, the standards for shelter units are as follows:

- Shelter units should be designed by considering climatic data. In warm, humid climates, they should not receive direct sunlight; in hot, dry climates, they should be shaded and ventilated; in cold climates, they should be designed to provide solutions to the heating problem.
- Necessary and appropriate areas for storage, nutrition and water supply should be allocated within the shelter unit.
- There should be a minimum of 3.5 m^2 of living space per person.
- Temporary shelter areas should be flexible enough for expansion. In case the population increases, new temporary shelters should be planned to be placed in the area (The Sphere Handbook, 2018).

The issues emphasized in these standards are to comply with minimum living space standards per person and to allow for flexibility. At this point, it is important that the units are capable of providing shelter for up to 4-6 people and are in alignment with international standards. The use of standard dimensions can facilitate the modification process in cases such as increasing the number of users, meeting different functions, etc.

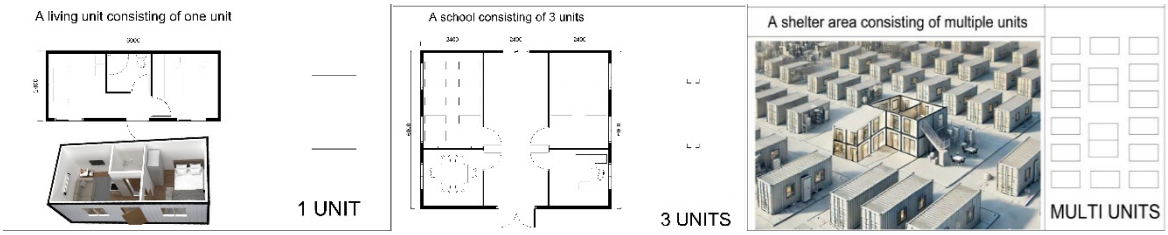

Figure 1 The use of temporary shelter units in different functions by integrating them with each other

Prefabricated containers used in our country are generally produced in accordance with specific standards. The most common dimensions are 3 m in width, 7 m in length, and 2.65 m in height. However, designs can be made in special cases and needs, and production can be carried out dimensions. Some container types are given as examples in Table 1.

Table 1 Container Types and Sizes Used in Our Country (AFAD Deprem Konteyneri-Konteyner Kent, 2024)

		
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		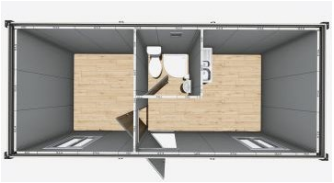
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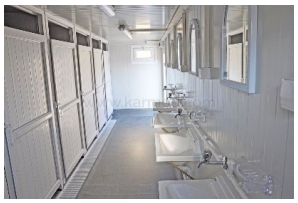	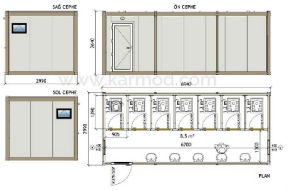	
WC Duş Konteyner: 300x700x265cm		
		
Özel Konteyner: 400x1200x265cm		

Most of the container cities established after earthquakes in our country are established as seen in Figure 2.

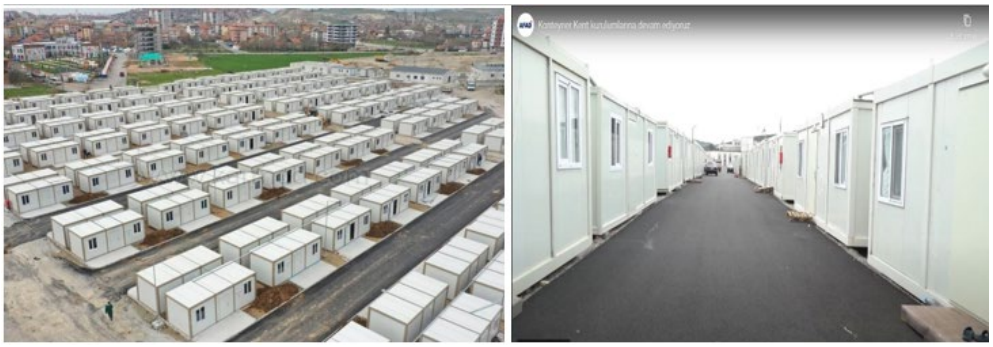

Figure 2 Kahramanmaraş container city

Temporary shelters after disasters are essential in the lives of communities affected by disasters in terms of creating a sense of normality, increasing hygiene conditions, and providing protection against climatic effects. To provide comfort consistent with the standard of living after a disaster, temporary shelters must be provided quickly. The design of these units is necessary to encourage a return to normal in a chaotic and uncertain situation. Temporary shelters may be unsustainable and inadequate in some cases due to the strategies used, misunderstandings about user needs,

