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Research And Evaluations

EDITOR

Prof. Dr.
Zübeyde Özlem PARLAK BİÇER

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İÇİNDEKİLER

BÖLÜM 1

PREFABRICATED SYSTEMS IN INDUSTRIAL BUILDINGS[1]

Kemal GÜVENÇ[2]

Prof. Dr. Zübeyde Özlem PARLAK BİÇER[3]

1 **NOTE:** This book chapter is a product of the thesis presented below.

Thesis Title: Cost Comparison and Environmental Impacts of Prefabricated Reinforced Concrete and Steel Construction Techniques Used in Industrial Buildings on a Sample Project

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PREFABRICATED SYSTEMS IN INDUSTRIAL BUILDINGS

The origin of the word industry is in Latin; "Lâ industria" means activity and activity. It has passed into French as "industrie". The word meaning of the concept of industry is explained in the Turkish Language Association dictionary (2024) as "The whole of the methods and tools used to process raw materials and create energy resources" (Türk Dil Kurumu, Turkish Dictionary, 2024). Seyidoğlu (1992) defines the concept of industry in the Encyclopedic Dictionary of Economic Terms as "the transformation of raw materials and intermediate products into goods and services in factories or production facilities with the contribution of worker labor together with existing knowledge, skills and technology" (Seyidoğlu1992). Hasol, on the other hand, in his Encyclopedic Dictionary of Architecture (2010) defines it as "all of the actions applied to transform raw materials into a built form and the tools used to apply these actions" (Hasol, 2010). Today, the words "industry" and "industry" are used synonymously (Turkish Language Association, Turkish Dictionary, 2024).

Industry refers to the economic activity related to the production of goods or processing of raw materials in factories, plants, workshops. It contributes to economic growth and development by playing an important role in the production and distribution of goods and services. Industrial buildings are structures specifically designed and built to accommodate industrial operations, machinery and equipment.

The 18th century Industrial Revolution, which started in England and then spread to other parts of Europe and the United States, is a turning point that led to significant changes in the thinking, life and environment of the society with its economic and socio-cultural aspects (Köksal, 2005). In this process, there was a significant transition from manual labor to machine-based production. This important change led to the need for industrial structures for production purposes. Industrial buildings have started to become complex designs in time to keep up with the requirements of the age.

1.1. Definition of Industrial Buildings

Industrial buildings are structures that directly or indirectly serve the mechanical production of products. These structures, whose purpose is to carry out production activities, are to serve the people working here and to ensure the creation of a comfort-oriented physical environment that will meet the necessary needs. The word meaning of the industrial structure; It is defined as the places where the whole of the actions related to the specific production method of a product are carried out. In other words, they are production areas where the work flow is organized and carried out (Akı, 2011).

According to GEMET (General Multilingual Environmental Thesaurus), industrial buildings are a type of building that houses direct, manufacturing or technically productive enterprises. Industrial buildings are usually not accessible except to workers. They are used directly for power generation, product manufacturing, raw material mining and storage of textiles, petroleum products, wood and paper products, chemicals, plastics and metals (GEMET, 2021).

Industrial buildings vary in size, design and function depending on the sector they serve. They provide spaces for the production, assembly, storage and distribution of products.

In the study published by A. Russel in Bangladesh Skill Development Institute, he mentioned the typical common features of industrial buildings (Russel, 2020). Apart from this, different sources in the literature emphasize on the subject. Some of these are

- Large floor areas: Industrial buildings usually have large open floor areas to accommodate machinery, assembly lines and storage areas.
- Stable building systems: These buildings are constructed using durable materials such as steel, concrete or precast panels to withstand heavy loads and provide structural stability.
- High ceilings: Industrial buildings typically have high ceilings to accommodate high equipment and provide ample vertical space for ventilation systems and overhead cranes.
- Specialized infrastructure: Industrial buildings include infrastructure for utilities such as electricity, water, gas and waste management systems to support industrial processes and provide a safe working environment.
- Access for transportation vehicles: Industrial buildings often have designated areas for transportation vehicles to access and load goods to facilitate efficient loading and unloading of goods.
- Adequate ventilation and lighting: Industrial buildings include ventilation systems to control air quality and temperature, as well as adequate lighting systems to ensure visibility and safety within the premises.
- Safety measures: Industrial buildings should create environments suitable for occupational and worker safety. They also have safety measures such as fire extinguishing systems and emergency exits.

Important considerations in industrial building design and construction include optimizing workflow and efficiency, ensuring that safety standards are met, meeting machinery and equipment requirements, and providing a suitable working environment for workers. Industrial buildings are often located in designated industrial zones or areas to ensure compatibility with surrounding land uses and minimize potential impacts on nearby residential areas.

Industrial buildings have necessary spatial needs according to the nature of production activities. Designing these structures in a way that can respond to production technologies, workflow chart and other product requirements will contribute to the production process. It is thought that businesses need rational industrial building designs in order to have effective resource management and to survive in the current economic market.

In recent years, there has been an increasing focus on sustainable and green industrial buildings that incorporate energy efficient technologies, renewable energy sources, waste management systems and environmentally friendly materials. This approach aims to reduce the ecological footprint of industrial activities and promote environmental sustainability. The coordinated work of all relevant departments during the design phase is important for sustainable buildings.

1.1.1. History of Industrial Buildings

In the 18th century, there were developments that emerged in England under the name of the "Industrial Revolution", which affected the whole world and whose consequences have extended to the present day. The effects of the technological developments in this period were reflected in the political, social and economic structure of the world. In this process, known as the mechanization of hand production called "Manufaktur" and the transition to industrial order, production sites were first established on the banks of rivers. The increase in logistics and transportation opportunities enabled production facilities to be built near raw materials and marketable areas. Thus, a rapid increase in new production facilities was observed. In line with these developments, serious changes have been experienced in urban planning, production and consumption balances of the society and social life (Köksal, 2005).

The emergence of industrial buildings can be seen in simple textile production structures from the late 1700s, the pioneers of modern factories (Figure 1). They were designed as simple wooden or masonry structures with modular forms and rhythmic openings (Figure 2). The coming together of these structures led to a change in urban architecture by monopolizing the rivers and canals that fed the mill wheels that powered their machinery.

The lack of electricity and lighting systems in the existing buildings limited working hours to daylight, and space designs were shaped accordingly in order to utilize daylight. Long and narrow, these buildings are multi-storey structures constructed with masonry brick and timber structural systems to achieve the largest possible column-free interior spaces (Figure 3). In terms of design features, the aim was not only to provide an efficient workspace, but also to construct fire-resistant buildings as they contained easily flammable raw materials. In this period, fire risks played an important role in shaping architecture. Spatial arrangements such as the search for open and partition-free interior spaces to facilitate fire extinguishing, large windows and the separation of interior spaces from stairwells were effective in the design of buildings (Jevremovic et al. 2012).

In 1768, R. Arkwright discovered the application of water energy in streams and rivers to yarn production, and in 1784 Cartwright discovered the application of the same energy source in weaving. For this reason, textile workshops were established in areas where they could utilize river energy. When the steam engines discovered by Watt in 1769 replaced hydraulic energy, industrial buildings could be located in any location independent of the water's edge (Benovolo, 1981).

The fact that new materials such as iron and steel can be used in buildings has provided new possibilities in designs. Glass and cast iron were used for the first time in the building field in the Crystal Palace, which was designed by Joseph Paxton in 1851 in Hyde Park in London (Tavşan et al. 2021). This building is an important example as it is a combination of new materials and production techniques. In the building, prefabricated iron skeletons were used for the first time and the iron frames were completed with glass surfaces in a short period of four months (Benovolo, 1981).

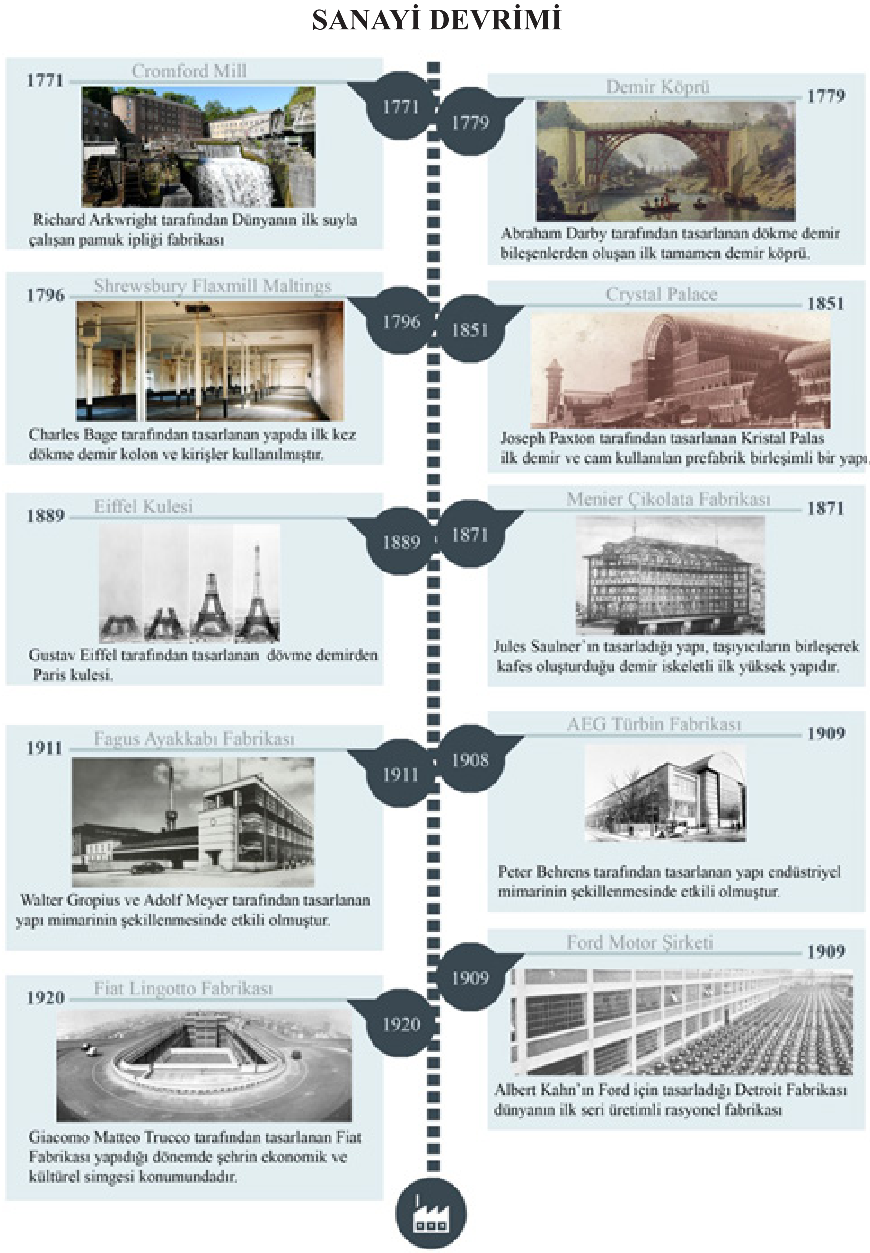


Figure 1. Historical Process of Industrial Building and Construction Techniques

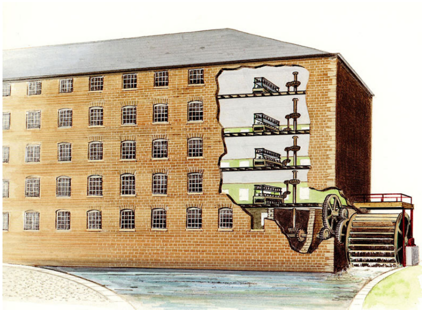


Figure 2. Water Powered Textile Mill, 1770s. (https://www.locallocalhistory.co.uk/ main-index.htm, access date: March 2024)

Figure 3. Trent Mill, Sample Cotton Spinning Mill, Manchester, England, 1882 (Jevremovic et al., 2012)

The development of new energy production techniques, the expansion of production products beyond textiles into different fields and the need for modular structures led to the rapid development of industrial buildings. Albert Kahn, one of the few architects who embraced the development of industrial buildings and functional design in this period, made significant contributions to the flexibility of industrial buildings by designing large-span structures using concrete and iron in industrial buildings. Building factories that could adapt to the vagaries of workflow required flexible designs. Kahn soon advocated single-story industrial buildings for flexible and adaptable production processes. The need for single-storey industrial buildings to utilize large areas of floor space eventually led to their relocation from urban locations to industrial districts (Jevremovic et al. 2012) (Figure 4, Figure 5).

Figure 4. Albert Kahn Designed Chrysler Truck Factory (Jevremovic et al., 2012)

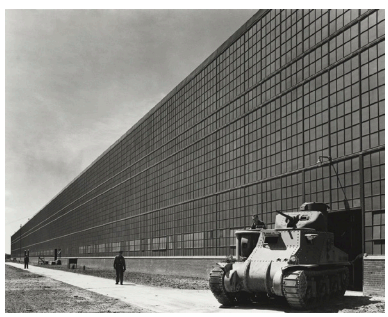


Figure 5. Albert Kahn Design Chrysler Tank Factory, 1941 (Jevremovic et al., 2012)

In the 19th century, the modern movement started to show its influence on industrial buildings. As the complexity and importance of industrial buildings increased, they started to become projects considered by architects. In this period, factories and production facilities started to gain corporate identity and began to attach importance to the competence of industrial building forms in architectural design. Industrial buildings were designed by some of Germany's most influential and famous architects; Peter Behrens, Walter Gropius, Miesvan der Rohe. The AEG factory, designed by Peter Behrens and considered as the "temple of industrial power", has a monumentality based on neoclassical principles (Figure 6). Walter Gropius and Adolf Meyer designed the Fagus Factory, one of the most important examples of early modern architecture, and made a significant contribution to the new dimension of industrial buildings (Jevremovic et al., 2012) (Figure 7).

In the 20th century, with the introduction of sliding belt and transfer belt systems in production facilities, existing industrial buildings became inadequate. In line with the new needs, multi-storey factory buildings were replaced by single-storey, wide-span, single-storey buildings with modular design approach, outside the city, in areas suitable for product and raw material logistics. The intensive use of concrete and steel and the lightening of the load in production with suspended systems formed the basis for the establishment of today's industrial buildings and complexes (Akı, 2011).

Figure 6. Peter Behrens Design AEG Turbine Factory, 1907 (https://www.khanacademy.org/humanities/art-1010/architecture-design/international-style/a/peter-behrens-turbine-factory, access date: March 2024)

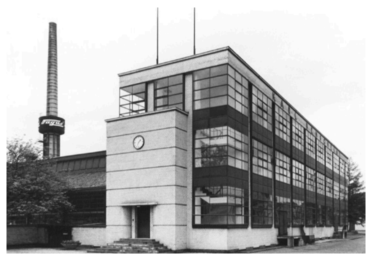


Figure 7. Fagus Shoe Factory Designed by WalterGropius and Adolf Meyer, 1911(https://www.ribapix.com/fagus-factory-alfeld-an-der-leine-lower-saxony_riba24085#, access date: March 2024)

The massive increase in investment in industry after World War II initiated the urban expansion of industrial centers in the mid-20th century, especially in the 50s and 60s. Due to the increase in job opportunities, the population in cities also increased the demand for labor, and hence for housing, services, roads and other areas. This growth was mainly focused on vacant land on the periphery of cities, contributing to the development of new roads and transportation networks for workers and transports to these areas (Jevremovic et al. 2012).

When the historical process of industrial buildings is analyzed in general, it is seen that the early buildings had systems that could be applied on site. With the development of technology and the discovery of new construction techniques, structural production systems preferred to use mass and practical production methods. For this reason, the concept of prefabrication has gained importance in industrial buildings. Since industrial buildings are mostly prefabricated in the following processes, these two concepts are often examined together.

1.2. Prefabrication in Industrial Buildings

The economic crisis following the Second World War and the lack of qualified personnel necessitated industrialization efforts in the construction sector, as in many other sectors, instead of worker-oriented work. In particular, the increase in the variety of building materials has been higher than industrial products. In addition, the necessity of having a large number of construction workers on the construction site in conventional (traditional) construction techniques has put the construction sector in an even more difficult economic situation. For these reasons, the prefabrication system, in which dimensional standards are provided between plans and standard building elements are created, has been adopted. Thus, prefabricated structures, which are mass-produced, have enabled economic savings. Prefabricated buildings developed rapidly over time and mass production of structural elements such as columns, beams and wall panels was achieved. These structural elements are produced and stored in factory conditions, allowing large-scale projects to be quickly transformed into buildings (Amil and Aydın, 2004).

In industrial buildings, prefabrication refers to the process of constructing building components or entire structures off-site in a controlled factory environment and then transporting and assembling them at the final construction site. The use of standardized and pre-engineered components produced in a factory environment, which may include walls, floors, roof trusses, columns, and other structural elements, in the structural manufacturing process forms the basis of the prefabricated building logic.

1.2.1. Definition of Prefabricated Structures

The word "Prefabricated", which literally means assembled and formed by preparing the parts in advance, has passed into Turkish from French. The emergence of prefabricated structures first emerged as an emergency solution to the building deficit that occurred after World War I (Amani & Niyazi, 2018). In the Turkish Language Association Dictionary, it is defined as "the method of assembling houses, ships, etc. as a whole according to a pre-prepared plan" (Turkish Language Association Turkish Dictionary, 2023).

In the study conducted by R. Patwari in 2020, prefabrication processes are examined (Patwari, 2020). Prefabricated structures basically follow these steps;

- Design and Engineering: Building components are designed according to project requirements and specifications.
- Manufacturing: Building components are manufactured in a factory using specialized machinery, tools, and skilled labor. This controlled environment ensures efficient production and quality control.
- Transportation: Once the structural fabrications are completed, they are transported to the construction site for assembly. Depending on their size, this can involve shipping them by truck, rail or even air.
- Assembly: On site, prefabricated components are assembled according to a predetermined design. This process usually involves the use of cranes or other heavy machinery to lift and position the prefabricated elements (Patwari, 2020) (Figure 8).

The general purposes of prefabricated structures are to ensure standardization by maintaining a certain level of working conditions with controlled monitoring of material quality in fabricated production environments, leaving a minimum level of work for the construction site and assembly process (Amil and Aydın, 2004).

Figure 8. Production Process of Prefabricated Buildings (Patwari, 2020)

1.2.2. History of Prefabricated Buildings

Prefabricated structures have been used in various forms throughout history, and the concept of building structures off-site and assembling them on site dates back centuries. Prefabricated construction techniques can be seen even in ancient civilizations. For example, the Egyptians used precut stone blocks to build pyramids. In ancient Rome, stone blocks were produced off-site and transported to the construction site for assembly. The Industrial Revolution in the 18th and 19th centuries brought significant advances in manufacturing and transportation, laying the foundation for modern prefabrication techniques. Cast iron and later steel components were produced in factories and shipped to construction sites for assembly. This approach was widely used for bridges, railway stations and other large structures (Figure 9).

In the mid-19th century, architects and engineers developed innovative prefabrication systems. The first application to shape the definitions was the Crystal Palace in Hyde Park in London, designed by Joseph Paxton in 1851. Prefabrication enabled the development of mass production ideas by famous architects such as Frank Lloyd Wright and Le Corbusier (Agren and Wing, 2014) (Figure 9).

One of the first comprehensive prefabricated buildings was built in 1905 by John Alexander Brodie in Liverpool, England (Figure 9). In 1936, an article written by George Goodwin in England marked the beginning of the concept of prefabrication used today. After World War II, the damage and unusability of residential buildings in cities increased the demand for building stock. Prefabrication systems were utilized to meet this housing demand. Increasing areas of use naturally led to the development of prefabrication technology. Worldwide, these structures have become widespread in Scandinavian and Eastern European countries (Hamid, 2017).

The first early attempt at modularization and prefabrication was the Dymaxion house designed by Buckminster Fuller in 1927 (Figure 9). Designed as a single-family dwelling, the structure was not fully prefabricated, but rather developed as small modules to be assembled on site. Fuller's design goal for the Dymaxion house was to industrialize housing construction through mass production and to produce housing partially similar to the production of an automobile (Steiner, 2005).