local conditions, etc. These units should be related to sustainability in terms of cost and environmental aspects (Félix et al., 2013).

Security, privacy, comfort, thermal and sound performance, ventilation, durability, etc., issues need to be considered. In addition to these concepts, planning for the future in producing solutions, contributing to possible future uses, and designing systems that can be adapted for reuse is essential. Therefore, temporary shelter units should be flexible, easy to install, dismantle, and use, and allow for simple and quick transformations (Avlar et al., 2023).

After a disaster, due to damage or destruction of structures, shelter areas need to be provided quickly. In reconstructing structures, a solution should be found for the shelter problem for the people living there. In addition to the shelter needs, alternative projects should be produced to meet other basic needs of people (Beyatlı, 2010).

The ready-made units used are solutions that are entirely built in the factory and need to be transported to where they will be placed. These solutions usually involve complex transportation systems, which can cause difficulties. Heavy transportation systems are needed, especially in regions with difficult access, since transportation will be even more challenging (Félix et al., 2013). Since only two containers can fit on a truck during the transportation of traditional containers, major transportation problems can be experienced. In addition, a severe storage problem arises when these containers are stored after they have completed their function after an earthquake. In addition, although standardly designed containers are universal, difficulties can also arise because they ignore the real needs of users, climatic differences, cultural values, and differences in daily life. When solutions cannot be adapted to user needs, they must make changes and additions. This makes containers unstable and unsustainable in the face of future problems (Félix et al., 2013).

Therefore, container designs that are more flexible and portable and based on modularity should be developed. Projects should be developed through kit solutions. While using the advantages of prefabrication, the kit concept means producing the elements that make up the unit instead of producing finished units. Transportation and local assembly can be facilitated by assembling the elements on-site (Félix et al., 2013). Thanks to these new designs, containers can be combined into more units, and more can be fitted into vehicles during transportation. Thus, transportation problems can be reduced, and more accommodation space can be provided. It also minimizes the storage problem and increases the reuse and sustainability of containers.

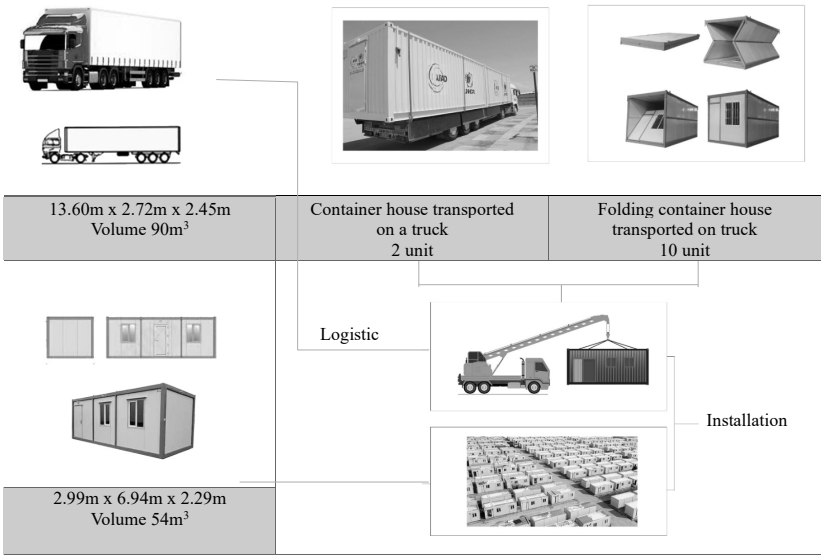

Figure 3 Container transportation and installation stages

3. Student Works Produced within the Scope of the Course

Within the scope of the study, the problem of shelter, which is one of the most important needs after a disaster, was addressed, the difficulties brought by traditional containers were analyzed and alternative design proposals were aimed to be developed. Alternative design proposals were prepared within the scope of an educational study.

Architectural education requires lifelong learning. Being able to respond to social relations and the needs of society, thinking critically on issues concerning society, and examining the relationship between architecture and society should be taught to students during the architectural education process (Yücel & Aydınlı, 2015). The design process in architectural education is a problem-solving action. Both international practices and social problems determine the requirements of education. Architecture and architectural education should be questioned, especially with the earthquake disaster experienced in our country.

Therefore, within the scope of the "Supporting System Information" course in the Department of Architecture of Gazi University Faculty of Architecture, students were asked to solve problems such as the need for shelter after disasters, bringing containers to the required area, and serving different functions. Within the scope of the course, the process started with the transfer of theoretical and technical information about the concept of the supporting system to the students. In the transfer of theoretical information stage, students are taught the basic principles of supporting system information; the technical information stage is carried out through modeling. This course aims to provide students with supporting system information and to provide them with experience in designing safe, durable, qualified structures that contribute to society. For this purpose, students were expected to design a "flexible container".

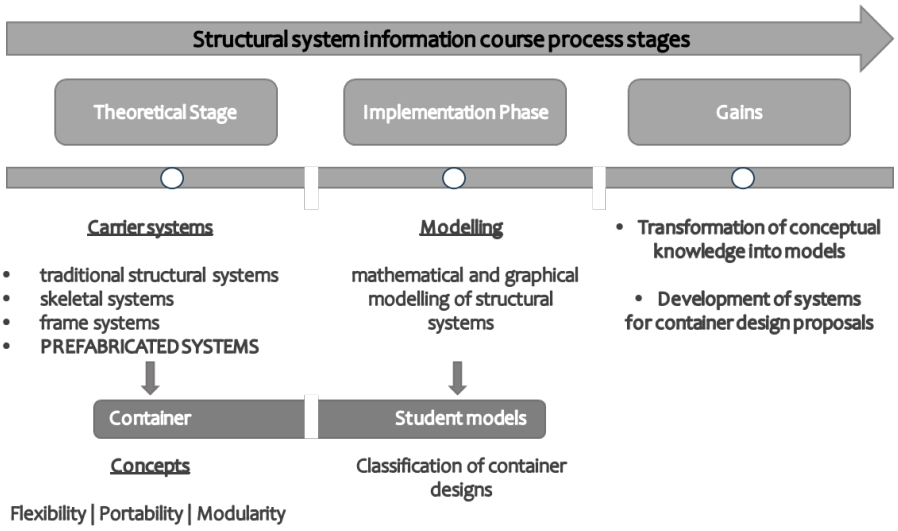

Figure 4 Structural system information course process stages (Created by the authors)

3.1. Theoretical Stage

In the transfer of theoretical knowledge stage: Carrier systems; traditional carrier systems, skeletal systems, frame systems and prefabricated systems were classified. It was decided to design containers from prefabricated systems. The concepts of flexibility, portability and modularity were emphasized; the possibilities provided by these concepts and how they are reflected in practice in container design were discussed. In architectural design, the concepts of flexibility, portability and modularity express the design's ability to adapt to changing needs and changing conditions and its capacity to overcome difficulties.

Flexibility is defined as the ability of a design to respond to the needs of different users and to be used for different functions (Tapan, 1972). Flexible design is a design that is adaptable rather than stagnant, that responds to change rather than rejecting it, and that is mobile rather than static.

The benefits of the concept of flexibility in design can be listed as follows; buildings can remain in use for a long time, can meet user experience and intervention, and can remain relevant to cultural and social needs in economic and ecological terms (Zenter, 2018).

Portability means that a structure can be easily transported and quickly assembled. It is a flexible approach where the structure is transported in a limited number of parts and assembled on-site. This approach allows for many different forms and follows the concept of a kit of parts during the assembly process (Wagemann, 2017). Portable designs provide ease of storage by being placed side by side or on each other when in a closed position. In addition, it is seen as efficient in terms of transportation in that many units can be transferred at once during shipment (Erdoğan Biter, 2023). Systems that can be disassembled, assembled with portable parts, and used repeatedly can offer an easy and modern lifestyle. Ease of transportation, not taking up much space, and not requiring tools during assembly are essential design features (Beyatlı, 2010).