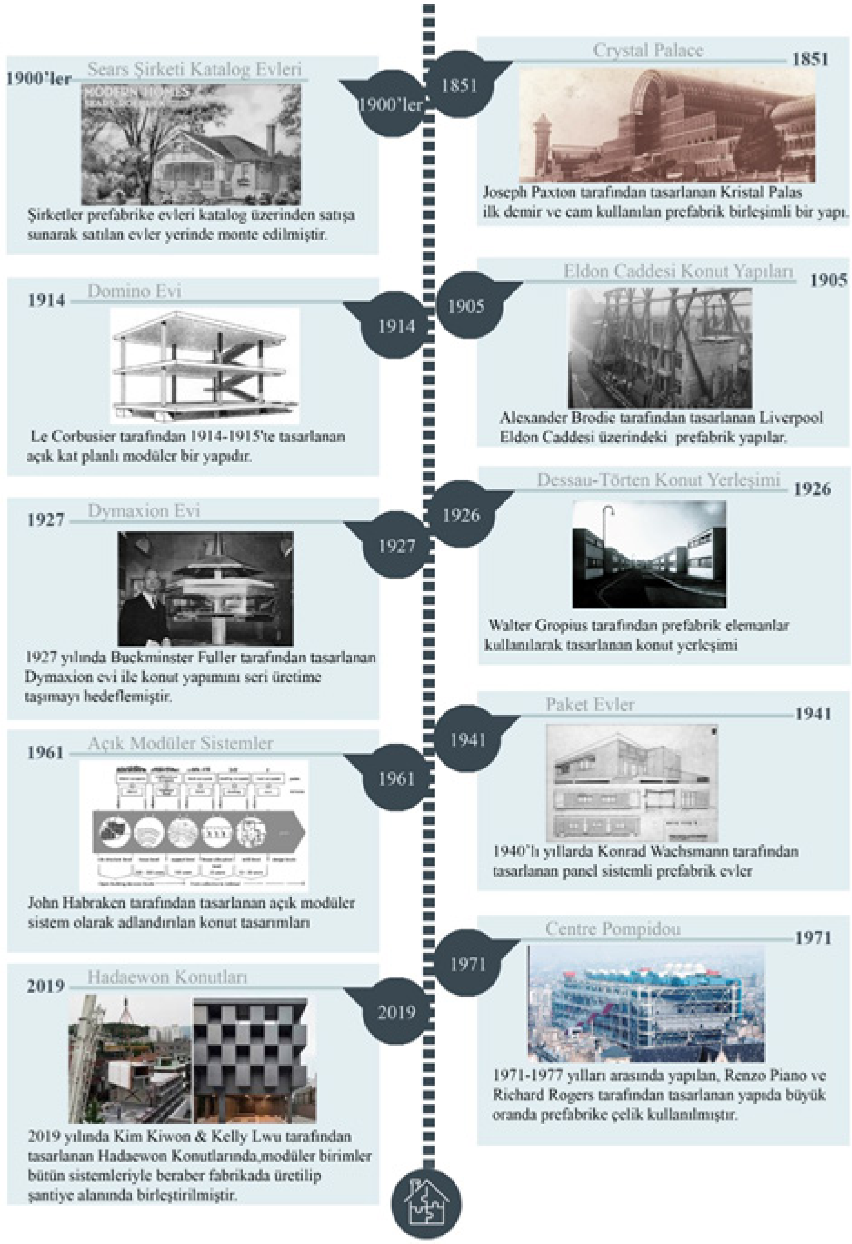


Figure 9. Historical Process of Prefabricated Building and Construction Processes

The Dessau Törten housing settlement, built by German architect Walter Gropius between 1926-28 and housing a total of 314 houses, tried to produce new housing typologies by developing with ready-made and industrial products unlike traditional construction systems (Figure 9). Ready-mixed reinforced concrete beams, window sills, glass and bricks, and industrially produced windows, which were innovations in this period, were used in the building (Sargın, 2014).

Konrad Wachsmann brought the concept of prefabrication to modularization and mass production by creating factory-produced panel and space frame systems (Figure 9).In 1962, John Habraken proposed standardized dimensions in modular designs to provide a wide range of options for end users, introducing ideas that led to what are now referred to as open modular systems (Figure 9). In the early 20th century, companies such as Sears in the United States offered mail-order houses to customers through their catalogs. These pre-built and packaged homes were shipped by rail and assembled by homeowners or local contractors (Agren and Wing, 2014).

Designed in 1971, the Centre Pompidou was constructed from 16,000 tons of cast and prefabricated steel. The building is built on a steel structural system where moving parts, including floors and walls, can be placed, dismantled and repositioned as needed. Most of the steel structural system was manufactured in the production facilities and transported to the construction site. Since the building is located in a central area with heavy traffic, the prefabricated elements were transported to the construction site during night hours when traffic is low (RSHP Project Office, 2024), (Figure 9, Figure 10).

Figure 10. Transport of prefabricated elements to the construction site during the construction phase of Center Pompidou (https://rshp.com/projects/culture-and-leisure/centre-pompidou/access date: March 2024)

In the construction sector, prefabricated structures are used in many areas where there are problems such as dense urbanization, traffic density and time constraints that cause problems in practice. Today, prefabrication of structural components as well as off-site production of ready-to-use units and on-site assembly is one of the preferred methods. This system provides a fast, quiet and clean construction process of prefabricated modules in a narrow space, such as the award-winning Hadaewon residences in South Korea (Figure 11-A, B, C) (Wang, 2023).

A B C

Figure 11. Construction phase of Hadaewon Residences

(https://architectureprize.com/winners/winner.php?id=4649, access date: March 2024)

In recent years, technological advances have further improved prefabricated construction methods. Techniques such as Computer Aided Design (CAD) and Building Information Modeling (BIM) facilitate precision and customization. Off-site production of building components such as wall panels, modules and bathroom partitions has become more common, and prefabricated construction is now used for a wide variety of structures, including residences, schools, hospitals and commercial projects. These expanding uses and methods have influenced the thesis' consideration of the environmental impacts and costs of prefabricated industrial buildings. It is thought that the thesis will contribute to addressing the positive and negative aspects of prefabricated systems to be used in industrial buildings in the future during the design and construction phase.

1.2.3 Advantages and Disadvantages of Prefabricated Systems

Prefabricated structures are generally considered advantageous for specific types of buildings and applications. However, they may not be the ideal solution for every construction project. When deciding whether to prefer prefabricated or traditional construction methods, certain project requirements such as the size of the structure, necessary interior space openings, usage type, as well as cost and aesthetic preferences, should be taken into account. Therefore, prefabricated structures, like all building systems, have certain advantages and disadvantages.

Prefabricated structures can be assembled much faster compared to traditional construction methods. Since components are produced in a controlled factory environment, weather conditions and other external factors do not significantly delay the construction process. The ability to be used in emergency situations, natural disasters, and humanitarian operations becomes another advantage of prefabrication. This short construction period is primarily due to the relocation of the production process to the interior of the factory, where it is not limited by adverse weather conditions, and is also due to production automation, digitization, and business continuity (Hořínková, 2021).

According to a report by McKinsey & Company, a leading global management and consulting firm, prefabricated structures can reduce construction time by up to 50% and construction costs by up to 20%. Prefabricated structures, within the construction sector in the United States and Europe, could capture approximately $130 billion of the market share, resulting in annual cost savings of approximately $22 billion (Bertnam et al., 2019).

The ability of prefabricated structures to be consistently repeatable with similar shapes, forms, and methods during planned production prevents encountering differences during the production stage. Additionally, the portability of prefabricated structures and their openness to conversion into new functions, being long-lasting, and partially recyclable at the end of their service life contribute to sustainability (Of and Öztürk, 2022; Hořínková, 2021). Studies have shown that prefabricated systems contribute to sustainability by reducing construction waste by up to 70%, on-site working hours by up to 70%, and noise pollution by up to 50% (Lawson et al., 2012). Furthermore, they have positive environmental effects by reducing material waste by 64%, greenhouse gas emissions by 40%, and production hours by 31% (Nahmens and Ikuma, 2012). Additionally, prefabricated concrete structures have been effective in reducing the use of wooden formwork by up to 70% compared to conventional reinforced concrete structures, resulting in an overall reduction of construction waste by approximately 52% (Jaillon et al., 2008).

Research in occupational safety indicates that over 20% of all fatal accidents occur in the construction sector. The primary causes of fatal accidents in the construction industry are falls from heights or depths, crushing by machinery or loads, and electric shocks. Since prefabricated structures are produced in fabrication areas that adhere to specific standards, occupational safety is more critical in these areas. Studies have indicated that there is a 80% lower occurrence of accidents in prefabricated structure construction sites compared to traditional construction sites (Hořínková, 2021; Lawson et al., 2012).

A study analyzing reports from the Construction Industry Institute (CII) suggests that prefabricated structures have construction durations 10-25% shorter compared to structures built using traditional construction methods (Hořínková, 2021). The shorter construction time, reduced need for construction site equipment, less labor requirement, and the ability to reuse prepared formwork or infrastructure multiple times make prefabricated structures economically advantageous (Amil and Aydın, 2004; Amani and Niyazi, 2018).

Factory-based production ensures greater quality control when standardized processes are used. Consequently, fewer defects and consistent high-quality final products are achieved. Prefabricated elements are designed to be easily transportable and assembled in different locations. This flexibility allows prefabricated structures to be converted into different functions or accommodate different extensions (Amil and Aydın, 2004; Amani and Niyazi, 2018; Hořínková, 2021).

In addition to their advantages, prefabricated structures also have disadvantages. One of the most significant issues in prefabricated construction is the method and cost of transportation. The distance between the factory where prefabricated structure elements are produced and the construction site increases the production cost of the structure, potentially compromising its economic viability (Hořínková, 2021; Baran, 2022). Producing large-sized prefabricated modules can lead to transportation difficulties. Detailed logistical planning is required for transporting prefabricated components to the construction site. Non-standard prefabricated elements incur additional transportation costs and affect construction speed.

The initial investment cost for establishing the necessary machinery and equipment support in production lines at facilities where prefabricated structure components are manufactured is high. Therefore, while prefabricated structures may vary regionally, they can be more costly than structures produced using traditional systems (Rahman, 2014). When deviating from modularization in these structures, systems become complex, leading to loss of time and economic advantages. Additionally, the inability to make changes at the construction site according to changing conditions is another limiting factor of these systems. Furthermore, resistance to earthquakes is one of the significant issues for prefabricated reinforced concrete structures (Arslan et al., 2008).

In general, studies suggest that prefabricated structures have significant advantages in terms of construction speed, cost, and quality control. However, lack of planning in design and construction, improper selection of prefabricated components, limited design flexibility, and restrictions on site modifications can turn their advantages into disadvantages.

1.3. Prefabricated System Types

In prefabricated systems, various types can be distinguished based on the main load-bearing structure of the building. The main factors contributing to this diversity include the materials to be used in prefabricated systems, production standards, production methods, intended use, cost, sustainability, among others. Prefabricated buildings can be produced in various sizes and shapes, ranging from small modular units to large multi-story structures. They are designed for different purposes such as residential, office, school, healthcare facilities, industrial buildings, etc. Therefore, the intended use and functionality create differences in the types of prefabricated systems to be designed.

Prefabricated structures are made from various materials such as steel, concrete, wood, and composites. Material selection influences the appearance, durability, and overall performance of the building, thus leading to differentiation of systems. Today, reinforced concrete prefabricated and steel systems constitute the foundation of the prefabricated building sector. The widespread use of steel and reinforced concrete in the structural field, the establishment of production standards, and the acquired skills in design and implementation play a significant role in their widespread use within the sector.

In recent years, various commercial groups and companies within the prefabricated building production sector have been establishing their own production networks through research and development (R&D) efforts and various hybridizations. This has led to the emergence of a wide range of patented prefabricated structural models by companies within the sector. In recent years, the prefabricated production sector has been able to develop structural productions tailored to specific designs by focusing on both building and project-oriented work. In this section, concrete, steel, and hybrid systems have been examined based on their frequency of use.

1.3.1. Reinforced Concrete Prefabricated Systems

Reinforced concrete prefabricated systems involve the preparation of the main load-bearing structure of a building using reinforced concrete in factory or production environments, which is then assembled at the construction site. The main load-bearing system of the building is created within concrete molds in production areas, guided by design and project specifications, using construction reinforcement bars.

The development process of reinforced concrete prefabricated structures began in the 1950s, and since then, they have gained widespread use in many countries (Seitablaiev and Umaroğulları, 2020).

Reinforced concrete prefabricated structures generally consist of the entire load-bearing system made up of pre-stressed or post-stressed reinforced concrete prefabricated elements, produced for various purposes. In these structures, the load-bearing systems consist of columns, beams, load-bearing partition panels, and their connections (Amil and Aydın, 2004).

In prefabricated reinforced concrete structures, the load-bearing system comprises pre-manufactured components such as columns and beams. Partitioning and covering processes are achieved using elements such as bricks and facade panels that are not part of the load-bearing system. While reinforced concrete trusses serve as the main load-bearing elements in the roofs of prefabricated reinforced concrete structures, various precast or metal ready-made roof panels fulfill the covering function. Special facade panels or standard wall systems can be used as facade cladding materials for these structures (Akçaözoğlu, 2003) (Figures 12, 13).

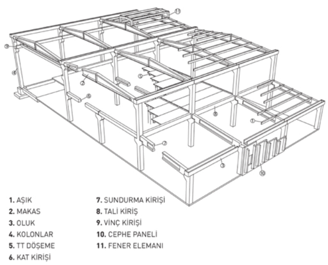


Figure 12. Sample Reinforced Concrete Prefabricated System Model

(https://www.mavitasprefabrik.com.tr/prefabrik/prefabrik-yapi, access date: March: 2024)

Figure 13. Sample Reinforced Concrete Prefabricated Structural System Photograph

(https://www.karadenizprefabrik.com.tr/uygulamalar/seyhanoglu-fabrika-binasi.htmlvitasprefabrik.com.tr/prefabrik/prefabrik-yapi, access date: March 2024)

Reinforced concrete prefabricated structural systems can be designed with variable prefabricated elements to meet different functional characteristics. These systems are classified into various groups based on the type, behavior, and assembly method of the elements used (Akçaözoğlu, 2003). Some of these include:

- Column-Beam Systems,
- Frame-Partitioned Systems,
- Column-Slab Systems (Akçaözoğlu, 2003).

Prefabricated reinforced concrete skeleton systems are structurally more quality-oriented compared to conventional systems (produced on-site using traditional methods) because they are manufactured in specialized production areas. However, the weaknesses of these systems lie in their joint points. Since joint points must be constructed at the construction site, special attention must be paid to these areas to safely transfer loads to the system (Çetinkaya, 2007).

Due to the fact that almost the entire country of Turkey is located within a seismic zone, it is crucial to consider the earthquake resistance of reinforced concrete prefabricated structures. Except for certain exceptions, there are generally no issues regarding material quality due to fabrication production under specific standards and compliance with earthquake regulations. However, ensuring conditions such as strength, sufficient lateral rigidity, and ductility, which are the fundamental principles of earthquake regulations, are the most significant challenges for prefabricated reinforced concrete structures (Arslan et al., 2008).

In recent years, many studies have begun to focus on increasing the seismic resistance and resilience of reinforced concrete prefabricated structures in the literature and practical applications. Today, reinforced concrete prefabricated systems are frequently used due to their standardized production, expansion of production networks, development of assembly and application techniques by companies, and economic reasons.

1.3.2. Steel Prefabricated Systems

Steel is an alloy obtained from iron. Structurally used steel is obtained by mixing 0.2-1% carbon and other additive materials into molten iron ore. Structural steel is formed by combining rolled profile elements with bolts, rivets, or welding. Additionally, structural steel can be cast into molds to create complex building forms. Quality management systems and measurement units in the production of structural steel are conducted in accordance with international standards (Eren and Başarır, 2013).

Structures with steel prefabricated systems are built using pre-engineered steel components that are fabricated off-site and then assembled on-site. The aim is to design these structures to provide flexibility, durability, and cost-effectiveness while ensuring a fast and efficient construction process (Figures 14, 15).

Figure 14. Prefabricated Steel System Photo

(Güvenç,2024)

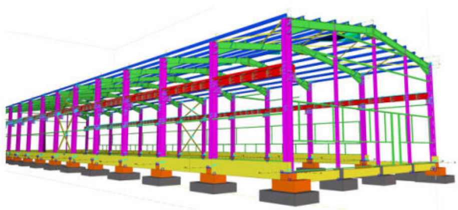


Figure 15.Prefabricated Steel System Model

(http://www.irmakcelikyapi.com/projeloji/tekla/ access date: March 2024)

When structural steel materials are examined, it is generally seen as suitable for designing structures with wide spans. Wide-span structures are characterized by creating integral spaces without the need for intermediate supports within the space, providing clear and expansive areas for use. Examining the historical process, it is known that the desire to produce larger and wide-span structures more economically has been a precursor to the development of prefabricated steel structures and has diversified carrier system types through scientific research (Kılıç Urfalı, 2012).

The becoming of steel as one of the fundamental materials in structure construction has occurred with the industrial revolution, which facilitated learning the production techniques of this material and providing ease of use. Several factors have played a significant role in using steel as a structural material. The most important of these factors is its resistance to earthquakes, its higher levels of flexibility compared to other structural materials, and its relatively lesser damage compared to reinforced concrete structures (Eren and Başarır, 2013).

Structural steel, which provides approximately 10 times more flexibility compared to reinforced concrete systems, also exhibits behavior suitable for earthquake vibrations. Unlike reinforced concrete structures that can suffer severe damage during earthquakes, steel structures can be economically repaired without major demolition or dismantling after damage. Japan, which has been a pioneer in earthquake awareness and the production of earthquake-resistant structures, is today the most important country where structural steel is produced and used, thanks to its emphasis on technology and R&D. In Japan, innovative developments in structural terms are seen to contribute to the formation of a disaster-resistant society when combined with earthquake awareness among the public (Of and Öztürk, 2022).

The initial investment costs of steel structures are perceived as expensive by investors today. However, one of the most significant features that distinguish sustainable construction systems from traditional construction systems is the consideration of buildings within the framework of the "life cycle assessment (LCA)" approach. Within this concept, all processes of buildings, including material, production, construction phase, service life, dismantling, recycling, and demolition, should be considered. When steel prefabricated systems are viewed from this perspective, with aspects such as replaceability for new functions and requiring less maintenance, more benefits can be obtained from the same source, thus reducing the life cycle cost and environmental impacts of the structure (Eren and Başarır, 2013).

The structural use of steel is becoming increasingly important with the increase in project and implementation standards. The fact that our country is located in a seismic zone and the performance of steel components against earthquakes increase the areas of use of steel structures. Moreover, since the general advantages of prefabricated systems are also applicable to steel systems, they are used in most building typologies in our country. Therefore, in this thesis, steel systems have been comparatively considered with reinforced concrete systems.

1.3.3. Hybrid Prefabricated Systems

Hybrid or composite structures are construction systems typically obtained by the connection of structural elements made from different materials, complementing each other. Depending on the combination of materials, the structural systems to which these systems are attached may vary (Loss et al., 2016).

In our country, hybrid prefabricated systems are generally referred to as structural systems formed by the combination of conventional load-bearing systems with precast elements. In these structures, the vertical load-bearing columns and connection points of the building are applied on-site using conventional systems, while horizontal load-bearing elements such as beams and slabs consist of precast elements. In some cases where the seismic loads are intense or the transportation of prefabricated building elements to the construction site is not feasible, hybrid systems are preferred when reinforced concrete prefabricated systems are not sufficient. Hybrid systems are produced by combining various advantages of conventional production techniques and prefabricated production techniques (Özkan, 2003) (Figure 16).

Hybrid systems are created by integrating prefabricated horizontal components of buildings in a manner that will perform equivalently to monolithic systems. Column and beam connections provide the same effect as conventional systems, unlike reinforced concrete prefabricated systems. Hybrid systems have been successfully used for many years in earthquake-prone areas around the world. Similar systems were developed in New Zealand in the 1980s, and joint tests conducted at universities yielded positive results. Most of the designed structures have managed to withstand various earthquakes with minimal damage (Özkan, 2003).

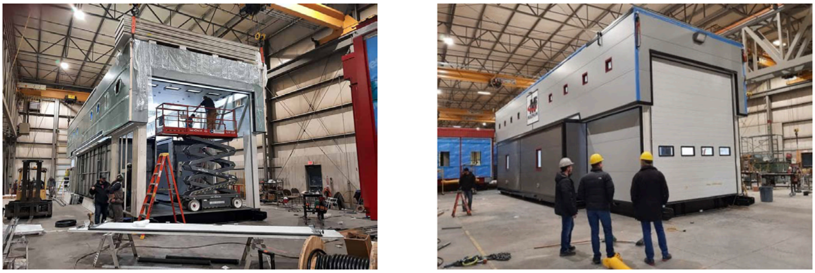
Figure 16. Prefabricated beams and hollow floor elements placed on cast-in-place columns (Özkan, 2003).

In earthquake-prone areas, the high seismic loads to be considered in the design of buildings have made the use of structural walls mandatory in some structures. In such buildings, designing the structural system with walls provides more economical solutions. Since structural wall elements cannot be prefabricated, casting wall panels and columns on-site and using prefabricated beams and slabs have emerged as the optimal solution (Özkan, 2003).

1.3.4. New Developments in Prefabricated Systems

In parallel with technological advancements, prefab building production has been evolving in recent years. The prefab manufacturing sector is increasingly incorporating advanced technologies such as BIM (Building Information Modeling), 3D printing, and robotics into production processes. These technologies contribute to greater precision and efficiency in the production of prefab components.

In recent years, the concept of "industrial modular units" has emerged in prefab building production. Industrial modular units are developed as a system where all sections of a building are manufactured off-site (Figure 17-A, B). This concept encompasses all systems that make a building ready for use, including its basic sections, mechanical, and electrical systems. Since building production stages take a long time and production speed is subject to various parameters focused on human factors, the transition to modular systems in prefab buildings is considered significant. Recognizing and regulating modular systems by design standards are seen as important steps to fill the gap in the building production sector (Gunawardena and Mendis, 2022).