Modularity is the ability to separate and recombine units in a system in line with functional needs. The design has a modular structure, and the modules are developed from a single prototype. The structure is formed by combining different modules within the framework of specific rules, and when these modules come together, larger and more complex structures can be created. Modularity allows easy rearrangement and expansion according to needs (Radev, 2017; Altunkaya, 2020). In this way, a constantly evolving and changing system emerges. Modular systems can be designed as semi-open, open, and closed according to the users' wishes. It can provide solutions for flexibility and mass production by creating various plan alternatives (Erdoğan Biter, 2023).

The relationship between flexibility, portability, and modularity in container production is based on the principle that components can be arranged in potentially infinite numbers and shapes. The primary purpose of such systems is to minimize damages and loss of time while producing rapid solutions to needs with an efficient organization, including the installation of modules and foldable panels, considering user needs. Systems can also include flexible, combined, and modular techniques that can change their shape and size with strategies that can open, close, and expand/contract thanks to their geometric and mechanical features (Wagemann, 2017). These concepts are of great importance, especially in container designs required for post-disasters, as they have high adaptability and capacity to produce solutions to problems.

Figure 5 Examples of foldable and demountable containers

3.2. Implementation Phase

In the transfer of technical knowledge phase: the gains obtained in the theoretical phase are tested with application and modeling methods. In this phase, students were asked to design a “flexible container”; the focus was on the concepts determined in the theoretical phase. In order to make the system more understandable, the carrier systems were expected to be modeled mathematically and graphically and their models were made.

What is expected from students;

- A flexible module design that can be attached, detached, and expanded is requested.
- Focus should be on the concepts of flexibility, modularity, and portability.
- Vertical and horizontal carriers should be arranged to form a frame.

• Insulation and materials should be considered in ready-made panel walls.

• Door-window gaps should be taken into account in the design.

• In the floor design, it is necessary to understand and apply the grid system, not the flat plate.

Expectations are planned to understand the skeletal and cladding systems of prefabricated containers and to raise awareness about flexible, portable and modular concepts that can be quickly and easily installed, fulfill vital functions in the design of temporary shelters.

As a result of the study, 16 different container designs were developed through group work; these designs were presented in the form of 1/10 scale models and 3D models. During the evaluation process, projects that comply with international standards, include conceptual approaches and structural system details were included in the scope of the study. The main reason for this selection is the aim of providing practically applicable solutions in accordance with the purpose and focus of the study. In student studies, container designs are examined in three groups in the transformation of concepts into models: Detachable systems, sliding systems and modular systems.

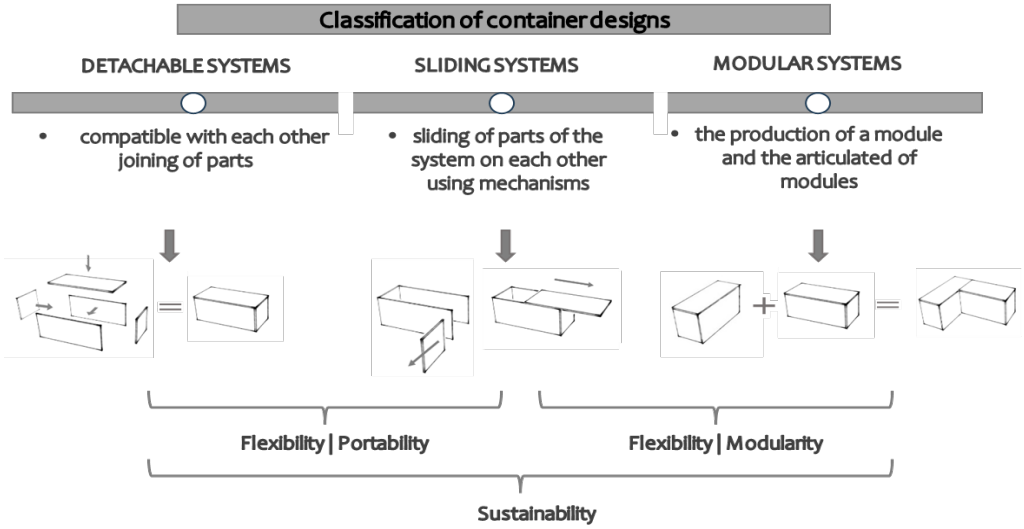

Figure 6 Classification of container designs (Created by the authors)

Recommendation 1-Detachable systems;

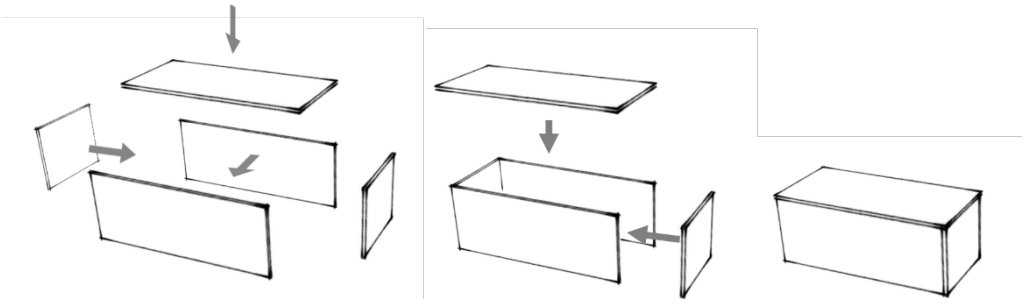

Figure 7 Detachable systems

In the first proposal, a removable/portable system model was created. Removable systems are formed by combining prefabricated panels that are compatible with each other. These systems can be preferred especially for post-disaster situations or when a removable structure is needed due to their features such as easy and fast production, low cost, and fast installation. Since prefabricated panels take up very little space while being transported, they provide both space saving and convenience in terms of carrying more systems at once. Unwanted panels can be removed during installation; panels that need to be changed can be easily replaced (İnan, 2014).

Figure 8 Detachable system-student model study

The detachable and attachable proposed design consists of 6 sandwich panels. It contains the shelter and bathroom/WC area. Since the volumetric reduction occurs when the unit is disassembled, it will provide ease of transportation and storage. When needed, it can be delivered to the desired location in larger numbers compared to traditional containers and easily installed.

Recommendation 2-Sliding systems;

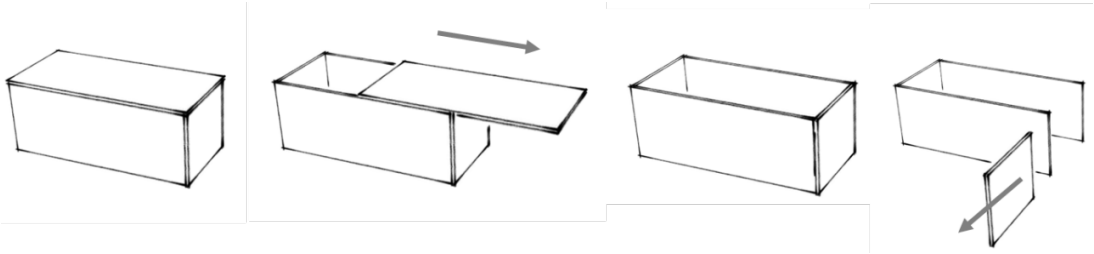

Figure 9 Sliding systems

In the second proposal, a sliding system model was created. Sliding systems are formed by sliding some or all of the panels on a special mechanism. Sliding panels are mechanisms that allow functional flexibility (Zenter, 2018).

Figure 10 Sliding system proposal-student model study

The proposed design consisting of sliding sandwich panels provides ease of both transportation and installation. With the interior panel mobility in the proposed system; interior layout and functions can be easily changed and adapted according to the needs of disaster victims. Open-closed space interaction is also possible with the sliding of the exterior panels on each other.