A B

Figure 17. Prefabricated fire station with all systems produced in a factory environment
(https://extrememodularbuildings.com/industrial-modular-buildings.php, access date: March: 2024)

Researchers have defined the concept of Design for Manufacture and Assembly (DfMA) for buildings with industrial production capabilities to keep up with innovative approaches in construction activities. This concept serves as both a philosophy and methodology, aiming to design structural products for manufacturing and assembly as optimally as possible. As the construction sector moves towards a combination of off-site prefabrication and on-site assembly, DfMA is gaining momentum within the industry (Gao et al., 2020). To better understand this definition, various principles have been established in another study for designing application models in accordance with the DfMA concept. These principles include reducing the number of prefabricated components related to the structural system, minimizing the number of assembly connection elements, using cost-effective materials, standardizing component dimensions and weights for ease of use, and minimizing material waste. It has been stated that structures designed in line with these definitions will align with the DfMA methodology (Chen and Lu, 2018) (Figure 18-A, B, C).

A B C

Figure 18. Installation stages of a prefabricated building example in accordance with the DfMA methodology
(https://www.archdaily.com/885915/italian-architect-designs-folding-house-that-can-be-built-in-6-hours, access date: March 2024)

In recent years, the prefab construction sector has been reshaped and made more sustainable and adaptable by incorporating various technologies such as 3D printing, robotics and automation, augmented reality (AR), virtual reality (VR), and aerial imaging systems with drones, alongside all these developments.

1.4. Conclusion

The conceptual framework of industrial buildings and prefabricated systems is built around principles such as cost effectiveness, efficiency, flexibility, and sustainability. Today, industrial buildings play an important role in shaping economies and societies. They are the driving force behind the production, distribution and consumption of goods and services for people. From small-scale production areas to huge production facilities, all industrial buildings play an important role in the building sector. Industrial buildings contribute to economic development by enabling working areas in various sectors such as production, research, logistics and construction.

Starting in the 18th century with the industrial revolution, the concept of production areas transformed into large mechanized areas in the 19th century. The renewal of energy resources, the advancement of technology and developments in mass production techniques have formed the basis of today's modern industrial structures. Today's modern facilities carry out production activities in countless areas with complex components and machines.

One of the biggest concerns for industrial buildings, which have many benefits in terms of raising the living standards of humanity and meeting their needs, is environmental sustainability. Industrial buildings can have negative impacts on the environment such as unconscious resource consumption and pollution. At this point, managers and industries have to adopt sustainable practices and work diligently to reduce the ecological footprint. The main purpose of efficiency in the production process is to try to achieve the maximum possible output with minimum input. The production of industrial buildings in accordance with the principle of efficiency will have positive cost and environmental impacts.

Today, industrial buildings, which are focused on production and functionality, are integrated with prefabricated production techniques and prefabricated structures. Prefabrication, also known as modular construction, involves producing various building components off-site in a controlled environment and then transporting them to the construction site for final assembly. This approach is gaining significant popularity due to its efficiency, sustainability and cost-effectiveness, playing an important role for the future of the construction industry.

Traditional construction processes are often associated with long timelines, cost overruns, insufficient standardization, and lack of safety measures. Prefabricated structures, on the other hand, are gaining an advantage in the construction industry. With growing concerns about environmental sustainability, the construction industry is under pressure to reduce its carbon footprint. It is clear that a properly designed and implemented prefabricated building will benefit in this regard compared to traditional buildings. As technology continues to evolve and society demands more sustainable and efficient building methods, prefabrication is becoming one of the essential applications for the construction industry.

The concepts of industrial buildings and prefabrication have been influential in shaping the world we live in today. Since the emergence of these concepts, they have driven economic growth, human welfare and technological developments. Balancing the damage caused by industrial progress to the environment and human beings with sustainability and design awareness is very important to leave a livable world for future generations.

REFERENCES

Akı, H. Y., (2011), Endüstri Yapılarının Esneklik Bağlamında Analizi, Y. Lisans Tezi, Mimar Sinan Üniversitesi Fen Bilimleri Enstitüsü, İstanbul.

Ågren, R., & Wing, R. D. (2014). Five moments in the history of industrialized building. *Construction management and economics*, *32*(1-2), 7-15.

Akçaözoğlu, S. (2003). Endüstri yapılarının üretiminde kullanılan prefabrik betonarme iskelet sistemler ve 1998 Adana-Ceyhan depreminde bu sistemlerde ortaya çıkan sorunlar. Y. Lisans Tezi, Çukurova Üniversitesi Fen Bilimleri Enstitüsü, Adana.

Amani, A., ve Niyazi, A. Q. (2018). Türkiye'de Prefabrik Yapı Sektörünün Hızlı Gelişimi. *Mühendislik Bilimleri ve Tasarım Dergisi*, *6*(3), 487-494.

Amil P. A., Aydın, A. C. (2004). Prefabrike Yapıların Başlıca Tasarım İlkeleri. *Atatürk Üniversitesi Ziraat Fakültesi Dergisi*, 35(3-4).

Arslan, M. H., Akın, A., Erkan, İ. H. ve Gülay, F. G. (2008). Prefabrike Endüstri Yapılarının 2007 Deprem Yönetmeliği Koşullarına Göre Deprem Güvenliğinin Belirlenmesi. *Selçuk Üniversitesi Mühendislik, Bilim ve Teknoloji Dergisi,* 23 (4), 1-10. Retrievedfromhttps://dergipark.org.tr/en/pub/sujest/issue/23257/248239

Baran, A. (2022). Prefabrik Yapı Sektörünün Ülkemizdeki Gelişimi. *TAS Journal*, 2(3), 01-05

Benevolo, L., (1981). Modern Mimarlığın Tarihi, Sanayi Devrimi, 1. cilt, Çevre Yayınları, İstanbul.

Bertram, N., Fuchs, S., Mischke, J., Palter, R., Strube, G., &Woetzel, J. (2019). Modular construction: From projects to products. McKinsey&Company: Capital Projects&Infrastructure, 1-34.

Çetinkaya, N. (2007). Prefabrik betonarme sanayi yapılarının deprem davranışının deneysel olarak incelenmesi. Doktora Tezi, Pamukkale Üniversitesi, Fen Bilimleri Enstitüsü, Denizli.

Chen K, Lu W. Design for Manufacture and Assembly Oriented Design Approach to a Curtain Wall System: A Case Study of a Commercial Building in Wuhan, China. *Sustainability*. 2018; 10(7):2211. https://doi.org/10.3390/su10072211

Eren, Ö., Başarır, B. (2013). Çelik Strüktürlerin Yaşam Döngüsü İçinde Sürdürülebilirliğinin Değerlendirilmesi, *NWSA-EngineeringSciences 1A0346,* Mimar Sinan Güzel Sanatlar Üniversitesi, İstanbul. 8(2), 120-135. doi:10.12739/nwsa.2013.8.2.1a0346

GEMET (General Multilingual Environmental Thesaurus – Genel Çok Dilli Çevresel Eşanlamlılar Sözlüğü), 2021. (1 Mart 2024 tarihinde: https://www.eionet.europa.eu/gemet/en/concept/4217 adresinden alındı).

Gunawardena, T., & Mendis, P. (2022). Prefabricated building systems design and construction. *Encyclopedia*, *2*(1), 70-95.

Güvenç, K., 2023, "Çelik taşıyıcı sistemle tasarlanmış endüstriyel yapı fotoğraf arşivi, Kayseri

Hamid, K. M. H. (2017). Betonarme Prefabrik Endüstri Yapılarında Cephe Panellerinin Bağlantısı İçin Özel Bir Elemanın İncelenmesi. Doktora Tezi, Deprem Mühendisliği ve Afet Yönetimi Enstitüsü, İstanbuk Teknik Üniversitesi, İstanbul.

Hasol, D., (2010). *Ansiklopedik Mimarlık Sözluğü,* İstanbul.: YEM Yayınları.

Hořínková, D. (2021). Advantages and disadvantages of modular construction, including environmental impacts. In *IOP Conference Series: Materials Science and Engineering* (Vol. 1203, No. 3, p. 032002). IOP Publishing.

Jaillon, L., Poon, C. S., &Chiang, Y. H. (2009). Quantifying the waste reduction potential of using prefabrication in building construction in Hong Kong. Wastemanagement, 29(1), 309-320.

Jevremovic, L., Vasic, M., &Jordanovic, M. (2012). Aesthetics of industrialarchitecture in the context of industrial buildings conversion. In International Symposium.

Kılıç Urfalı, F. (2012). Güncel Çelik Yapı Sistemlerinin İncelenmesi. Yüksek Lisans Tezi, Yıldız Teknik Üniversitesi , Fen Bilimleri Enstitüsü', İstanbul.

Köksal, T. G. (2005). İstanbul'daki endüstri mirası için koruma ve yeniden kullanım önerileri. Doktora Tezi, İTÜ Fen Bilimleri Enstitüsü, Mimarlık Anabilim Dalı, İstanbul.

Lawson,R.M.,Ogden,R.G.,&Bergin,R.(2012).Applicationofmodularconstruction in high-risebuildings. Journal of architecturalengineering, 18(2), 148-154.

Loss, C., Piazza, M., &Zandonini, R. (2016). Connections for steel timber hybrid prefabricated buildings. Part I: Experimentaltests. Construction and Building Materials, 122, 781-795.

Nahmens, I., & Ikuma, L. H. (2012). Effects of lean construction on sustainability of modular homebuilding. Journal of architectural engineering, 18(2), 155-163.

Of, N. ve Öztürk, S. (2022). Depremlerden Sonraki Yeniden Yapılanma Süreci Üzerine Küresel Bir Araştırma: Çelik Prefabrik Malzeme Kullanımının Gerekliliği. Afet ve Risk Dergisi, 5 (1), 346-360. DOI: 10.35341/afet.1092649

Özkan, Ü. (2003). Yapı Merkezi Prefabrikasyon A.Ş., İstanbul, Türkiye. (1 Mart 2024 tarihinde**:** https://docplayer.biz.tr/4475261-Pre-karma-yapi-sistemi.html adresinden alındı.)

Patwari, R. (2020). A Qualitative Study Of The Sustainability Of Prefabricated Buildings. 10.13140/Rg.2.2.34203.39200.

Rahman, M. M. (2014). Barriers of implementing modern methods of construction. Journal of management in engineering, 30(1), 69-77.

RSHP Proje Ofisi, 2024. (1 Mart 2024 tarihinde: https://rshp.com/projects/culture-and-leisure/centre-pompidou/, adresinden alındı).

Russel, A., 2020. *Industrial architecture and it's key element*s (1 Mart 2024 tarihinde: https://bsdi-bd.org/industrial-architecture-and-its-key-elements/# adresinden alındı.)

Sargın, H. (2014). Kolektifliğin Varoluşsal Mimarlığı: Dessau Törten Konutlarına Görüngübilimsel Bir Yaklaşım. *Sanat ve Tasarım Dergisi*, *6*(6), 128-155.

Seitablaiev, M. Ö., ve Umaroğulları, F. (2020). Dünya'da ve Türkiye'de Betonarme Prefabrikasyon. *Journal of Architectural Sciences and Applications*, 5(2), 309-320.

Seyidoğlu, H. (1992). *Ekonomik terimler: Ansiklopedik sözlük*. Güzem yayınları.

Steiner, H. A. (2005). The architecture of the well-serviced environment. *arq: Architectural Research Quarterly*, *9*(2), 133-143.

Tavşan, C., Özen, E., ve Tavşan, F. (2021). Tarihsel Süreç İçerisinde Gelişen Malzemenin Endüstri Devrimi Sonrası Yapılara Etkisi. *Social Mentality And Researcher Thinkers Journal*, *7*(48).

Türk Dil Kurumu, Türkçe Sözlük. (2024) (1 Mart 2024 tarihinde: https://sozluk.gov.tr/ adresinden alındı.)

Wang, Y., Cao, Y., & Meng, X. (2019). Energy efficiency of industrial buildings. *Indoor and Built Environment*, *28*(3), 293-297.

BÖLÜM 2

NOTES ON THE BOSPHORUS AND ITS SETTLEMENT ON MAPS UNTIL THE EARLY 18TH CENTURY

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1.Introduction

Istanbul, one of the first and important centers of Christianity before the Ottoman Empire, was a frequent destination for travelers going to the East. After the conquest of the Turks, it stood out as the capital of the Ottoman Empire and as an important center of culture and civilization in the world. During this period, the Bosphorus became the focus of attention of Western travelers and painters with its beauty. These beautiful waterside residences have added beauty and value to the natural beauty of the Bosphorus with the contributions of Ottoman culture and architecture.

Today, we can attribute one of the reasons why Istanbul is universal to the fact that it has the Bosphorus. Istanbul has become a city defined by the sea. The Marmara, Golden Horn and Bosphorus architecture in Byzantium, Constantinople and Istanbul was formed together with the sea. Istanbul preserved its sea-related architecture before losing its historical values that were formed with the sea and reaching the size of the city supported by apartment buildings, skyscrapers and slums that started to form after the 1960s.

2.Change of the Bosphorus in the Historical Process

Bosphorus settlement in ancient period the Bosphorus, which connects the Black Sea (Pontus Euxinus) and the Marmara Sea (Propontis), was named "Stenon" in the Byzantine period. In Ottoman sources, the Bosphorus was referred to as "Halic-i Bahr-i Rum", "Halic-i Bahr-i Black", "Halic-i Konstantiniye Strait", "Macmaü'l Bahreyn", "Istanbul Strait" and "Boğaz" (Eyice , 1976, p.12, Artan, 1994, p.281).

Starting from prehistoric times, the Bosphorus has served as a bridge from Asia to Europe and from Europe to Asia and has been a strategically important region in every period. It is an important transition area rather than a settlement area in the pre-Byzantine period. During excavations around Istanbul, ruins from the Paleolithic Age were unearthed. Old tools and findings from the Middle Paleolithic Age found in the Yarımburgaz Cave in the north of Küçükçekmece reveal traces of people who lived by fishing and hunting in this region. During the excavations carried out in Fikirtepe on the Anatolian side, Chalcolithic Age finds were unearthed. The community living here made their living by hunting, fishing and rudimentary agriculture. The finds seen on the shores of Kurbağalıdere near Kadıköy belong to the Chalcolithic Age. In B.C. 1000, Thracians, Phrygians and Bithynians settled Bosphorus. Megarians lived on the western side of the Istanbul peninsula in the middle of the BC 7th century (Salman, 2004, p.18).

The oldest known work about the Bosphorus is “Anaplus Bosporu”, written by Dionysus of Byzantium towards the end of the 2nd century. In this work, it is written that there are several villages and many altars on the shores of the Bosphorus (DionysII ByzantII, Güngerich, 1958,). M.S. When the Roman Empire was divided into two in 395, the capital of the Eastern Roman Empire was moved to Byzantium by Constantine I. Although names associated with Rome were used at first, the name Constantinople became widespread over time. During this period, detailed planning studies were carried out for the expanding city as a necessity of creating a new capital, and Rome’s city management scheme and monumental architectural style were transferred to Constantinople. The city expanded westwards, including business, administrative and residential areas. However, the fear of the city being sieged prevented settlement outside the walls. (Eyice, 1976, p.5; Salman, 2004, 18).

Bosphorus Settlement in the Roman and Byzantine Periods In 196 AD, Roman Emperor Septimus Severus demolished the original walls of Byzantium and built a new wall covering a larger area. The hippodrome, monumental buildings, main arteries and squares built during this period showed the interior of the city, and the walls showed the macro form of the settlement. The construction of the city by building new walls is considered the first planned development of the city. M.S. In the 400s, according to St. John Chrysostom, around 150,000-200,000 people lived in Constantinople, 100,000 of whom were Christians, along with Jews and pagans. M.S. In 542, the population of Constantinople decreased with the plague epidemic. M.S. In 640, Egypt, the grain warehouse of the empire, was taken over by the Arabs, and the population of the capital continued to decrease for 2 centuries (Artan, 1994, p.271).

The Bosphorus has faced attacks in various periods. At the beginning of the Byzantine period, the Sasanian army captured Halkedon and set up camp on the Anatolian side of the Bosphorus. In 717 A.D., the Arab navy attacked the Bosphorus, and in 813 A.D. the Bulgarians plundered the Bosphorus. M.S. In 755, Constantine V wanted to settle Istanbul with immigrants he brought from outside the city, and the city began to revive again in the 840s. M.S. Towards 860, the Vikings destroyed the shores of the Bosphorus and besieged Constantinople. As a result of the 4th Crusade forces capturing the city, the Latin Kingdom was established in 1204. During this period, the Bosphorus was left to the management of Baudoin I (Berger, 1994, 271).

The names of some village settlements along the Bosphorus coast from the Byzantine period are known. Bosphorus villages, except for “Ayios Mamas”, where today’s Beşiktaş is located, which are considered natural extensions of “Sykai” and “Hrisopolis”, did not participate in urban life. The previous name of Ayios Mamas was "Diplokionion". Ayios Mamas was a saint for whom three churches were built in the city. Ayios Mamas has become the most suitable district to cross to the Anatolian side. M.S. In the district, which suffered a great fire in 469, Leo I built a palace and a hippodrome with its harbor. Bulgarian armies under the command of Krum Khan attacked Ayios Mamas in 813. Bulgarians turned the city environment into ruins. They damaged palaces, monasteries and villages overlooking the Bosphorus. Palace of Leo I, rebuilt by Tefofilos. It was abandoned and destroyed after the 9th century. We do not have information about how the connection made by boats on both sides of the Bosphorus during the Ottoman period was like in the Byzantine period (Artan, 1994, p.271, Eyice, 1976, p.14).

There were many hunting kiosks, villas, monasteries, and churches on the Bosphorus during the Byzantine period. It is thought that hunting kiosks and villas turned into monasteries or religious institutions over time. Castles were built at strategic points for security purposes. During the strong periods of Byzantium, facilities such as summer palaces, guest-houses, prisons, almshouses, hospitals, and lepers' homes were built in some villages. During the reign of Justinian, the increase in construction activities in the city and the demolition and reconstruction of dilapidated churches show that settlements intensified. It is thought that there were 3 palaces, 19 churches, 16 monasteries, and 1 almshouse on the European side, and 3 palaces, 14 monasteries, 11 churches, 4 almshouses, and 1 orphanage on the Anatolian side. The fact that the western side of the Bosphorus is covered with lush vegetation and the Anatolian side is more suitable for protection caused the construction to be located mostly on this side (Artan, 1994, p.271).

The Bosphorus was the scene of conflicts between Byzantium-Ottoman-Genoese-Venice in the last years of the Byzantine Empire. With the Battle of Pelekanon in 1329, Greek towns (Pendik, Kartal, Hereke Castle and Üsküdar) were captured by Orhan Gazi. Long before the conquest of Istanbul, the Üsküdar region was taken over by the Turks after the conquest of Hereke and Pendik during the reign of Orhan Gazi (1324-1362). The Ottomans settled in Rumelia in 1354. While the Genoese conquered Herakleon Castle, the Ottomans conquered Tsympe (Cinbi) Castle in the south. These regions were the first settlements of the Ottoman Empire in Europe (İnalcık, 2005, p.13). The Byzantines fought with Venice and the Genoese on the Bosphorus in 1377. The Turks attempted to take Istanbul twice, in 1391 and 1402. The transition of the Turks who settled on the Anatolian side to Thrace and Rumelia and their efforts to keep the Bosphorus under control began in 1391 when Beyazıt I captured Yoros Castle, north of Anadolu Kavağı, from the Genoese. The Turks later captured Şile

Castle in 1396. After the Anatolian Fortress was built, the Turks settled in Kadıköy and Üsküdar. The Anatolian Side became the settlement area of the Turks. According to foreign travelers who visited Constantinople in the 14th and 15th centuries, the population was around 30,000–50,000 (Artan, 1994, p.271, Berger, 1994, p.271).

Figure 1. Florentine cleric and traveler Christoforo Buondelmonte's drawing (URL 1)

After conquering Constantinople on May 30, 1453, Mehmet II started construction activities to make the city an administrative, economic, and religious center. At the beginning of the 15th century, the population of Constantinople was about 50,000. This number decreased further with the escape from the city during the conquest. A. M. Schneider thinks that the city had a population of between 40,000 and 50,000 in the mid-15th century when it was surrounded by the Ottomans (Berger, 1994, p.272). Mehmet II allowed every fugitive who returned within a certain period to settle in his house. He forced Muslims, Christians, and Jews from various parts of the empire to come to Istanbul. He encouraged well-known merchants to come to the city for the development of commercial life. He settled the Golden Horn and granted tax exemption (Artan, 1994, p.272).