Recommendation 3- Modular systems;

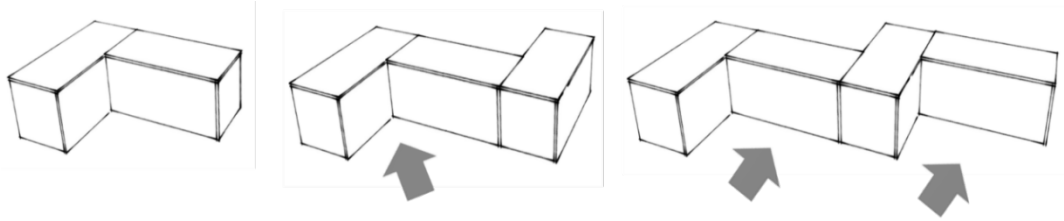

Figure 11 Modular systems

The third proposal focuses on modular and compact units. Modular systems are formed by a standard module produced and the appropriate combination of these modules. Parts can be disassembled and combined when necessary. Since modular systems provide growth flexibility, they can also respond to possible scenarios (İnan, 2014).

Figure 12 Modular systems-student model study

Unlike other suggestions, in this proposed design, modules can be articulated side by side or on each other. This way, volumetric growth occurs; different functions requiring different volumetric capacities can be served. Modular units can also be a solution in the face of changes in the number of users. They can also be arranged in a way that creates courtyards between them; thus, users can connect and socialize. Creating transition areas such as gardens between modules can provide privacy between neighbors and allow open areas for common work, rest, etc.

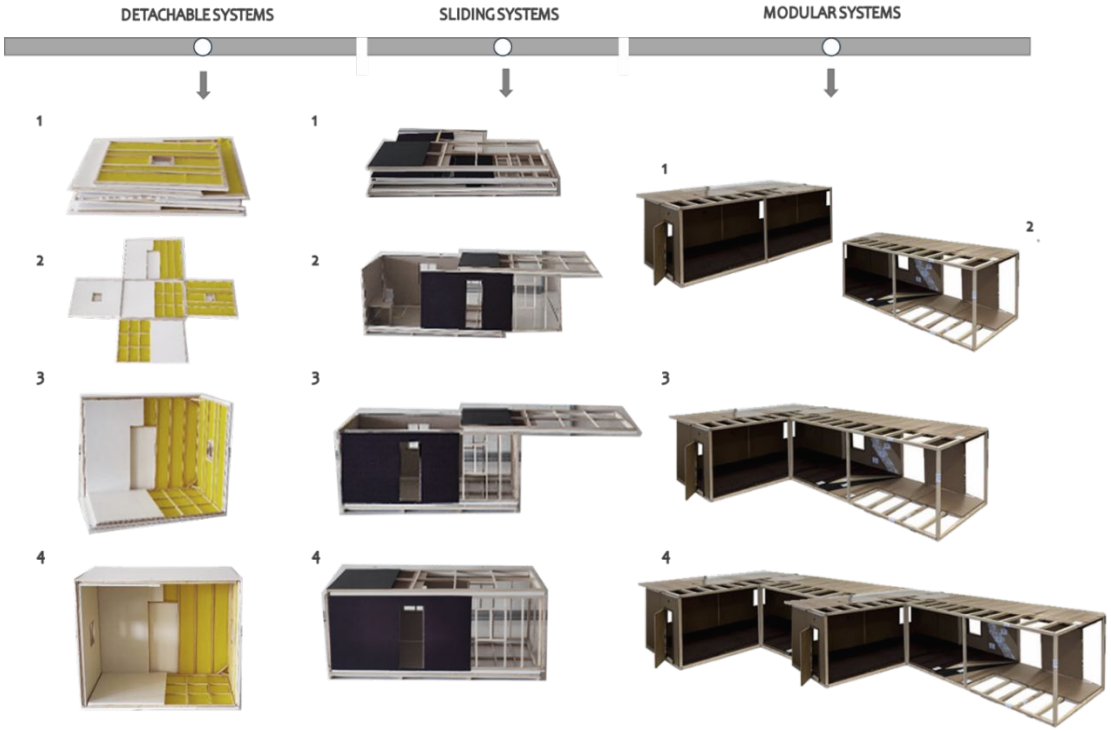

Figure 13 Flexible model suggestions and stages for temporary shelter after disaster

3.3. Evaluation

The models are designed in a rectangular form, with a width of 270 cm, length of 650 cm, and height of 270 cm, considering fixed dimensions. The models are elevated with 30 cm high feet on the four lower corners for protection against cold conditions and insects.

- In the 1st proposed system, thanks to the detachable and attachable panels, the model can be opened and closed when necessary—especially in the pre-emergency preparation phase; stocking shelters and moving them from warehouses to usage areas after disasters are essential. Portable systems provide great convenience in storage and transportation/transportation from warehouses since they will take up less space.
- In the 2nd proposed system, thanks to the sliding movable panels, both portability and flexibility can be provided. In sliding systems, opening a section of the structure by sliding can define the open area-closed area relationship in addition to the flexibility of expandability/reduction and flexibility of use.
- In the 3rd proposed system, combining modules that can accommodate a family of four makes it possible to create larger living spaces for larger families. In addition to adapting to

the number of users, thanks to volumetric change, different functions can be served (health, education, etc.).

The models have a kit concept; instead of producing finished units, they produce the elements that make up the unit. They are packaged so that more than one piece can fit on a truck. They can be lowered and installed in the area of use with the help of a portable crane. Manpower is sufficient to install the models; there is no need for a comprehensive mechanical system or electrical energy. They can be placed, repaired, or stored by anyone in a short time.

The suitability of the developed container model proposals as temporary shelter units after a disaster was evaluated based on the criteria in the literature. This evaluation was made within the scope of usage features (assembly, storage, transportation, privacy, permanent housing opportunity) and performance features (endurance, adaptation to different functions, adaptation to different climates, reuse). The results are expressed in a table in comparison with traditional containers.

| Flexibility | Portability | Modularity |

		Traditional Container	Detachable Systems	Sliding Systems	Modular Systems
Usage features	Assembly	Expertise is not required. Easy to assemble.	○	○	○
	Storage	It does not require large areas. It does not take up much space..	○	○	
	Transportation	Easy to transport.	○	○	
	Privacy	It is sufficiently isolated from the external environment.	●	○	○
	Permanent housing opportunity	Suitable for long-term use.		○	○
Performance features	Endurance	There is no negative situation regarding durability.	●	○	○
	Adapt to different functions	It can adapt to different functions.		○	○
	Adapt to different climates	It enables control of the physical environment.		○	
	Reuse	Suitable for reuse.	●	○	○

Figure 14 Comparative analysis of flexible model proposals for temporary shelter after disaster (Created by the authors)

4. Conclusion

This study discusses the work carried out by students under the "Flexible Container Design" title. It emphasizes the importance of flexible and easily transportable and installed systems, especially for rapid post-disaster intervention. In the design of temporary shelter units, meeting users' personal, social, and community needs and producing durable and comfortable space that is easy to install and dismantle and has fast-transportable solutions should be a priority. Flexible, portable, and modular designs can be made with the systems used in the proposed shelter units.

- Flexibility: Adaptability to different scenarios and ability to adapt to different geographical and climatic conditions.
- Portability: Portability, detachability, easy installation.
- Modularity: Expandable, reducible, capacity to respond to different needs.

With flexible, portable, and modular designs, adaptability can be achieved according to the number of users and their needs; with the kit concept, more containers can be transported to the disaster area, containers can be collected and reused after the disaster, and storage costs can be significantly reduced.

In addition to these advantages, the proposed designs bring a humane design as they can provide effective and rapid response in emergencies. They can save cost and time. They can be environmentally friendly when produced with recyclable materials; they can support sustainability.

As a result, this study has emphasized the essential features of post-disaster container designs, such as flexibility, modularity, and portability through student designs. The importance of the use of new and innovative design approaches in post-disaster intervention and recovery processes has been emphasized. This study reveals the necessity of flexible, portable and modular designs as an alternative to traditional container systems that do not accommodate the number of users, climatic conditions, portability, easy installation, etc. The systems proposed in the study are designed as prototypes at the theoretical stage, but it is possible to increase their applicability in practice and make them usable in the site. It is hoped that the technical details of the proposed systems will be optimized and used in practice by architects, designers and aid organizations. The development of successful solutions for temporary shelter units will only be possible when the concepts of flexibility, portability, and modularity are considered.

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Resume

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