After the conquest of Istanbul by the Turks, settlements began to be built along the Bosphorus for recreational purposes as well as defensive purposes in the second half of the 15th century. Apart from the Istanbul Peninsula, the peace and war situation of the empire and the thoughts of the rulers of the state played an important role in the development of settlement areas. While Istanbul was being reconstructed by the Turks, settlements were moved to areas outside the city walls. After the conquest, as security concerns decreased, the people brought from all over the empire settled densely within the city walls, along the shores and slopes of the Golden Horn. Some Turks coming from the Black Sea, Sinop, and Samsun were settled on the Bosphorus outside the walls of Galata. Some of the smaller groups were settled around the old Bovis Forum (today's Aksaray), Armenians in Sulumanastır, and Greeks on the Marmara coast (Kuban, 2000, p.188). During the reign of Mehmet II (1451-1481), Fındıklı, Kabataş, Beşiktaş, Ortaköy, Arnavutköy, Bebek, Rumelihisarı, Baltalimanı, Kefeliköy and Büyükdere became residential areas on the Bosphorus. While settlements were sparse in the areas after Tophane, Beşiktaş was a dense district. Greeks and Jews settled in Ortaköy, a Turkish neighborhood was established in Kuruçeşme and a group of Greek minorities were also settled here. Mehmet II built a mosque in the Bebek district and opened it to the settlement of Turks. He added a neighborhood to Anadoluhisarı and expanded it by building a mosque. In this period, control of the Bosphorus is still important. The settlement in Anadoluhisarı was born with the settlement of the people and their families who took part in the construction of the castle built by Beyazıt I (Yıldırım) during the siege of Istanbul in 1397 to cut off aid from the Black Sea. After the conquest, this settlement within the castle continued its existence. The settlement inside the castle in Rumelihisarı later moved outside the castle. (Artan, 1994, p.272).

Settlement outside the walls led to the establishment of new neighborhoods along the coasts and the development of districts such as Eyüp and Üsküdar. During the reign of Mehmet II, Üsküdar was an important settlement with a Muslim majority. The fact that Mehmet Pasha built his mosque on the hillside behind Damalis Burnu in 1470 indicates that the first settlements were established towards the south, around the hills on the Kadıköy road. During the reign of Mehmet II, there were 8 neighborhoods in Eyüp, 2 in Kasımpaşa, 61 in Galata, and 3 in Üsküdar. During these dates, the number of houses in the neighborhoods also increased.

The first Turkish shipyard was located in Kasımpaşa, outside Galata. Evliya Çelebi states that the Sultan built several shipyards, a Divanhane-i Kapudan Pasha, and a mosque. When the Ottoman navy made great progress during the reign of Selim I (1512-1520), it is thought that approximately 150 workshops with vaults or roofs were established in the first quarter of the 16th century, from the Galata walls to the Aynalıkavak Mansion, and the northern slopes of the Golden Horn began to fill towards the hill (Kuban, 2000, p.210). Population censuses carried out in the Ottoman Empire since the second half of the 15th century were made according to the male population, as the number of 19 households. The number of Christian families, which was 5162 in 1478, reached 5462 in 1489, and the number of Jewish families increased from 1647 to 2491. According to the censuses of this period, although it is not certain, an increase in Christian and Jewish households was observed (Çelik, 1996, p. 20, Akbayar, 1985, p. 238).

16th century Istanbul, the period of Suleiman the Magnificent (Suleiman I, 1520–1603) and the sultans that followed him is described as the image of Classical Ottoman culture. According to Kuban (2000), if an evaluation is made between urban development and monumental formation and residential architecture, the classical period can be extended to the 18th century. The highest point of the Ottoman Empire politically, militarily, and economically was the 16th century. During this period, Mimar Sinan's works became the most important works of Ottoman monumental architecture. In this century, the garden city texture dominates the Bosphorus. Suleiman the Magnificent directed various uses in the Bosphorus. During this period, the Bosphorus was inhabited, some places were developed, and some places were arranged as new settlements. New constructions on the shores of the Golden Horn and the Bosphorus marked the beginning of the urban development of the 16th century, and the city continued to grow in this direction. In the second half of the century, residential areas on the Bosphorus were distant from each other, as in previous periods. There are several neighborhoods around the mosques on the shores, vineyards, and gardens among them, and groves on the slopes. Settlements were established in the valleys and at the foot of the hills. This linear settlement trend on the foothills of the groves and gardens on the hills was also valid for the northern side of the Golden Horn. In the 16th century, a regular population increase was observed in the villages along the Bosphorus. The trend driving this increase started when the sultans and the dignitaries of the state built their summer palaces and seaside palaces on the Bosphorus. In addition since the reign of Beyazıt II, there was a garden and a pavilion belonging to the palace in Beykoz (Kuban, 2000, p.254).

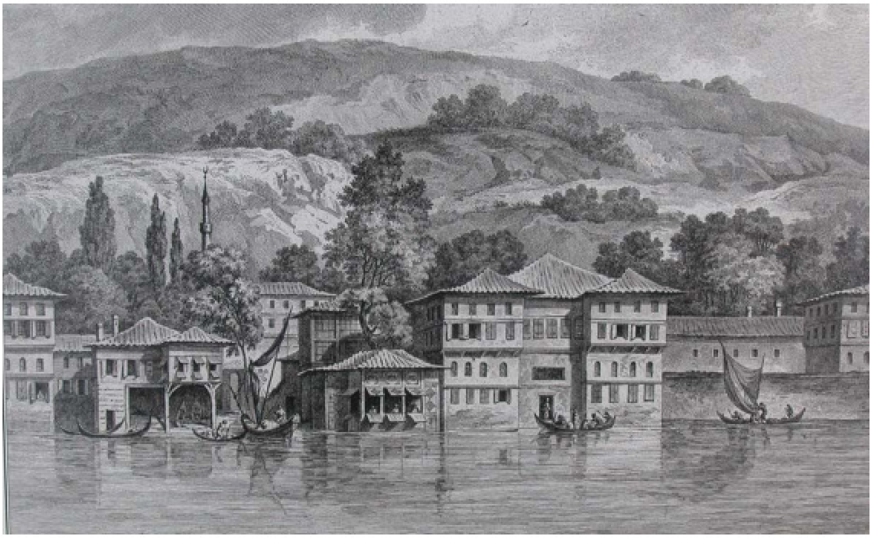


Figure 2. Bostancıbaşı Kiosk, Fauvel 1784-1892 (Sevim, 1997)

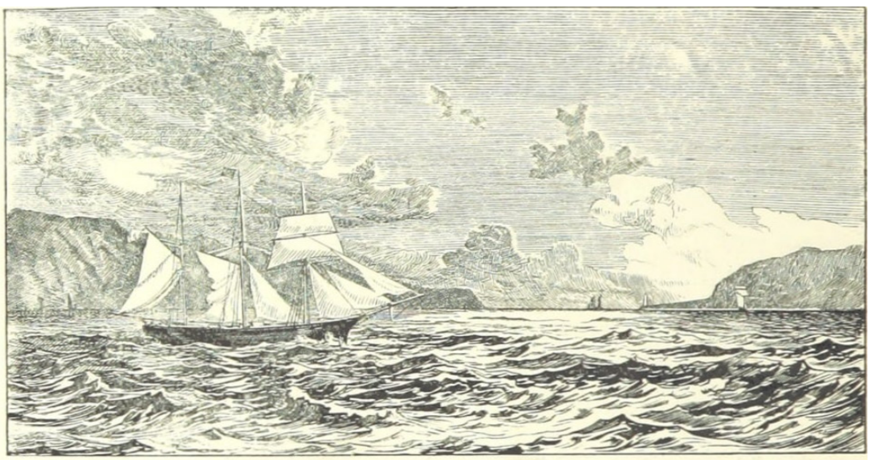


FIG. 69.—BEST ANCHORAGE—BOSPHORUS—ENTRANCE TO BLACK SEA—BUYUKDÉRÉ BAY—

Figure 3. Bosphorus, Entrance to Black Sea Buyukdere Bay (URL2)

In Çengelköy, where Kuleli Barracks now stands, there was once a palace of Suleiman the Magnificent, and in Kandilli, several mansions had Sultan 3. Murad. During this period, some villages along the Anatolian coast, such as Çengelköy and Kuzguncuk, were inhabited by Christians. In Kanlıca, Turks settled around the mosque built by İskender Pasha in 1559-1560. The villages on the European side of the Bosphorus were more developed compared to those on the Anatolian side. In this century, Ortaköy, Arnavutköy, Bebek, and İstinye were Turk and Greek villages. The establishment of a Turkish village in İstinye indicates the coexistence of Turks and Christians. According to Evliya Çelebi, Yeniköy took its name when it was founded by Suleiman the Magnificent. In the 20th century, Sultan Selim had a palace in Bebek, the 16th-century writer Feridun Bey had a garden in Emirgan, and Sultan Selim II had a mansion in Büyükdere Cove. The Dolmabahçe Palace of Sultan Selim II is considered a precursor to the palaces in Beşiktaş and Dolmabahçe. During this period, the shore palaces of the Grand Admirals (Kaptan-ı Derya) were mostly located in Beşiktaş. Sinan Pasha had a mansion in Beşiktaş, which served as the departure point for the Ottoman navy's expeditions. Similar to the Byzantine period, Beşiktaş remained the easiest crossing point between the two shores during this era (Kuban, 2000, p. 255).

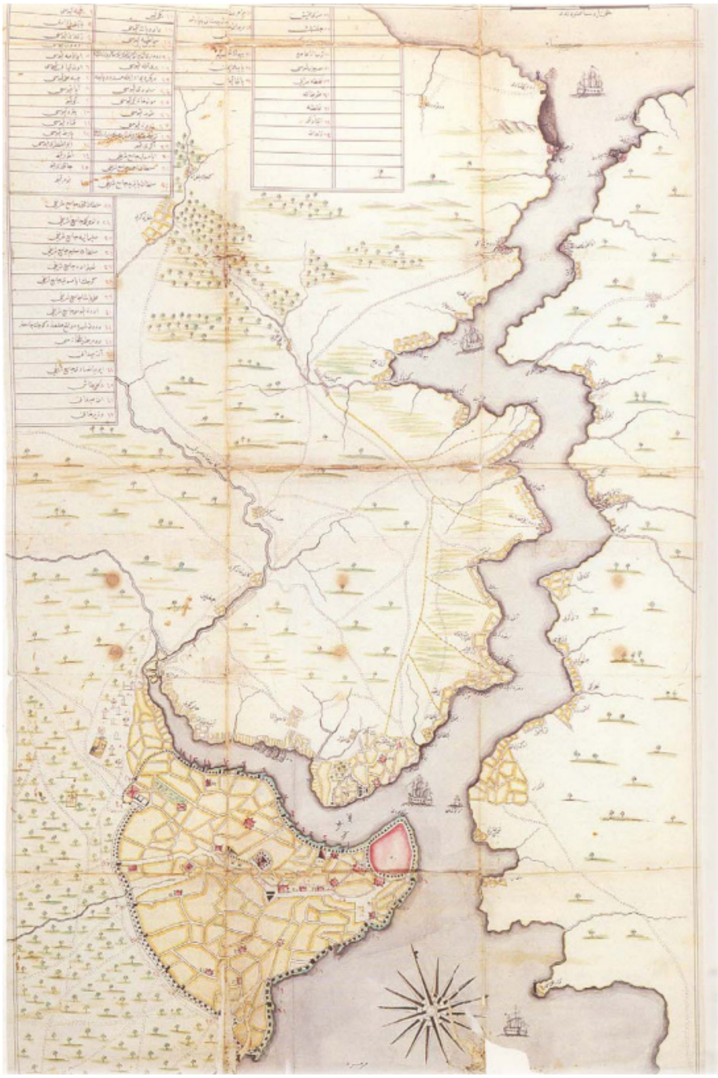


Figure 4. Istanbul ve Bosphorus map, 17th. century (Kayra, 1990)

Üsküdar, which was thought to have a population of between 30,000 and 40,000 in the mid-16th century, had now become a large district. Mihrimah Sultan's social complex, completed in 1548, emphasizes the importance of the Anatolian side and Üsküdar in this period. The increasing importance of Üsküdar was once again seen with the Atik Valide Complex built by Sinan between 1580 and 1589 for Nurbanu Sultan, the mother of Murat III. In the 16th century, there were structures on the northern slopes of the Üsküdar hills. There were mansions of the dignitaries of the state in Salacak, Sarayburnu and on the rocks overlooking the Port. The palace of the sultans, known as the "Kavak Palace", was built on a hilly promontory opposite the Topkapi Palace. Kavak Palace, thought to have been designed as a mansion for Suleiman I, was expanded and demolished towards the end of the 18th century, and "Selimiye Barracks" was built in its place. It is thought that during the Roman period, a sultan's garden and a pavilion were built by Suleiman I in Fenerbahçe Cape, which was famous for its imperial residences, and that in the 16th century, there was a neighborhood around the masjid and sultan's residence in Feneryolu, next to the sultan's gardens (Kuban, 2000, p.257).

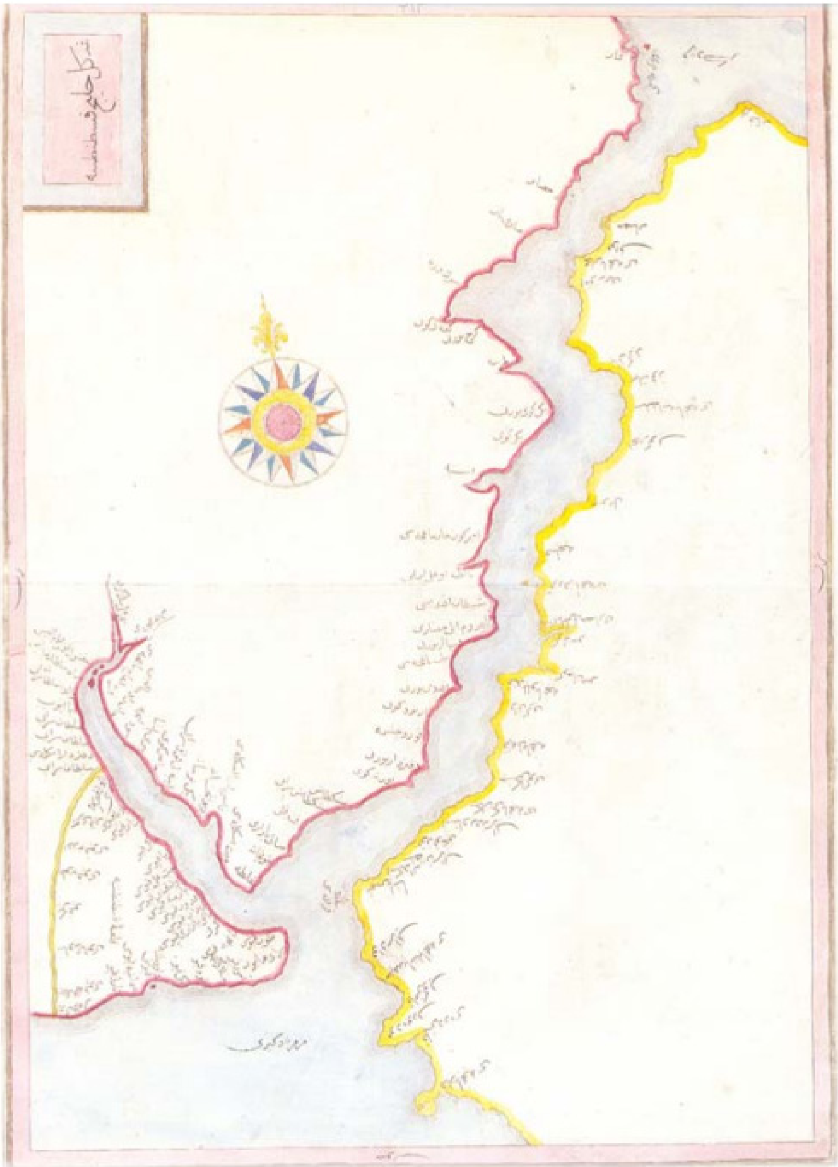


Figure 5. Bosphorus, Katip Çelebi, 1608-1657 (Kayra, 1990)

The Bosphorus contained many villages on both sides in the 17th century. These villages consisted of mosques, churches, synagogues, and wooden houses, as well as waterside mansions, pavilions, and palaces. There were also many gardens, orchards, and parks on the Bosphorus. Houses, palaces, and mansions belonging to this period have been almost destroyed. Of the mansions on the Bosphorus mentioned by Evliya Çelebi, only the divanhouse section of Amucazade Hüseyin Pasha Mansion has survived to the present day. In the 17th century, Kuruçeşme, Arnavutköy, Yeniköy, Tarabya, Büyükdere on the European side, and Çengelköy, Kuzguncuk and Üsküdar on the Asian side were villages where Greeks lived densely. It is thought that some of the Greeks living in these villages are the descendants of those who lived before the Turkish conquest. Evliya Çelebi, on the other hand, evaluated the Greeks living in Arnavutköy during this period as Greeks of Trabzon origin (Mantran, 1986, pp.44–57). According to Çelebi in the 17th century, the inner and outer city neighborhoods where Jews lived include Ayazma Kapısı, Balat, Ayvansaray, Cibali, Tekfursaray, Hasköy, Kasımpaşa, Galata and Mumhane, and Beşiktaş, Ortaköy, Kuzguncuk and Üsküdar on the Bosphorus. Neighborhoods where Armenians lived in Istanbul in the 17th century; Samatya, the area from Yenikapı to Kumkapı, Balat, Topkapı, Hasköy on the northern shore of the Golden Horn, Beşiktaş, Ortaköy, Kuruçeşme 22 and Üsküdar (Mantran, 1986, p. 61).

In the 17th century, Turks settled in all the villages from Bebek on the European side, except Kuruçeşme, and from Çengelköy to the north on the Anatolian side. However, the settlements around Anadolu Kavağı, Rumeli Kavağı, Anadoluhisarı and Rumelihisarı were entirely Turkish settlements. In this century, other population elements other than the Turks and the three major minority groups settled in Istanbul. These include Albanians, Egyptians, Gypsies, Moldavians and Vlachs. Albanians gave its name to Arnavutköy on the Bosphorus. However, no clear information could be found about the neighborhoods where Albanians settled (Mantran, 1986, p. 51).

In the 17th and 18th centuries, Istanbul continued its development pattern in the 15th and 16th centuries. Although the economic power of the empire decreased in these centuries, the population in Istanbul continued to increase. There is no official census data from the 17th century. Additionally, the information about foreign travelers from this period is not clear. However, as the 17th century approached, it was stated that the population of Istanbul was close to 500,000 (Kuban, 2000, p. 273). However, according to foreign travelers, it is estimated that a population between 700,000 and 800,000 lived in Istanbul and its districts in the 17th century. During this period, the Bosphorus, the Golden Horn and Üsküdar expanded, and up to 40% of the population moved outside the city walls. According to Evliya Çelebi, there were 9990 Muslim neighborhoods, 304 Greek neighborhoods, 657 Jewish neighborhoods and 27 Armenian neighborhoods in Istanbul. These results, stated as a total of 1005 non-Muslim neighborhoods, are hesitant according to Mantran (1986), and more minorities live in this period than a ratio of 1 to 10 (Mantran, 1986, p. 51).

In the 17th century, the people of Bosphorus earned their living from gardening, fruit growing, vegetable growing, fishing and maritime. Rumeli Kavağı and Sarıyer's cherries, Anadolu Kavağı's pears and chestnuts, and Ortaköy's artichokes were famous. During this period, Arnavutköy and Yeniköy became rusks production centers. In the 17th century, sailors working on merchant ships lived in villages such as Yeniköy and Sarıyer. Boats and kayaks were being repaired in İstinye Bay. Rumelihisarı and Beşiktaş are boatman or boater villages in this century. People and animals cross these villages (Mantran, 1986, p.85). While Sandys stated that at the beginning of the century, there was a population of 700,000 people in Istanbul, half of whom were Turks and half were non-Muslims, in 1640 the Venetian Contarini wrote that the population of Istanbul exceeded one million. In 1681, another traveler, Pietro Civrano, wrote that the population was around 800,000 (Mantran, 1986, p.49).

Figure 6. Gravures of Bosphorus (Sevim, 1997)

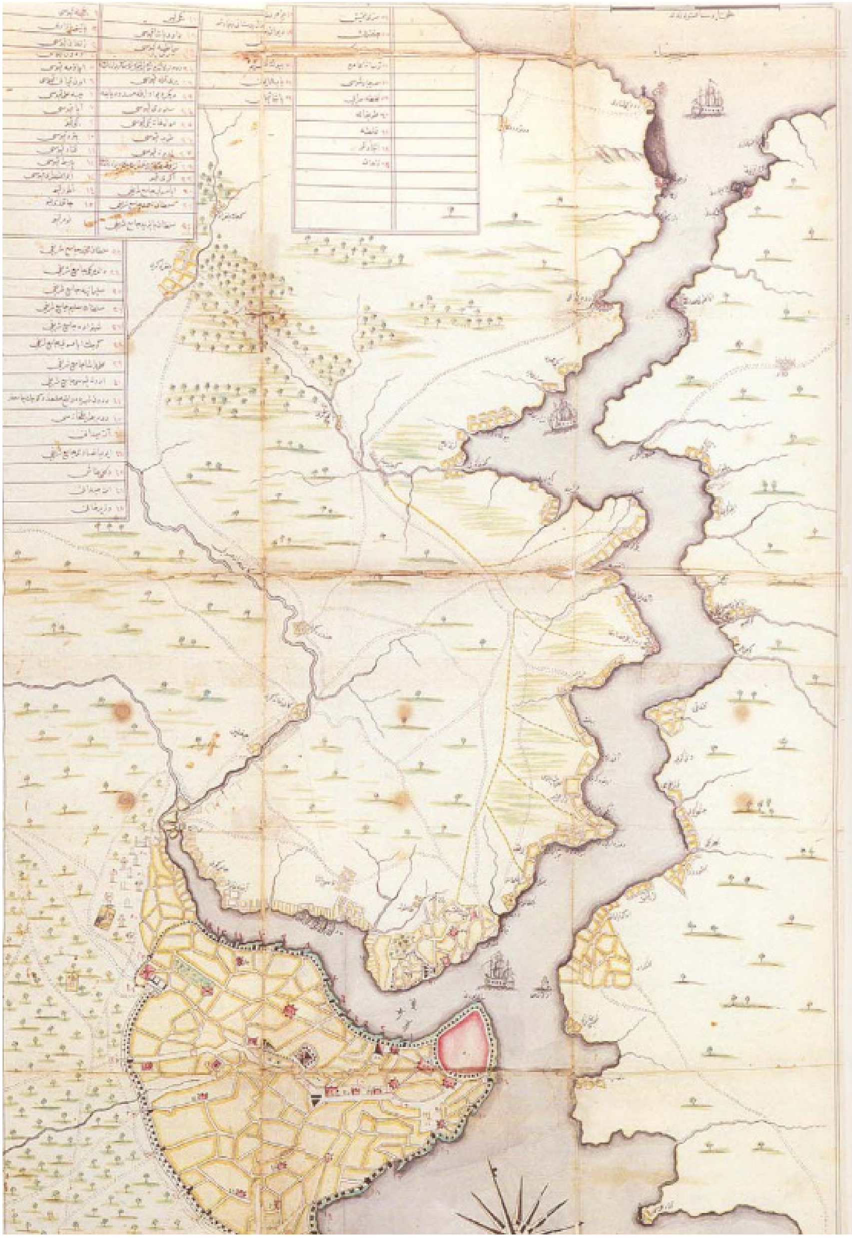


Figure 7. Istanbul ve Bosphorus, 17th century (Kayra, 1990)

A strong reason for the development of Istanbul outside the city walls was the unstoppable fires and the fear of fire. In the 17th century, the city became crowded, and the number of irregular living spaces increased. The biggest fires in Ottoman history were seen in this century. These fires devastated the city and disrupted the vital balance. Major fires include the Cibali Fire, which started in the Golden Horn in 1633, and the fires that started near Çemberlitaş in 1652, in Galata in 1660, and in Eminönü in 1690. After the great fires, the population within the city walls lost, and the burned areas were turned into vineyards and gardens (Kuban, 2000, p.273).

The Ottoman Tulip Era (1718–1730) was a turning point in Ottoman culture with its social and cultural movements. According to historians, the beginning of the Tulip Era architecture was the letters of Yirmisekiz Çelebi Mehmed Efendi. Mehmed Efendi led the westernization movement by suggesting to the sultan what he saw in France (Kuban, 2000, p.313). This period was a period of building activities focusing on examples of civil architecture on an urban scale, palaces, public or private gardens, and public fountains, and marked the beginning of the westernization of the Ottoman society in the capital in the context of urban form and scale. The society, which was used to living introvertedly, started to live outwardly in urban areas with the Tulip Era (Kuban, 2000, p.315). Starting from the beginning of the 18th century, new palaces and waterside residences were built on the Bosphorus and some were renovated. These construction works started during the reign of Ahmet III and Nevşehirli İbrahim Pasha and created a second Istanbul in the 18th century. The development movements, which started with the palaces of Sultan's daughters, lady sultans and vizier palaces in Sütlüce-Haskoy on both banks of the Golden Horn, later started from Tophane and reached Kuruçeşme and Bebek. During this period, the first appearances of western influences in architecture were seen with the applications in landscaping, and foreign elements gradually gained importance. The facades of palaces, pavilions and large mansions were dynamised, and new motifs emerged in interior wall decorations (Denel, 1982, p.49).

Figure 8. Panorama containing a view of Istanbul from the 17th century in French painter and traveler Guillaume Joseph Grelot's book Relation Nouvelle D'un Voyage A Constantinople (1680), (URL1, IBB Archives)

Figure 9. A very detailed Engraving of the City and Harbor of Constantinople, showing almost the entire part of Istanbul from the Anatolian side from a semi-bird's eye view, adapted from the book "Moreurs Et Usages Des Turcs" by the French lawyer Jean-Antoine Guer in 1746. (URL 1 Topkapı Place Archives)

When mansions and mansions were built on the Bosphorus during the reign of Ahmet III, a coastline was created on both shores. There are groves and mansions behind them. Wealthy families divided their year into three parts: winter, summer, spring-autumn. They were spending the winter in the city. When the weather started to warm up, families moved to their mansions in Erenköy or Çamlıca. On hot summer days, they came to the shores of the Bosphorus. In addition, many palaces were built on the Bosphorus in the 18th century, which can be visited in summer. Feyzabad in Çubuklu, Hümayunabad in Bebek, Neşetabad in Ortaköy, Ümn-amad located before the Dolmabahçe Pavilion, Beşiktaş Palace, Çırağan Palace, Eminabad in Salıpazarı, Şerefabad in Üsküdar were the palaces and recreation areas built during this period (Şehsüvaroğlu, 1986, p.23).

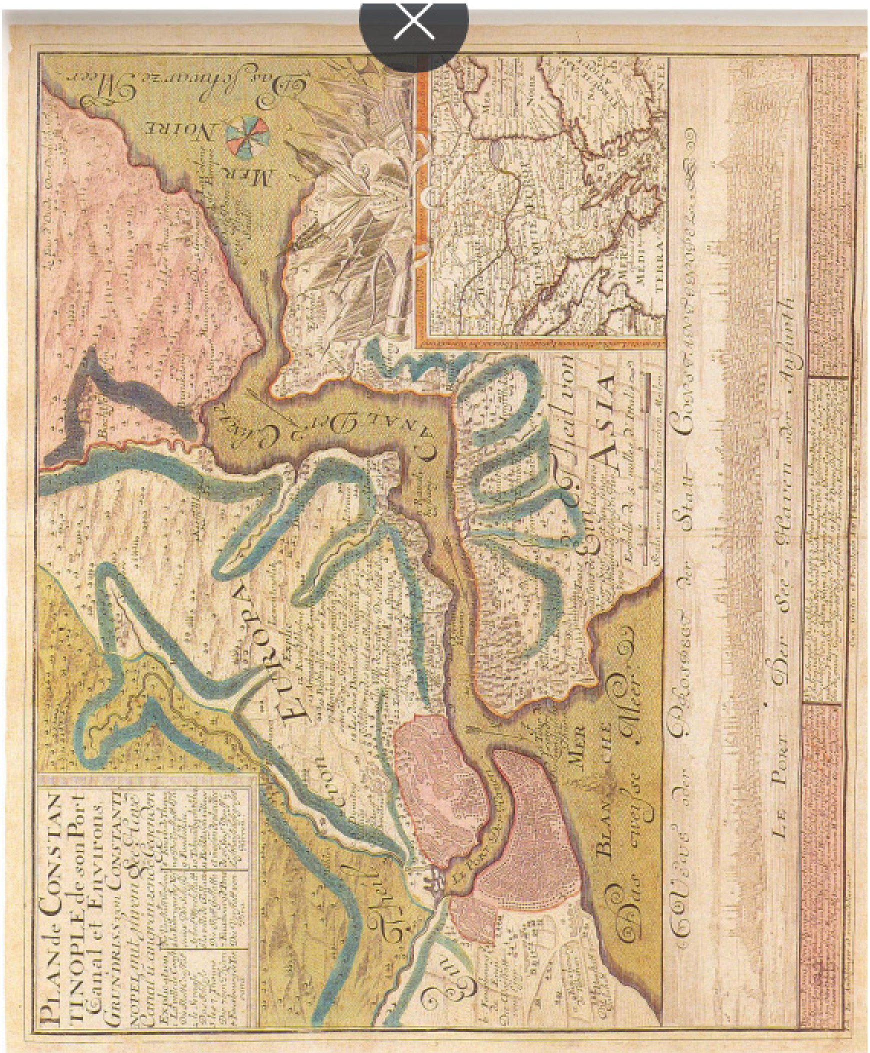


Figure 10 . Istanbul, Grundrise von Constanti map, 1715 (Kayra, 1990)

In the 18th century, the land around Hasan Halife Garden in Bebek was parceled out and sold to the public. Along with the Humayunabad Pavilion, Bebek Mosque, school, fountain, bath, mill, and bazaar were effective in the concentration of Bebek. Grand Vizier Nevşehirli İbrahim Pasha invited the sultan to Saray-ı Asafi in Beşiktaş and Kasr-ı Dilnişin, which he had built on Kuruçeşme. Damat İbrahim Pasha had a new seaside palace named Çırağan built between Beşiktaş and Ortaköy. On the Rumelian side of the Bosphorus, Çırağan Palace was followed by Neşedabad Palace. After Neşedabad on the Rumelian side of the Bosphorus, the name Bebek Sahil Sarayı is mentioned. After Bebek Coast Palace, comes Kalender Pavilion, located between Yeniköy and Tarabya, built by Nevşehirli İbrahim Pasha.

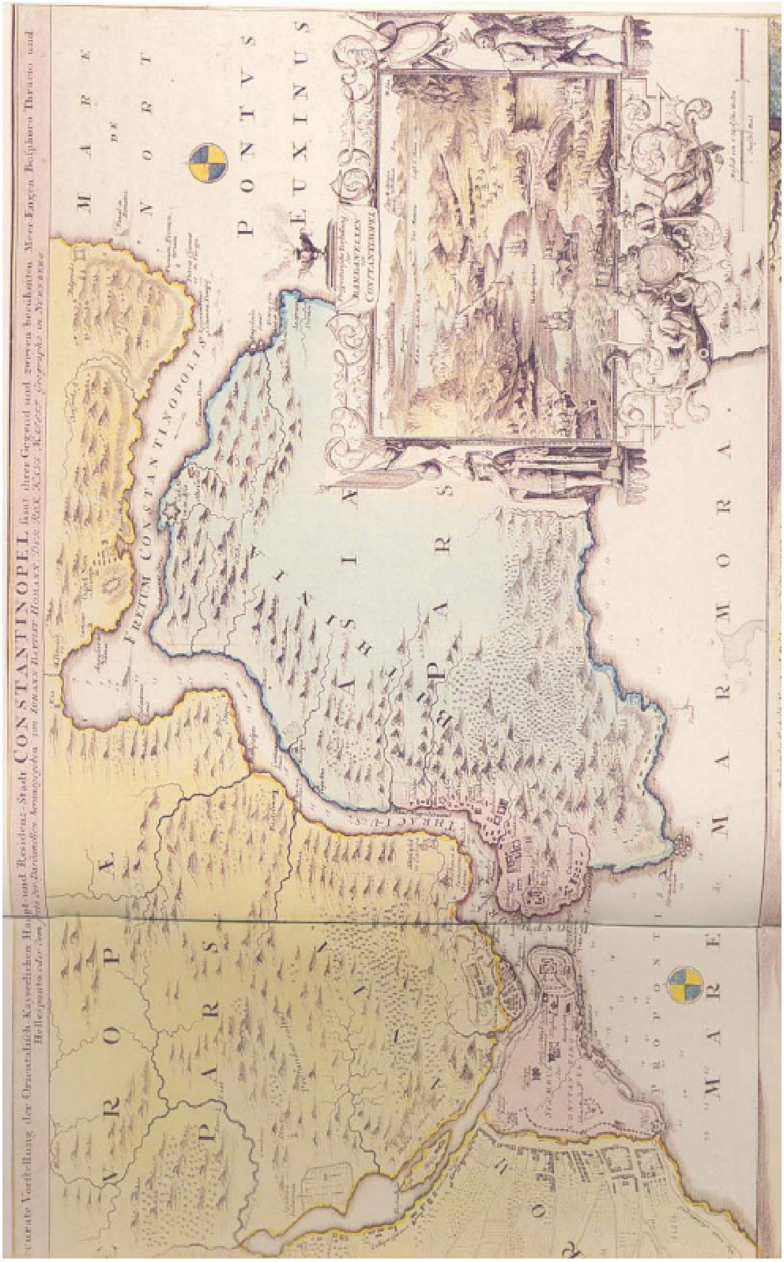


Figure 11. Bosphorus, 18th century (Kayra, 1990)

On the Anatolian side of the Bosphorus, the seaside palaces started from Üsküdar. In the 18th century, there were seaside residences of scholars and non-Muslims between the shores of Üsküdar and Beylerbeyi. After these coastal palaces, there was the Istavroz Palace and then the Şevkabad Pavilion. A waterside mansion was built in this area, which was known as Istavroz until the 18th century and was home to special gardens, in the garden known as Ferahabad during the reign of Ahmet III. After this palace, the first building belonging to the sultans is the Kandilli Palace. It was repaired again by Nevşehirli İbrahim Pasha. Küçüksu Pavilion was built in 1165 during the reign of Mahmud I. Water was brought from the mountain next to it and pools, fountains. However, during the reign of Ahmet III, many old mansions were repaired, and many new social complexes were built (Şehsüvaroğlu, 1986, p.23). Incicyan (2000) wrote that during this period, Kuruçeşme was a larger settlement than it appeared from the sea, Tarabya was a settlement on the seashore and inland, and Yeniköy was a crowded settlement. Lady Montagu (1988) described waterside residences on the Bosphorus in detail in her letter (İnciciyan, 2000, p.114).

The Tulip Era ended with massacres, destruction, looters taking over and revolution. The Bosphorus, created by Grand Vizier Nevşehirli İbrahim Pasha, has demolished. After Ahmet III and his grand vizier Damat İbrahim Pasha, Mahmut I became Sultan. After the rebellion was suppressed and Patrona Halil was executed, westernization efforts continued. Mahmut I (1730–1754) parceled out the private garden in Kandilli and opened it to public use by renting and granting usage rights. Waterside mansions for the dignitaries of the state were planned on the lands on the Kandilli coast. The groundwork was prepared for the development of the district with the mosque, fountain, bath, pier and well built during the period. During this period, Beylerbeyi also showed great development (Gökbilgin, 1994, p.689).

Figure 12. Istanbul Map, T.C. Lotter, 1770 (Kayra, 1990)

During the reigns of Abdülhamit I (1774–1789) and Selim III (1789–1808), development movements took place in the Bosphorus. During the reign of Abdulhamit I, new settlements were established on the Bosphorus and policies were followed to encourage settlement there. The residence and gardens belonging to Murat IV next to the old Istavroz neighborhood were sold to the public. A mosque was built here in 1779. Beylerbeyi became a

Turkish village. Abdulhamid I built a mosque and fountain in Emirgan and founded a new Turkish village here. With the construction of Humbarhane, Ayazma Mosque, Selimiye Barracks and Mosque in Üsküdar, respectively, the settlement progressed towards Haydarpaşa (Kuban, 2000, p.331).

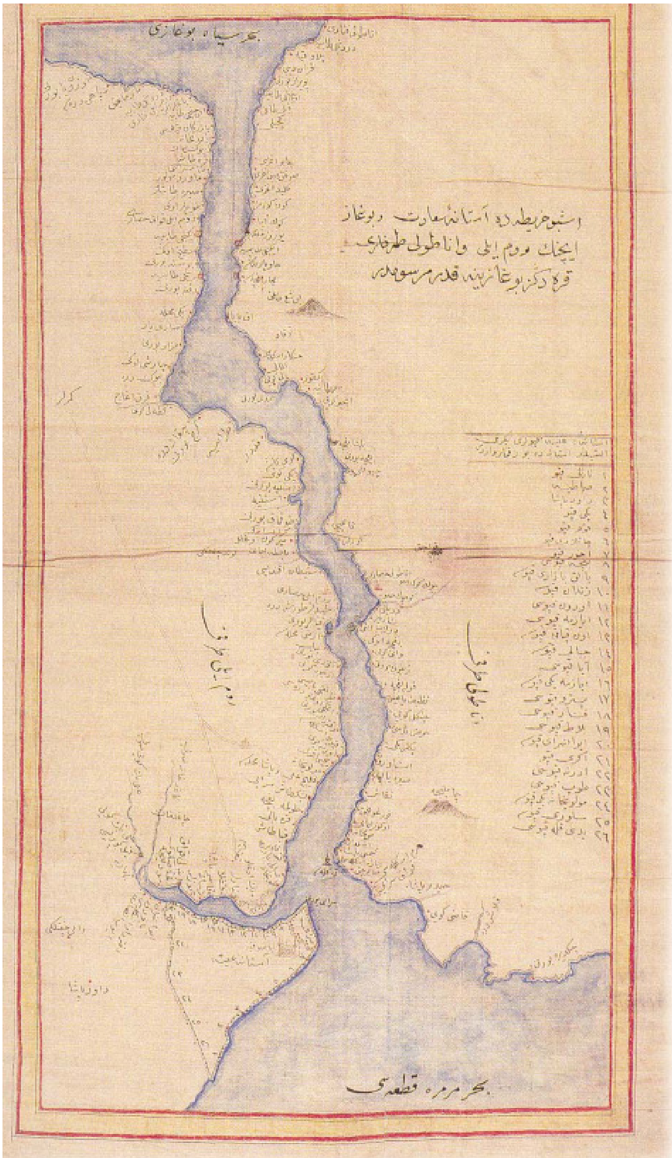
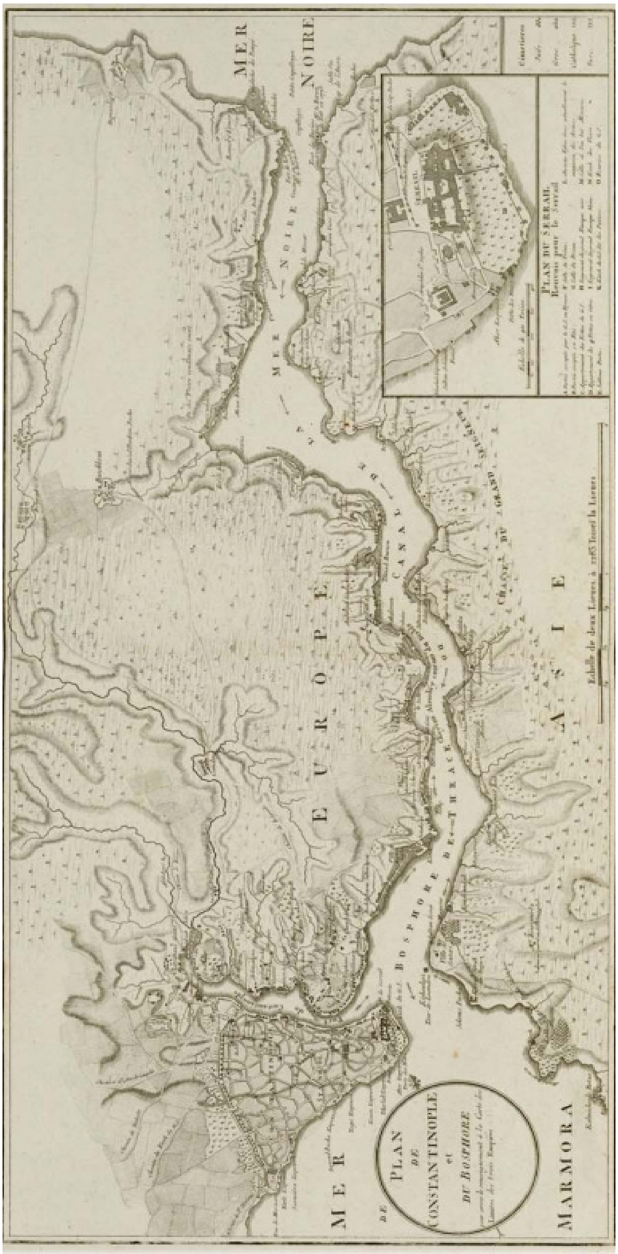


Figure 13. Istanbul ve Bosphorus, 1800 and before (Kayra, 1990)

In the 18th century, with the increasing population along the Bosphorus shores, new settlements began to form. Many fountains were built outside the city walls in this century. If the number of fountains is taken as a criterion in the 18th century, it is understood that there was a strong tendency to settle in Üsküdar and the Bosphorus. Approximately 40% of the newly built fountains were built in these regions. In parallel with the population increase, in this century, old waterside mansions, water side residences and their gardens on the shores of the Bosphorus were demolished and new ones were built in their places. While the Bosphorus became the scene of a western life in this century. However, in the 18th century, settlements on both shores of the Golden Horn and the Bosphorus concentrated within themselves, and the lives of the villages there began to participate in urban life. However, the characteristics of the streets did not change, and the cramped texture of the settlements continued. Many fires occurred in Istanbul in the 18th century, as well as in the 17th century. The Cibali fire, which started from the Golden Horn, destroyed one fifth of the residential area. In another fire that broke out in the Golden Horn and Balat, one eighth of the city was burned. During the reign of Osman III (1754–1757), successive fires devastated the people (Denel, 1982, p.49).



ıtanbul ve Boğaziçi'nin Planı, T. Mollo, 1793-1802 (Atatürk Ki

Figure 14. Istanbul ve Bosphorus Plan T. Mollo, 1793-1802. (Archives of Atatürk Library)

In the 18th century, Baltalimanı, Kefeliköy, Emirgan and Yenimahalle on the European side and Kandilli, Vaniköy, İncirliköy and Yalıköy on the

Anatolian side were among the new settlements. Armenians in this century; on the European side, they settled in Bebek, except Beşiktaş, Ortaköy and Kuruçeşme, and on the slopes in that region, İstinye, Yeniköy and Tarabya, except Rumelihisarı. On the Anatolian side, they lived in Kuzguncuk, Kandilli and Beykoz. Jews did not leave the districts where they settled in the previous century. In the 18th century, Greeks spread to new settlements. Along with Bebek and Turks on the European side, Istavroz became the new settlement of Greeks on the Anatolian side during this period. Turks lived in Baltalimanı, Emirgan, Kefeliköy and Yenimahalle on the European side and in Vaniköy, İncirköy and Yalıköy on the Anatolian side, and Armenians lived in Kandilli with a small number of Greeks. It is stated that there was a European population in Sarıyer in the 18th century (İncicyan, 2000, p.94).

At the end of the 18th century, mansions of sultans and courtiers were lined up on the shores of Beşiktaş, Ortaköy and Kuruçeşme. During this period, non-Muslims lived in Arnavutköy. The Sublime Porte was located in Bebek, and the mansions of the ilmiye dignitaries were located in Rumelihisarı. There were high-class Turks in Emirgan and İstinye. Yeniköy, Tarabya and Büyükdere were the districts where Frankish mansions were lined up. Rich Greeks who were engaged in trade lived in the mansions between Tarabya and Yeniköy, and there were about 60-70 mansions on this coast. In Tarabya, there were embassies and waterside residences for people with political duties. Between Kireçburnu and Büyükdere, embassy translators and some Greek bazaar mansions were lined up. Sarıyer was considered as the district where middle-class Turks lived, and Yenimahalle, which came after Sarıyer, was considered as the district where middle-class Greek families lived (Şehsuvaroğlu, 1986, p. 31).

According to Kuban, (2000), despite the construction of many buildings and the advancement of residential architecture in the 18th century, Istanbul had the character of a city surrounded by walls when viewed from the Marmara Sea. The walls were repaired from time to time. Kadıköy did not extend beyond Kurbağalıdere. In the Bosphorus silhouette, the domed mosques of Istanbul and the homogeneous and horizontal development of residential areas were effective. When we look at Istanbul from an architectural perspective in the second half of the 18th century, the influence of the artistic style and the influence of modern military institutions on an urban scale are noticeable. Both influences were brought by French architects, engineers, artists and military officers. In the last quarter of the 18th century, shipyard structures, barracks and schools with foreign influence began to form the cosmopolitan Istanbul of the 19th century (Kuban, 2000, p. 327).

4. Conclusion

The Bosphorus played a crucial role as a bridge between Asia and Europe throughout history. In prehistoric times, the Bosphorus served more as a transition area than a settlement, with ruins from the Paleolithic Age found around Istanbul. Thracians, Phrygians, and Bithynians settled in the Bosphorus around 1000 B.C. The Megara colony on the European side later became Byzantium, with other settlements forming the outskirts of Constantinople and Ottoman Bosphorus districts. The Byzantine period marked the Bosphorus as an extension of the city, with significant developments such as the Maiden's Tower and the construction of walls by Roman Emperor Septimus Severus in 196 A.D. Byzantium's expansion, especially towards the Golden Horn, included ports like Neorion and Prosforion. Megara's strategic location at the intersection of trade routes and defensibility led to Byzantium's growth, later becoming Constantinople. Byzantine settlements along the Bosphorus included hunting kiosk, villas, monasteries, and churches. The area saw conflicts between Byzantium, Ottoman, Genoese, and Venice. Orhan Gazi's conquests marked the Ottoman presence, with settlements in Rumelia in 1354. The 14th century witnessed a decline in population due to Crusader invasions, while the Ottomans later revitalized Istanbul after the conquest in 1453. After the conquest of Istanbul by the Turks, settlements were built on the Bosphorus for recreational purposes as well as defensive purposes.

After the conquest, it is evident that the Bosphorus was not yet a settlement within the city but rather an external point. Post-conquest construction in Istanbul is described as single-story, primarily using rubble stone and bricks, based on data found in endowment deeds and miniatures. In the 16th century, during the reign of Suleiman the Magnificent, the Bosphorus saw partial settlement and development in certain areas, with new settlements arranged in others. Settlements in this century were established in valleys and on the slopes of hills. Alongside rubble stone and brick, wood became more widely used during this century. The Bosphorus, post-conquest, was not a fully developed urban settlement, but rather a location undergoing gradual transformation and adaptation in response to changing societal habits and influences over the centuries. During the 16th century, characterized by the rule of Suleiman the Magnificent, the Bosphorus exhibited a garden city texture. Various uses and developments took place, with new constructions along the Golden Horn and the Bosphorus contributing to urban growth. The establishment of summer palaces by the sultans fueled population increase in Bosphorus villages, marking a trend that continued throughout the Ottoman Empire's classical period.

In the 17th century, the Bosphorus contained villages with mosques, churches, synagogues, wooden houses, mansions, pavilions, and palaces.

Notable villages on both sides included Kuruçeşme, Arnavutköy, Yeniköy, Tarabya, Büyükdere on the European side, and Çengelköy, Kuzguncuk, and Üsküdar on the Asian side. During the 17th and 18th centuries, Istanbul continued its growth pattern. The Bosphorus, Golden Horn, and Üsküdar expanded, with up to 40% of the population moving outside the city walls. Economic activities included gardening, fruit and vegetable cultivation, fishing, and maritime. In the 17th century, although the Bosphorus was not yet a widespread settlement area, it transformed into an extramural retreat for the Ottoman society, reflecting changes in lifestyle after the conquest. Western influences were not strongly felt in the coastal lifestyle during this century, with traditional planning, style, and interpretations continuing. While wood types used in the 17th century increased, standardization and specialization in wood usage were observed.

In the 18th century, with the increasing population along the Bosphorus shores, new settlements began to form. Many fountains were built outside the city walls in this century. If the number of fountains is taken as a criterion in the 18th century, it is understood that there was a strong tendency to settle in Üsküdar and the Bosphorus. In parallel with the population increase, in this century, old waterside mansions, coastal palaces and their gardens on the shores of the Bosphorus were demolished and new ones were built in their places. While the Bosphorus became the scene of a western life in this century, the participation of the people in the region was ensured by the increase in recreation areas, and the bourgeoisie life lived in the coastal area, village life and entertainment areas colored the Bosphorus. However, in the 18th century, settlements on both shores of the Golden Horn and the Bosphorus concentrated within themselves, and the lives of the villages there began to participate in urban life. However, the characteristics of the streets did not change, and the cramped texture of the settlements continued. Many fires occurred in Istanbul in the 18th century, as well as in the 17th century.

In conclusion, until the end of the 18th century, we observe that the maps of the Bosphorus were not accurately drawn. However, these maps are important in terms of depicting the settlements along the Bosphorus. Until the 18th century, we observe in the maps drawn for the Bosphorus that the settlements along the strait were depicted as villages. The maps also illustrate gardens behind the waterfront mansions located along the coasts. Since there were no roads passing behind the coastal structures at that time, they are not depicted on the maps. Bosphorus has played a vital role as a transition area, a strategic region, and a settlement area throughout ancient and medieval history, witnessing various civilizations and historical events.

Bosphorus has always attracted attention with its nature and its architecture in harmony with nature, which has developed since the Ottoman period. It is important to protect and develop the richness of the Bosphorus.

References

Artan, T., (1992), Boğaziçi'nin Çehresini Değiştiren Soylu Kadınlar ve Sultan Efendi Sarayları, 106-118, İstanbul. Artan, T., (1994), "Tarihte Boğaziçi", Dünden Bugüne İstanbul Ansiklopedisi, 2:281-286.

Atalan, O. (2008), Boğaziçi Kıyı Yerleşmelerinin Tarihsel Değişim Süreci Ve Koruma Yöntemleri Üzerine Bir Araştırma; Ortaköy-Kuruçeşme Sahili, Yıldız, FBE, Doktora tezi, İstanbul.

Berger, A., (1994), "Nüfus", Dünden Bugüne İstanbul Ansiklopedisi, 6:107-108.

Denel, S., (1982), Batılılaşma Sürecinde Tasarım ve Dış Mekanlarda Değişim ve Nedenleri, ODTÜ Mimarlık Fakültesi Yayınları, Ankara.

Eldem, S.H., (1969), Köşkler ve Kasırlar I, DGSA Yayınları, Ankara. Eldem, S.H., (1979), Boğaziçi Anıları, Aletaş Alarko Eğitim Tesisleri AŞ, İstanbul. Eldem, S.H., (1993), Boğaziçi Yalıları, Koç Vakfı, İstanbul. Eldem, S.H., (1944), "Bir Yalı", Arkitekt, 1944, 147.

Eyice, S., (1976), Bizans Devrinde Boğaziçi, İstanbul Üniversitesi Edebiyat Fakültesi Basımevi, İstanbul.

Gökbilgin, M.T., (1953), "Boğaziçi", İslam Ansiklopedisi, 2:672.

Güngerich, R., (1958), Anaplus Bospori, Berolini Apud Weidmannos, MCMLVIII [1958]. xliv, [2], 45 s,

Kuban, D., (1994a), "Kentin Gelişmesi", Dünden Bugüne İstanbul Ansiklopedisi, 4:527-547. Kuban, D., (1994b), "Yalılar", Dünden Bugüne İstanbul Ansiklopedisi, 7:417-422. Kuban, D., (1998), İstanbul Yazıları, T.C. Kültür Bakanlığı, İstanbul. Kuban, D., (2000), İstanbul Bir Kent Tarihi Bizantion, Konstantinopolis, İstanbul, Türk Tarih Vakfı, İstanbul. Kuban, D., (2001), Kaybolan Kent Hayalleri Ahşap Saraylar, Yapı Endüstri Merkezi Yayınları, İstanbul.

Kayra, C., (1990), İstanbul Haritaları, Ortaçağdan Günümüze, Türkiye Sınai Kalkınma Bankası, İstanbul.

Mantran, R., (1991), 16.-17. Yüzyılda İstanbul'da Gündelik Hayat, Çev., M. A. Kılıçbay, Eren Yayıncılık, İstanbul. Mantran, R., (1986), 17. Yüzyılın İkinci Yarısında İstanbul, V Yayınları, 85, Ankara.

Salman, Y.,(2004), Boğaziçi Tarihi Sit Alanlarının Yok Olma Süreci ve Kalan Sınırları Değerlerin Korunma Olasılıkları, Yayımlanmamış Doktora Tezi, İstanbul Teknik Üniversitesi Fen Bilimleri Enstitüsü, İstanbul.

Şehsuvaroğlu, H.Y.,(1986), Boğaziçi'ne Dair, Türkiye Turing ve Otomobil Kurumu Şişli Meydanı 364, İstanbul.

Sevim, M.,(1997), Gravürlerle Türkiye, Kültür ve Turizm Vakfı Yayınları, Ankara.

Toprak, Z., (1994a), "Altıncı Daire-i Belediye ", Dünden Bugüne İstanbul Ansiklopedisi, 1:220-223. Toprak, Z., (1994b), " Fetihten 1950'ye", Dünden Bugüne İstanbul Ansiklopedisi, 6:108-111.

Türker, O., (1999), Mega Revma'dan Arnavutköy'e Bir Boğaziçi Hikayesi, Sel Yayıncılık, İstanbul.

URL 1 https://sehirplanlama.ibb.istanbul/beyoglu-arsivi-haritalar/

URL 2 https://timelessmoon.getarchive.net/amp/media/bosphorus-from-pen-and-pencil-in-asia-minor-or-notes-from-the-levant-illustrated-ed07ab

BÖLÜM 3

THE DEVELOPMENT STORY OF SHELTER AND SETTLEMENT FROM THE CAVE TO MARS

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Introduction

Housing, which is the lowest level of Maslow's Hierarchy of Needs among human vital needs, is defined as the close physical environment inside and outside buildings where families and households live and meets the shelter function (United Nations Centre for Human Settlements (Habitat), 1992). Adequate housing means adequate privacy and includes adequate space. This space is physically accessible; adequate the security, including security of tenure; structural stability and durability; adequate lighting, heating and ventilation; adequate basic infrastructure such as water supply, sanitation and waste management facilities; appropriate environmental quality and health-related factors; It must provide an adequate and accessible location and favorable economic conditions in terms of jobs and basic amenities. Housing is defined as a livable, enclosed living space that provides privacy for its occupants and a safe, healthy living environment where the dignity of its occupants is protected (Corsellis and Vitalle, 2005).

When we follow human history, the evolution of housing and housing conditions has shown significant development in parallel with social, economic and cultural changes. In this study, how housing and housing conditions have evolved throughout history and the factors behind this evolution are briefly examined. This long journey, from cave life to ancient cities, from feudal orders to the Industrial Revolution and today to life in space, will help us understand the factors that shape people's living spaces. At the same time, it will be possible to discover how changes in housing and housing conditions affect the structure of societies and reflect their cultural accumulation. The human house-building process reflects not only the life spent within the walls of a house but also the history of civilizations.

1. Shelter, Dwelling and Settlement in Prehistoric Periods and Ancient Ages

Information about the human history of life intertwined with housing extends beyond urbanization. Findings obtained from studies carried out by archaeologists show that the dwellings point to a very old period in human history. Early humans generally lived in caves and natural shelters. Especially caves were used intensively by humans approximately in the Upper Paleolithic Age (Image- 1). Theopetra Cave, one of these caves considered is approximately 500 m2 in size and is characterized by a roughly quadrangular shape with small recesses around it (URL-1). The entrance of the cave is quite large, which allowes plenty of natural light to penetrate well into the depths of the cave. In this period, shelter construction was limited to natural formations or simple structures, to adapt to basic shelter needs and natural conditions. For this reason, shelters such as pre-urban villages, pre-village camps, caves and temporary shelters emerged as a planned result of the first houses that emerged with the transition to agriculture in the Neolithic Age. During the Neolithic period, more permanent shelters were built using materials such as mud brick and stone. It is observed that the buildings that form the basis of agricultural housing traditions around the world generally have flat roofs. Flat roofs emerged as versatile structures where food, pottery and madder textiles were dried, under which agricultural products were stored and people were sheltered. These flat roofs formed important elements of the first houses and the settlements consisting of these houses.

Image 1. *Theopetra Cave, 130,000 Years Ago (URL-1).*

Excavations in Çatalhöyük show that the flat roof form was widely used in Neolithic Age settlements. In such settlements, houses were often adjacent to each other and arranged in groups. Dwellings were usually accessed through a hole in the ceiling. While large rooms contained earthen benches, niches and stoves, small rooms were generally used as storage. Human skeletons under the seating benches show that the first houses were also used as graves. This situation shows that spatial separation and division of labor have not yet been fully realized. The first residences operated as versatile structures that combined various functions such as shelter, warehouse, tomb and temple (Hodder, 2006; Salihoğlu, 2017).

Image 2. Çatalhöyük Settlement and Housing Illustration (URL-2).

In the Bronze Age, with people settling in fertile lands, the development of agriculture and trade, and the emergence of educational and judicial institutions, these human settlements turned into cities. The most important cities of this period emerged between the Tigris and Euphrates rivers, which we know as the Mesopotamian Civilization. The first durable and permanent structures in Mesopotamia were shaped according to public needs and revealed the first examples of architectural structures. While a great civilization was dominant in Mesopotamia during the Bronze Age, trade colonies were established in Anatolia, which were extensions of the great states in Mesopotamia. For example; Hassek Mound near Şanlıurfa, known as the early Sumerian settlement, consisted of houses protected by walls and built with a plan type called 'bit-hilani'. Bit-hilani was a special type of residence consisting of rooms on both sides of the courtyard (Demirarslan, 2011). Hilani (Bît Hilani bit, Hilani) type dates back to B.C. From the 1500s B.C. It is a form of construction that emerged in Asia Minor and the Middle East until the late 7th century. This term is derived from the Hittite word 'hilatar, hilannas', which means palace (URL-3).This plan type is still used with local interpretations in Anatolian building tradition and space designs. In Visual-3, it is seen that this plan type is applied in a house in the Adıyaman Kahta Region today (Salihoğlu, 2017).

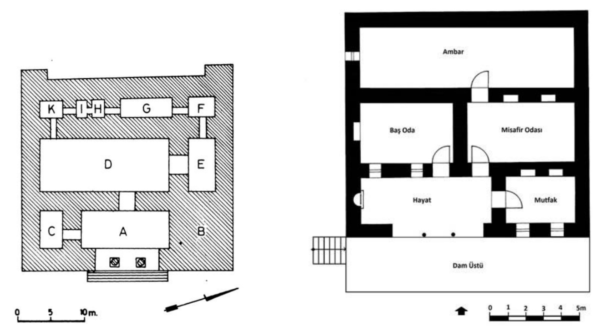

Image 3. Bithilani Plan Type (URL-3) and the Plan of a House in the Kahta Region of Adıyaman Today (Eraslan, 2013).

It is seen that long rectangular planned houses called 'Megaron' were built in the port city of Troy near Limantepe-Çanakkale, which was established in Western Anatolia, and the Demircihöyük settlement near Eskişehir and Bilecik. This plan type also formed the basis of Mediterranean residential architecture over time (Efe, 2003) (Image 4).

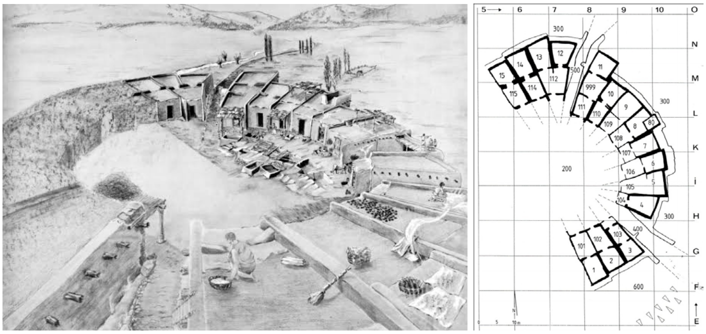

Image 4. *Demircihöyük Settlement (Efe, 2003) and Adjacent Houses with Megaron Plan (URL-4).*

When we examine the Ancient Egyptian Civilization, we see a clear distinction between social classes in Egyptian society. The first inhabitants of Egypt lived in huts made of papyrus reeds. However, later on, houses continued to be built with bricks obtained by transforming the mud left behind after the annual floods of the Nile into bricks that could be used for construction. The rich class usually owned large and luxurious houses, while ordinary people lived in more modest residences. Pharaonic palaces often contained large courtyards, temples, and private rooms. The residences of the rich class also had similar features. Especially the noblesse lived in villas with large gardens on the outskirts of the cities. When you entered the house from the garden gate, there was a small doorman's hut on the left. An Aton temple was located separately from the house in a section close to the entrance of the garden. The house, on the other hand, had the distinction of harem and selamlik within itself. The houses were generally of the courtyard plan type, the windows in the thick mud brick walls were kept quite small to reduce heat gain, and the central sections were raised for ventilation and lighting through skylights. Around the main house were the kitchen, warehouses, stables and servant quarters. It is known that while the nobles lived in such a comfortable position, the common people lived in very modest houses (Demirarslan, 2011). Lower-class workers and slaves generally lived in smaller, simpler dwellings. These dwellings were generally made of soil or adobe and could be simple structures with one or two rooms. Social housing areas such as Deir El Medina, where pyramid and temple workers would live, were being built (Image 5).

Image 5. *Noble House (URL-5) and Deir El Medina Settlement Ruins in Ancient Egypt (URL-6).*

The urban phenomenon, which started in Mesopotamia in the Bronze Age, progressed in the Greek Civilization. Since trade and administrative affairs related to daily life were carried out in the agora in the cities, the houses of the Greeks were generally small and sloppy. Although the Greek house developed from the megaron plan type, it consisted of the men's living room 'andron', the main reception room and other rooms around a central courtyard. These houses, which were generally single-storey, had roofs that sloped inward towards the open central courtyard. Especially in the homes of the craftsmen, there was also a workshop reserved for the production of pottery and wrought iron (Image 6).

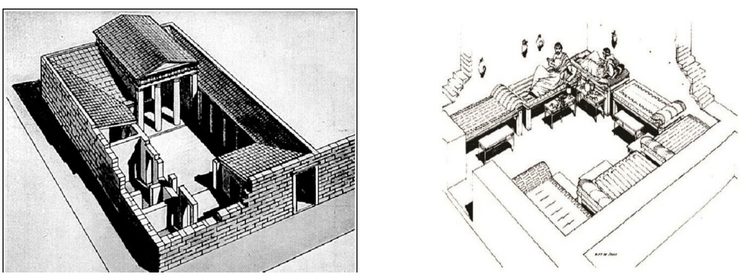

Image 6. *A Reconstruction of Ancient Greek (Priene) Houses (Leopore, 2017) and Andron (Demirarslan and Demirarslan, 2021).*

Roman civilization was essentially an urban civilization. Cities were the building blocks of the Empire and the center of social life and trade. The city of Rome was a giant city with a population of one million during the reign of Emperor Augustus. It is known that the Roman people complained about inadequate housing, high rents and pollution. Most of the people lived in apartment houses called 'Insula', which consisted of large blocks of three or four floors opening to inner courtyards with gardens. In these houses, sometimes 12 people could stay in a single room. These buildings, built haphazardly by land speculators, would sometimes collapse and cause people's deaths. These structures, made of Roman mortar and brick, had balconies that surrounded the entire block and were also connected to neighboring insulas by bridges over narrow streets. The rich part of the population lived in large country villas with gardens. Where possible, these houses of the courtyard plan type mostly had symmetrical floor plans. The roof of the courtyard called the 'Atrium', was inclined inwards. Thus, rainwater was collected in the pool in the middle of the courtyard. Beyond the atrium was the main room, which was closed off with a curtain, and a dining room large enough to accommodate three large sofas. Some houses in the cities were built with two-storey balconies and porticoes (Demirarslan, 2011). The most beautiful and distinctive examples of houses from the Roman period were built in Pompeii and Herculaneum. With the discovery of the ash-covered building area in the 18th century and the start of surface excavations in 1748, the first detailed evidence of Roman residential life was uncovered.

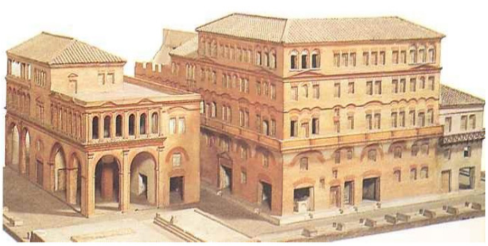


Image 7. Insula Reconstruction (URL-7) on the left, Two-Storey House with Portico, Herculaneum (URL-8) on the right.

2. Housing and Settlement in the Middle Ages

During the Early Middle Ages, as cities shrank and the urban money economy was replaced by a rural barter economy, productivity shifted to feudal castles outside the city. With this change, feudal castles became the center of small rural villages. Simple residential settlements were formed around the feudal lord's castles surrounded by thick adobe walls. Although the feudal lord's residence has not yet reached the palace level, it is more organized than the ones next to it. Another form of housing construction in the Middle Ages was castles. From the time of Charlemagne (after 750 AD), a settlement style dominated by towers and the courtyard around them has been observed. In the courtyard, there were workshops, cellar buildings and various residences surrounded by thick walls surrounding the tower. Over time, to increase security, the wooden towers of these castles were built in A.D. It started to turn into stone towers around the year 1000 (Roth, 2000). This transformation shows the evolution of the castle built for defensive purposes in rural areas during the Middle Ages and the settlement that developed around it (Image 8). All medieval cities, both in the East and in Europe, developed and continued their existence within walls.

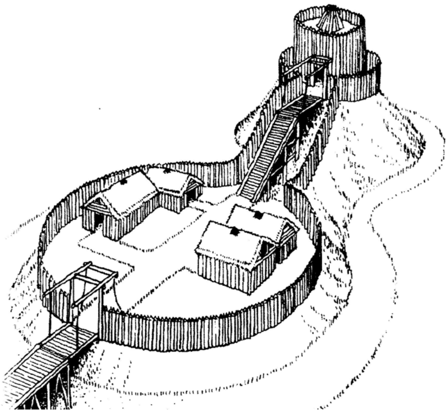

Image 8. *Medieval Wooden Overlord's Residence (Roth, 2000).*

The private wealth accumulation of the Gothic period led to the revival of cities and led to the emergence of a new urban residential architecture. Bishops' houses, which were first built adjacent to cathedrals, were generally planned as two or three floors. Although some of these residences continue to exist today, their interiors have changed over time. The ground floors were generally used as the center of commerce. While there was a courtyard and a kitchen behind the shop on these floors, the living room and a bedroom overlooking the street were in the foreground on the upper floors. There was another bedroom at the back. The third floor contained sleeping space for apprentices and areas for storing goods (Roth, 2000). In the Middle Ages, under the influence of the feudal system and the church in general, defensive and religious structures came to the fore; Settlements in cities consisted of narrow and labyrinth-like streets. Urban residential architecture in the Gothic period is an important turning point that reflects not only living spaces but also the functioning of commerce and daily life (Image 9).

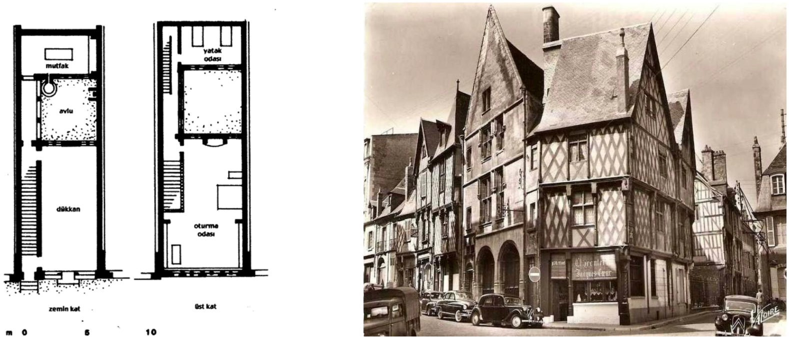

Image 9. *On the left is the 12th-century European Merchant House (Roth, 2000), on the right is the 15th-century City Residence in Bourges (URL-9).*

3. Housing and Settlement in the Periods Between the 15th and 18th Centuries

The Renaissance period, in which Thomas More dreamed and wrote his Utopia and pioneered today's housing and settlement planning with this utopia, led to the development of the understanding of perspective and the construction of buildings that gave importance to symmetry, together with the interest in ancient Roman and Greek architecture. Details of Classical Roman architecture along with the Renaissance are included; Multi-storey city residences were built for rich merchants and nobles with an understanding that cares about proportion and gravity. After the collapse of the Roman Empire, a type of residence called villa, which was not seen in Europe and where nobles and rich people lived outside the city, re-emerged (Image 10).

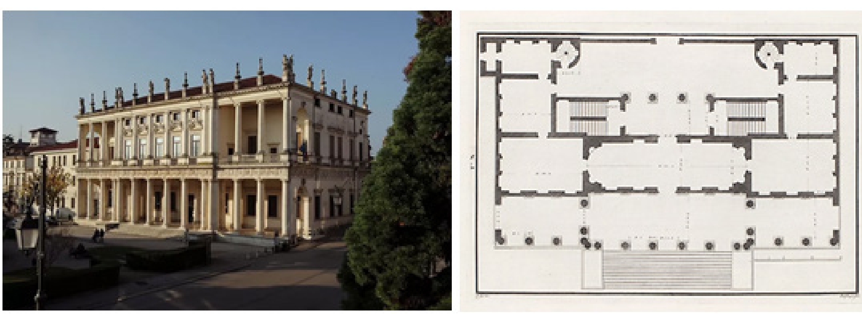

Image 10. *"Palazzo Chiericati' Residence (URL-10) and Plan (URL-11), 1550, Andrea Palladio.*

The Baroque period is characterized by intricate details, decorations and grand palaces. XIV. In France during the reign of Louis XIV, members of the court at Versailles faced difficult living conditions. They had to live in narrow and neglected residences in the palace or in poor conditions in the city. XIV. With the death of Louis, these people left Versailles and built private houses called 'hôtels' on the outskirts of the city. These hôtels were built on large irregular plots and provided access to the entrance pavilion of the house and the stables through an entrance courtyard separated from the street. It also allows the creation of large private gardens. One of the best examples in Paris is the Hôtel de Matignon, designed by Jean Courtonne, and built between 1722 -1724. These new residences open to garden terraces through doors called 'French doors' (Roth, 2000) (Image 11).

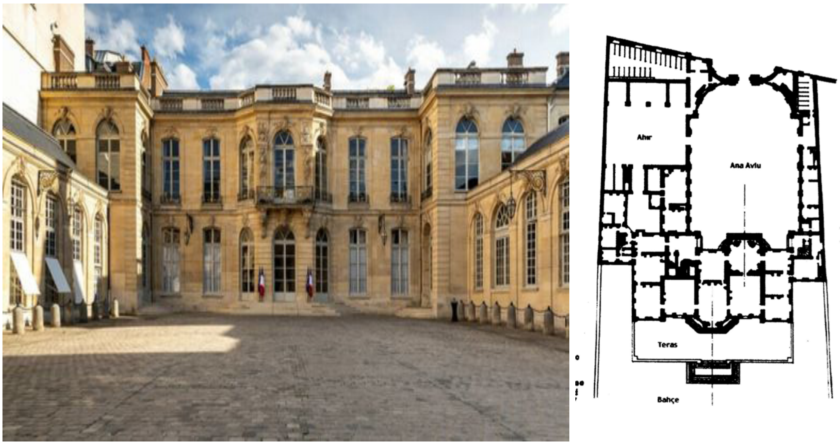

Image 11. *Visual 11. Hótel de Matignon (URL-12) and Plan Diagram. Jean Courtonne, Paris (1722-1724) (Roth, 2000).*

In the 18th century, the intellectuals began to strive to find primitive, pure and unspoiled in art and architecture. Thus, it was argued that the most basic human needs should be included in architecture and that the best examples of this were in ancient architecture. Architecture had to get rid of ornamentation and return to its essence. In 1748, canal workers accidentally found the ruins of the city of Pompeii while excavating near the city of Naples, and the residential architecture of the period underwent major changes. It is seen that Roman forms and space arrangements began to be used in the interior designs of houses. The person who led this revival was architect Robert Adam. Housing and settlement in Europe and America during this century varied greatly depending on factors such as social class, economic status, and geographic location. Housing and settlement conditions in this period generally bore the effects of the feudal social structure and pointed to a period when the Industrial Revolution had not yet taken full effect. In big cities, usually in areas where trade was intense, there were ostentatious houses built by wealthy merchants and businessmen. However, the general population consisted mostly of people living in cramped conditions on narrow streets.

In America, in the early 18th century, especially in Britain's colonies, housing was generally made of wood and brick materials. Mansions owned by nobles and wealthy merchants were generally large and magnificent houses built on large lands. Most people lived in rural areas engaged in agriculture and animal husbandry. Simple farmhouses were generally built to meet the needs of families. Towards the end of the century, the Industrial Revolution began to take effect, leading to significant changes in housing and settlement conditions. However, the housing and settlement in this period generally bore traces of the traditional and feudal social structure.

4. Housing and Settlement in the 19th Century

The 19th century was a period when Europe and America witnessed radical transformations. The Industrial Revolution was at the root of this transformation. With the Industrial Revolution, the greatest movement in human life was observed after the invention of agriculture and writing. However, the spatial conditions of human existence have also been transformed. While nature was replaced by industry, the urban revolution also took place. In a short period, societies have broken away from their past, and human mentalities, life patterns and consumption norms have also changed. With the Industrial Revolution, architecture was influenced by industrial production techniques and the use of new materials such as iron and steel increased. During this period, apartment buildings, residential blocks and industrial complexes became widespread.

Population growth occurred due to reasons such as the discovery of the smallpox vaccine, the development of medicine, and easier births, and as people migrated to cities to find work in the industry, the population of cities in England and Northern Europe exceeded 1 million. During this period, class separation emerged and workers and civil servants began to live in separate housing types. While the working class lived in narrow and cramped housing in cities, middle and nobles lived in rural areas and suburbs. In workers' houses, families of 4-5 people lived in two-room row houses with toilets. The best examples of these 19th century workers' residences are in Amsterdam. In these houses, service areas such as kitchens, toilets and bed niches were built around the main space of 20-25 m^2. Thus, the comfort of the house was ensured by keeping the width of the house to a minimum (Demirarslan, 2022).

In the continental Europe of the period, especially in Austria and Germany, large block houses with courtyards were built. Houses with courtyards became more common with the Berlin city plan in the 1860s. These blocks were divided into volumes as desired by the homeowner. In other words, the rooms were not rigid and the interior of each house was different from the other. The social status of families and houses was determined by whether the house faced the street or courtyard, whether it was in the basement or on the upper floor, and the number of rooms. City administrators believed that such a structure, which brought together different income units under the same roof, would contribute to social peace.

The phenomenon of collective living that emerged with the industrialization process led to residential architecture in which forms taken from nature were used, together with a separatist spirit, at the end of the 19th-century. Casa Milá (1905-1910), the large apartment block built by Antoni Gaudi in Barcelona, is one of the impressive examples of this period. Casa Milá has irregular wall plans, like an enlargement of a microscopic view of a cross-section of a tree trunk. It is clustered around the building's inner courtyards and consists of four apartments on each floor. On the exterior, the massive cut stone walls have gained a natural cliff appearance with their wrought iron railings shaped like seaweed folds (Roth, 2000) (Image 12). This design reflects Gaudi's effort to integrate extraordinary and organic forms into residential architecture, inspired by nature. Casa Milá is a remarkable example not only in terms of architectural aesthetics but also with its functional arrangements.


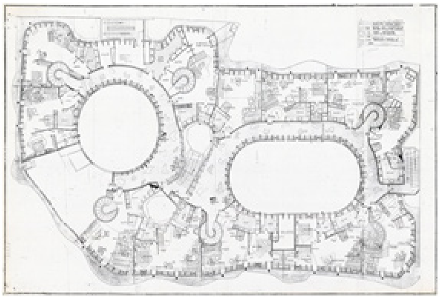

Image 12. *Casa Milá (1905-1910) (URL-13) and Plan (URL-14), Antoni Gaudi, Barcelona.*

5. Housing and Settlement in the 20th Century

While the 19th century was the age of industrialization, the 20th century has now become the age of modernization. Since the new century will be the age of mechanization, communication, speed and movement, the residential architecture of the new age should also keep up with this development. At the beginning of the 20th century, housing problems in big cities, especially housing problems that arose with the increasing migration following the While the 19th century was the age of industrialization, the 20th century has now become the age of modernization. Since the new century will be the age of mechanization, communication, speed and movement, the residential architecture of the new age should also keep up with this development. At the beginning of the 20th century, housing problems in big cities, especially housing problems that arose with the increasing migration following the industrial revolution, led architects and planners to search for new solutions. In this context, the mass housing movement emerged. Inspired by Thomas More's Utopia, the 'Garden City' concept put forward by British urban planner Ebenezer Howard aimed to plan cities sustainability and healthy Howard's vision included plans that combined rural and urban features. Bahçeşehirler emphasized large green areas, common areas and sustainability principles. In America, Radburn, New Jersey, designed by Clarence Stein and Henry Wright, was one of the examples of public housing. Here, a planned living model was envisaged, including parking lots and green areas, planned within large pieces of land called 'superblocks' (Image-13).

Mass housing and satellite city model settlements, which spread all over the world in the 20th century, have led to the development of housing and living habits and interior arrangements in a similar way due to the influence of globalization.

Image 13. Radburn Settlement, New Jersey (URL-15, URL-16).

Architects such as Frank Lloyd Wright, under the influence of Organic Architecture, designed low-rise single-family residences that integrated with nature (such as Waterfall House, Robie House, and Ward Willits House), some architects such as Ludwig Mies van der Rohe and Le Corbusier designed large multi-storey apartment buildings under the influence of modernism. They made the blocks. Ludwig Mies van der Rohe's 1948-1951 Chicago Lake Shore Drive apartment towers, with their prefabricated aluminum window registers and glass tower appearance with a glass-enclosed lobby on the ground floor, became a symbol of urban renewal and modernization, first in the United States and later throughout the world (Tietz, 1999). (Image- 14). These high-rise housing models have spread all over the world and have created the widespread and popular housing model of the century as 'Residence' housing. On the other hand, with the influence of Organic Architecture, architects such as Frank Lloyd Wright designed low-rise single-family residences that integrated with nature (Şelale House, Robie House, Ward Willits Some architects such as his house), Ludwig Mies van der Rohe, and Le Corbusier also built large multi-storey apartment blocks under the influence of modernism. Ludwig Mies van der Rohe's 1948-1951 Chicago Lake Shore Drive apartment towers, with their prefabricated aluminum window registers and glass tower appearance with a glass-enclosed lobby on the ground floor, became a symbol of urban renewal and modernization, first in the United States and later throughout the world (Tietz, 1999). (Image- 14). These high-rise housing models have spread all over the world and have created the widespread and popular housing model of the century as 'Residence' housing.

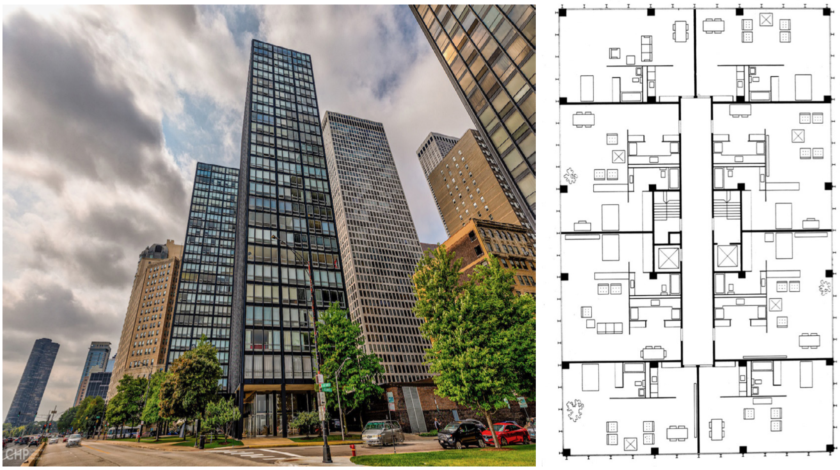

Image 14. *Chicago Lake Shore Drive Apartments (URL-17), Mies van der Rohe.*

However, even though the designs of the Archigram group were not implemented, especially in the second half of the 20th century, they are of great importance as they will be a source of inspiration for the housing and settlements of the future. Archigram is an architectural group founded in the early 1960s, a movement often referred to as 'architectural pop art'. This group is known for its projects that include original and often fantastical ideas about urbanization and lifestyles of the future. Archigram has adopted a perspective that addresses not only architectural design but also cultural, social and technological changes. Archigram has designed 'plug-in' cities using modular and portable building elements. These cities are built on a system where buildings and living spaces can be changed, added and moved. The 'Walking City' project, designed by Ron Herron, includes a city design consisting of portable capsules with giant legs (Image 15). These modular capsules allow users to move to their desired locations. The Instant City project proposes a city design that can be built instantly using a comprehensive infrastructure and portable building elements. This temporary city, where art events, residences and commerce came together, responded to the cultural and technological changes of that period. Living

Pod is a project designed by Peter Cook. This project offers a portable living space for global travelers. The sphere-shaped capsule contains all the necessary life functions. Archigram projects are based on the technological developments and science fiction influences of their time. This caused many of their designs to include technological elements that were not available at the time .

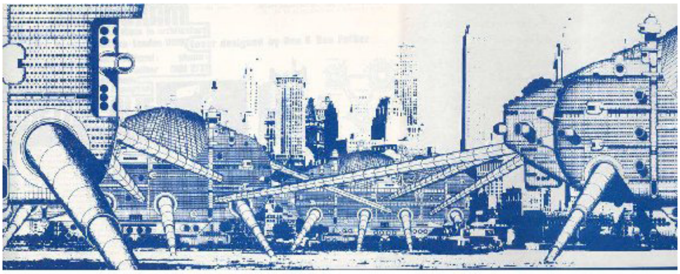

Image 15. *Walking City, Archigram (Herron ve Harvey, 1964).*

The cinema and cartoon industries were also influential in the development of housing and settlement utopias in the 20th century. Ideas about the residential spaces and cities of the future have been put forward in many science fiction films and animations. Undoubtedly, 'The Jetsons' has an important place in our minds. The city where the Jetsons live has a residential area dominated by tall buildings and suspension roads. Buildings are often interconnected and occupation occurs via suspension pathways above ground. This provides fast and efficient transportation within the city. The Jetsons' homes are modern residences with extensive use of automation and robotics. Many functions of the home are performed through robots and automated systems. This makes the family's daily life more comfortable and practical. The Jetson family's home is equipped with artificial intelligence and advanced technology. Innovative features such as home automation and personal assistants powered by voice commands are used to make the characters' daily lives easier. The Jetsons has been a series that has expanded viewers' imaginations about what the future could be like. Advanced technological elements in urban planning and housing design have contributed to the popularity of the cartoon series and to attract the attention of the audience. Essentially, the predictions in this movie formed the basis for smart home and artificial intelligence space installation in the 21st Century.

Image 16. *Jetgiller Çizgi Filminde Yerleşim (URL-18).*

6. Housing and Settlement in the 21st Century and Beyond

Despite the housing utopias that were developed with so many progressive ideas in the 20th century and some of them were implemented, in the 21st century, people began to experience a major residence problem with the migration phenomenon brought to cities by industrialization. In developed and developing countries, this residence problem is tried to be solved with social housing, public housing and even satellite city designs. As a result of many natural and man-made disasters, including earthquakes and the global climate crisis, and migration as a result of events such as war and terrorism, the housing problem has evolved in another direction and attempts are being made to solve it with solutions in the form of temporary or permanent shelters and settlements (Image-17). In fact, it is seen that housing problems related to migration started in some societies in the late 19th and 20th centuries and continue exponentially until today (Salihoğlu, 2023). In this century, which is called the information age, the concept of housing is no longer a shelter designed for a single family to live in; It has turned into a satellite city where thousands of people will continue all their vital activities.

Image 17. Kilis Öncüpınar Temporary Accommodation Center (URL-19).

In the 21st century, housing and settlement have evolved in parallel with technological, environmental and cultural changes. It is possible to classify some important features of housing and settlement from this period as follows:

1)Smart Home Technologies:

Houses are equipped with smart technologies. Features such as smart thermostats, lighting systems, security cameras, and voice control systems provide higher comfort and security in residences.

2) Sustainability and Green Buildings:

With increasing environmental awareness, sustainability is at the forefront in housing designs. Green buildings have energy-saving features and are constructed using environmentally friendly materials.

3) Housing and Settlements with Multiple Use Areas:

Modern residences focus on multi-use spaces. Spaces such as home offices, study corners, and multifunctional rooms increase their suitability for today's working and lifestyles. Likewise, planning residential areas to have more than one function saves time, space and economy.

4) Online Platforms and Virtual Reality:

Housing search, purchase or rental processes occur more frequently through online platforms. Virtual reality allows home buyers to take virtual tours and examine homes in more detail. Likewise, it plays a role in determining the wishes and needs of the user in the architectural and interior design planning of houses, and in transforming the users into participants of the design by perceiving the designed space.

5) Urbanization and Urban Planning:

Urbanization continues rapidly with global population growth. Urban planning is evolving to include elements such as sustainable city models, transportation infrastructure and green spaces.

6) Modular Housing and 3D Printing Technologies:

Modular housing offers home designs that can be built faster and more economically and have advantages in terms of energy efficiency and sustainability. Additionally, residences built using 3D printing technologies also attract attention.

7) Community Formation and Sharing Economy:

Community-oriented housing projects and the sharing economy aim to create living spaces where people can interact more closely and share common areas.

8) Impact of COVID-19 Pandemic:

The COVID-19 pandemic has impacted home designs in response to changing lifestyles such as remote working and learning. Houses can now serve not only as shelter but also as an office or a school. In residential areas and residences, more emphasis is placed on sports areas and personal spaces.

9) Interest in Housing Design for Disadvantaged Groups: Housing designs for individuals in disadvantaged groups in society, such as the elderly, disabled individuals, children, disaster victims, immigrants, and the planning of settlements where these houses come together are becoming increasingly important, especially in developed countries. Settlements consisting of specially designed residences using gerontechnology, smart home systems and sustainability technologies are planned in countries such as the Netherlands, Japan, South Korea, Spain and Ireland.

10) Space Age Architecture: Studies on life on Mars and the Moon appear as complex and high-tech projects that aim to ensure the long-term existence of humans in space. The usability of modular structures designed for life in space is being investigated. Modular design is considered an important principle in the design of these housing units, as it allows parts to be easily replaced and layouts to be customized as needed. For the sustainability of settlements, energy efficiency and resource use should be taken into consideration. Since there is no atmosphere, air production and cleaning is necessary in Mars and Lunar settlements. Appropriate technologies should be used to ensure air circulation. Identification and recycling of water resources is important. Water may need to be produced or cleaned with technologies used in space missions. Since there is no atmosphere in space, radiation protection is important in settlements. Settlements may contain structures underground or covered with special materials. Food production is important for the sustainability of settlements. Greenhouse farming or other innovative methods could be used in space. Harmony among team members to be selected for Mars and Moon settlements is very important. In long-term missions, community psychology and social support play an important role. In order to play this role, the perceptual, physiological and psychological effects of the interior space on people must be well designed. Communication must be maintained between settlements and with Earth. Additionally, transportation within the settlement should also be planned. It is important for settlements to be environmentally friendly. Waste ma-

nagement, recycling and environmental protection measures should be planned. Specially designed technological infrastructures are required for Mars and Moon settlements. This includes energy production, water supply, waste management and other basic needs.

Each of these elements must be meticulously planned and implemented for space life projects to be successful. Space agencies and the private sector are constantly working to develop and realize these concepts. These elements show that in the 21st century, the understanding of housing and settlement has diversified and evolved with a focus on technology and sustainability. Today, various scientific institutions such as NASA and universities organize various competitions and workshops on life and settlement on Mars and the Moon to produce ideas for the future (Image-18).


Image 18. *Examples of Project Studies on Housing and Settlement on Mars (URL-20, URL-21).*

Conclusion

This study addressed a unique turning point in the history of human evolution and settlements. Our understanding of housing, shaped by technological developments starting from caves, is now expanding with a perspective on distant planets such as Mars. The study examined the idea of housing and settlement, which will have a significant impact not only on the past but also on the future of evolution in human history.

In the early settlements, planned houses such as megaron and bithilani generally responded to the needs of communities engaged in agriculture and animal husbandry. Housing structures, which developed in inner city areas in the form of single houses until the 19th century, began to be considered as mass settlement areas from the 19th century onwards. Along with urbanization and industrialization processes, mass housing emerged in the 19th and 20th centuries. The Industrial Revolution, population growth and urban migration required settlements where more people lived and worked together. During this period, structures such as apartment buildings and terraced housing blocks emerged. In the mid-20th century, overcrowding and infrastructure problems in big cities triggered the formation of satellite cities. These cities were independent settlements, usually built in a planned manner, away from the main cities. Satellite cities have developed to provide easy access to housing, education and employment opportunities. The future evolutionary step may be taken towards space settlements. The advancement of science and technology increases the potential for humans to establish habitats outside the world. Space settlements can offer opportunities to live and work in space, beyond humanity's boundaries.

This evolutionary process has continued from past to present, adapting to the needs of people in residential areas, technological developments and social changes. Each period reflects people's adoption of different housing and settlement models to adapt to their environment and respond to evolving conditions.

References

United Nations Centre for Human Settlements (Habitat).(1992) *Multilingual Glossary of Human Settlement Terms*, https://digitallibrary.un.org/record/830503/files/HS_252_92-EN.pdf.

Corsellis, T. Vitale, A. (2005). *Transitional Settlement, Displaced Populations*. Oxfam GB, Oxford.

Demirarslan, D., Demirarslan, O. (2021). "An Overview Of The Criteria Affecting The Design Of Housing Furniture". *Research & Reviews in Architecture, Planning and Design.* Ed. H. Burçin Henden Şolt. s.23-49, Istanbul: Gece Kitaplığı Publishing.

Demirarslan, D. (2011). *Tasarım Tarihi Tarih Öncesi Dönem ve Antik Çağ Uygarlıklarında Mekân ve Mobilya Tasarımı*. KOÜ Press, Kocaeli.

Demirarslan, D. (2022). *Ütopya ve Toplu Konut*. Istanbul: Gece Kitaplığı Publishing.

Efe, T., "Batı Anadolu", *Arkeo Atlas Dergisi*. No:2, s.94-137, 2003.

Erarslan, A. (2013) . "Kırsal Mimaride Tarihsel Sürekliliğin Bir Yorumu Olarak

Kahta Bölgesi "L-Hilani" Yapıları". *Mimarlık Dergisi*: no. 370

Hodder,I., (2006). *Çatalhöyük Leoparın Öyküsü*. Istanbul: Yapı Kredi Press.

Herron, R., Harvey, B. (1964). "A Walking City" , *Archigram 5*.

Lepore, M. (2017). The Right to the Sun in the Urban Design. *Vitruvio – International Journal of Architectural Technology and Sustainability*. 2(1) s.25-43.

Roth, L. (2000). *Mimarlığın Öyküsü*. İstanbul, Kabalcı Press.

Salihoğlu, E., F., (2017). Eski Anadolu Uygarlıklarında Mekân-Donatı Elemanları Tasarımları Ve Etkiler. KOÜ, SBE, Master Thesis Kocaeli: Kocaeli University.

Salihoğlu, E. F. (2023). *Geç Osmanlı Döneminde İstanbul'a Yapılan Zorunlu*

Göçlerin Kent Mekânları Üzerinden İncelenmesi. Phd Thesis. KOÜ, FBE, Kocaeli: Kocaeli University.

Tietz, J. (1999).*The History Of Architecture*. Könemann.

URL-1. https://www.thearchaeologist.org/blog/the-theopetra-cave-ancient-secrets-of-the-worlds-oldest-habited-cave, Date of Access:10.3.2024.

URL-2. https://www.catalhoyuk.com/site/architecture, Date of Access:10.3.2024.

URL-3. https://memim.com/bit-hilani.html, Date of Access:10.3.2024.

URL-4. https://www.wikiwand.com/tr/Demircih%C3%B6y%C3%BCk#Media/Dosya:Demircih%C3%B6y%C3%BCk_plot_plan.jpg, Date of Access:10.3.2024.

URL-5. https://www.crystalinks.com/egypthomes.html, Date of Access:10.3.2024.

URL-6. https://exploreluxor.org/ancient-egyptian-houses/, Date of Access:10.3.2024.

URL-7. https://theromanlifeforum.wordpress.com/2018/06/13/the-roman-insulae/, Date of Access:10.3.2024.

URL-8. www.wings.buffalo.edu, Date of Access:10.3.2024.

URL-9. https://archimaps.tumblr.com/post/122206325892/the-medieval-houses-bourges, Date of Access: 10.3.2024.

URL-10. https://www.italia.it/it/veneto/vicenza/luoghi-della-cultura/palazzo-chiericati, Date of Access: 10.3.2024.

URL-11. https://it.wikipedia.org/wiki/Palazzo_Chiericati#/media/File:Palazzo_Chiericati_pianta_Bertotti_Scamozzi_1776.jpg, Date of Access:10.3.2024.

URL-12. https://www.leparisien.fr/etudiant/sortir/paris/eve-jep-visite-de-l-hotel-de-matignon-la-cour-d-honneur-le-bureau-de-la-premiere-ministre-les-salons-du-rez-de-chaussee-le-jardin-journees-du-patrimoine-2023/, Date of Access:10.3.2024.

URL-13. https://www.metalocus.es/en/news/mila-house-la-pedrera-antoni-gaudi-one-most-emblematic-buildings-barcelona, Date of Access:10.3.2024.

URL-14. https://www.arquitecturacatalana.cat/en/works/nous-apartaments-a-les-golfes-de-la-casa-mila, Date of Access:10.3.2024.

URL-15. https://interactive.wttw.com/ten/towns/more/radburn, Date of Access:10.3.2024.

URL-16. https://arquiscopio.com/archivo/2013/04/28/supermanzana-de-radburn/?lang=en, Date of Access:10.3.2024.

URL-17. https://www.archdaily.com/54260/mies-van-der-rohe-lake-shore-drive-restoration-kruek/5037dc3f28ba0d599b000010-mies-van-der-rohe-lake-shore-drive-restoration-kruek-photo, Date of Access:10.3.2024.

URL-18. https://aghostinthefigures.com/2023/01/06/keeping-up-with-the-jetsons/, Date of Access:10.3.2024.

URL-19. https://tr.wikipedia.org/wiki/Kilis_%C3%96nc%C3%BCp%C4%B1nar_M%C3%BClteci_Kamp%C4%B1#/media/Dosya:AFAD_Kilis_kamp%C4%B1.jpg, Date of Access:10.3.2024.

URL-20. https://www.dezeen.com/2018/07/27/nasa-announces-winners-3d-habitat-centennial-challenge-competition-printed-habitat-mars/, Date of Access:10.3.2024.

URL-21. https://www.archdaily.com/1000446/how-architecture-and-design-on-earth-helps-to-plan-for-life-on-mars, Date of Access:10.3.2024.

BÖLÜM 4

FROM PAST TO FUTURE; ADOBE AS A SUSTAINABLE BUILDING MATERIAL

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1. INTRODUCTION

"What we observe is not nature itself, but nature exposed to our method of questioning" -Werner Heisenberg

Mankind has benefited from caves, tree hollows and other natural formations in the early periods for shelter, which is one of their most basic needs, and then has developed a conscious building production tradition with technical and technological developments. The building production practice, which is an action as old as the history of humanity, has a multidimensional structure that includes construction technique, material preferences and design processes. Changing technology, living conditions and social dynamics transform this building production practice, which has existed since the very beginning of humanity, and material preferences, in addition to the construction technique and design discussions, is on the agenda again, especially within the framework of sustainability and ecological design approaches.

Today, with rapid urbanization, industrialization and uncontrolled use of natural resources, new architectural approaches in the context of sustainability have come to the fore with the highest level of human damage to nature and other living things (1). In this period, when the damage caused by humans to nature is at the highest levels in human history, the effects of climatic crises, global warming, and environmental risks in terms of both world and human health are quite thought-provoking. In all these negative scenarios, building production practices are being questioned again and it is thought that the use of nature-friendly, long-lasting and recyclable materials can be an approach that can provide a solution in this crisis environment within the framework of sustainable architecture (2).

It is seen that certain criteria expected from buildings have been agreed upon within the scope of the concepts of sustainability and ecological design, which are among the topics that have been discussed intensely in the last few decades; use of natural and recyclable materials, initial production cost and lifetime, energy efficiency, climatic and usage performance. It is thought that an irreversible process has begun in the Anthropocene era, where humans have absolute dominance over nature and the damage to nature is at its highest level, and it is emphasized that urgent measures should be taken in this regard (3). Today, where the use of environmentally friendly materials is at the center of these discussions, the possibilities of using adobe and earth-based materials which can be considered as old as human history, are questioned through experimental studies. In today's world, where both construction techniques and material contents are transforming with the developing technology, the usage areas of adobe in alternative technological systems have been evaluated within the scope of the study and projections and suggestions have been developed on the future course of this process.

2. THE ANTHROPOCENE AGE AND CRISES

"Things derive their being and nature by mutual dependence and are nothing in themselves" –Nagarjuna, 2nd century BC

As a reflection of the industrial revolution, with the progress of industrialization and modernization, energy has become an indispensable commodity of modern life. The concept of Anthropocene defines a geographical period in which humans dominate the entire world ecosystem and all kinds of conscious or unconscious ecosystemic movements are under human control within the framework of theories of geography and critical theory (4). In terms of geography theory, the Earth has been in an era called the Holocene (Holocene) for the last 12 thousands years. The Holocene period covers the period in which the Earth worked as a holistic ecosystem and therefore produced boundary conditions. Boundary conditions mean that the earth's working state is limited to optimum conditions in the form of a metaphorical metabolism (5).

Crutzen and Stoermer (2000) refer to the new geographical period in which man became the main transforming force as the "Anthropocene" (Anthropocene). Crutzen and Stoermer (2000), who define the concept of Anthropocene, claim that while describing the current geographical situation, it is no longer possible to talk about the boundary conditions formed in the context of the Holocene epoch (6). In this context, Castree (2014) defines the Anthropocene briefly as the "Post-Holocene Age" (7).

The world is facing an environmental crisis unprecedented in human history. Carbon dioxide levels have reached heights not seen in the past three million years. Such far-reaching changes mark a new geological era, the Anthropocene (8), in which humanity has disrupted the balance of nature at the highest level. This age requires a major transformation in the way we produce and consume energy against the pressures (such as climate change) caused by environmental destruction through natural plunder because the biggest cause of environmental degradation today is the global dependence on fossil fuels (oil, natural gas, coal) (9) .

The Anthropocene offers a socio-cultural-spatial integrated framework for understanding global environmental change and provides a platform for environmental policy. Thus, it offers an understandable and compelling key narrative that brings together epistemological, political and normative concerns. Rockström et al. (2009) discussed the Anthropocene Age in the Nature (journal) under nine main headings in the context of the Earth ecosystem (10). These titles are; climate, ocean acidity, chemical balance, atmospheric emissions, biodiversity, land use patterns, clean water, nitrogen and phosphorus cycles, ozone layer thickness (3).

Industrialization, which is one of the most fundamental reasons for the emergence of the Anthropocene era, has led to important transformations in the building sector as well as in many areas. This change has affected many components of the construction industry, from construction techniques to building materials. With each change came new problems. Rapid production and new materials, which are far from being natural, have brought another system that will come after it, for example, problems related to building physics, and while using different materials for problem solving, situations that negatively affect the health of living things have begun to emerge. The solution of the negativities that emerged in this process, which developed like the domino effect, began to be sought in ecological approaches (11). As a result, the importance of sustainability and ecology concepts has increased and these concepts have gained popularity in the academic environment. Especially in building production activities, subjects such as low-cost, fast production, use of natural and harmless resources for human health and energy efficiency have been the prominent topics. In building production processes against the potential crises of the Anthropocene era, the concepts of energy efficiency, conservation and correct use of natural resources, sustainability and ecology have gained great importance and solutions have been sought throuht these copcepts for climatic disaster scenarios on the agenda (9).

3. ADOBE AS A SUSTAINABLE MATERIAL AND ITS HISTORICAL PROCESS

Earth based construction systems, the world's first known building production practice, are first seen in structures using adobe bricks in Mesopotamia around 10,000 BC, according to documented records (12). According to Houben and Guillaud (1994), the rammed earth technique was first developed during the Three Kingdoms Period (221–581 AD) (13). Currently, approximately 30% of the world's population lives in buildings made of earthen material; The earth construction system exists in many different cultures around the world and is still used in some countries as the most basic construction technique (14).

Earth constructions offer economic and environmental benefits, especially when used in developing countries where material and labor costs cannot be covered and other construction materials and technologies are not available (15). The earth construction tradition is a type of sustainable architectural method often encountered in vernacular structures. Vernacular architecture is based on local requirements and building materials and reflects local traditions (16). According to the Brundtland Commission (1987) of the UNCED (United Nations Conference on Environment and Development), sustainable architecture is a structure that fulfills the requirements of contemporary society without denying the ability of the next generation to meet their needs. Earth construction is an environmentally friendly technique with a social and cultural contribution (17).

Due to its relatively easy applicability and the use of local materials, the costs in such construction systems are quite low. Earthen buildings generally have a lower embodied energy and carbon footprint than buildings with more advanced systems such as concrete, steel or masonry (18). This is because the earth-based materials generally do not need any firing process before use. Although earth-based materials are obtained with different methods and mixtures in different regions, the most widely used one is adobe (Figure 1).

Fig 1. Unesco World Heritage sites and Earth constructions across the globe (28)

Made from humid sandy soil, adobe bricks are obtained by drying in the sun after mixing and moulding. Lime or Natural fibers such as straw are often added to improve their mechanical performance. Adobe is an extremely simple form of earth construction and with this technique the shrinkage associated with the construction of large structures is avoided. Mud bricks can be produced from various soils and can be evaluated in two groups: earth adobe and lime adobe. However, the soil content affects the moisture uptake and swelling of the adobe blocks as well as the moisture level in the walls. In this sense, the soil mix content should be of workable consistency, but the moisture level should be well adjusted as swelling and shrinkage can damage the walls (19).

It has been documented by archaeologists that the adobe construction technique was frequently used in the ancient world and that there are still surviving examples of mud-brick structures in many parts of the world

(20). If an adobe building is built with the right materials and techniques, it can last for hundreds of years, is fully recyclable and consumes low energy. Today, it is still possible to find hundreds of years old adobe buildings that require minor interventions around the world. This situation increases the interest in the use of adobe as an environmentally friendly material for sustainable construction techniques (21).

There is no consensus on the origin of earth-based buildings. According to Torgal and Jalali, the first adobe structures discovered in Turkmenistan are dated between 8000 and 6000 BC (22). Daudon et al. (2014) states that this technique emerged in Europe during the Iron Age (23). Although it is not possible to date the beginning of the adobe construction technique, it is known that this building type emerged in a period between 6000 and 10,000 BC. The first use of mudbrick in Europe can be dated to the small houses built on stone foundations in the Greek settlement of Sesklo around 5300 BC. The use of earth with timber in northern Europe means that many archaeological sites have decayed and only foundations remain, making building materials difficult to evaluate. In central Turkey, the remains of mudbrick buildings date back to 1600 BC (22).

Since it is the simplest and easiest construction technique, the production of adobe structures has spread all over the world, especially in countries where natural earth materials are easily available. However, with the scientific and technological developments, the use of this construction technique has decreased over time, especially in more developed countries, despite the advantages it offers in terms of sustainable development (24).

Composition and properties of adobe

Adobe is considered a very simple production and construction technique. For this reason, many old adobe buildings are still in use today. Depending on the construction, adobe blocks come in many different shapes and sizes. Although there are many dimensions depending on the usage common adobe block sizes are approximately 0.45 × 0.30 × 0.12 m when used in residential buildings and 0.45 × 0.20 × 0.12 m when used in the construction of boundary walls (24). The adobe construction technique requires the use of plastic soil and clay, which is mostly used where water is available. The use of clay soil leads to cracks in the drying phase due to shrinkage of the material. For this reason, straw or other plant fibers are often mixed into adobe mixture to prevent cracking (25).

To obtain the best mechanical and thermal properties, adobe walls must be thick. Accordingly, there is a high risk of cracking during drying and axial shrinkage may occur. Certain stages of adobe manufacturing require skilled labor. According to the literature, the soils used for adobe production should contain 15-16% clay (26). To achieve the best possible results, the material used must have sufficient machinability and plasticity. There are different opinions about the use of natural fiber in the adobe material mixture. While some think that this is a necessity to prevent cracking, others state that deterioration of the fibers over time may cause a decrease in the mechanical strength of mudbrick blocks (27).

Calatan et al. States that adding 9-10% fiber by volume is the optimum value for the properties of adobe bricks (26). Properties such as water absorption and mechanical strength develop in mud bricks where there is sufficient kaolinite. It should be noted that the amount of clay minerals should be moderate in order to avoid cracking in the material (24). The adobe construction is simplistic, similar to the traditional brick masonry technique. Gomaa et al., in their study in 2022, developed a proposal for the classification of earth construction systems (Figure 2) (28).

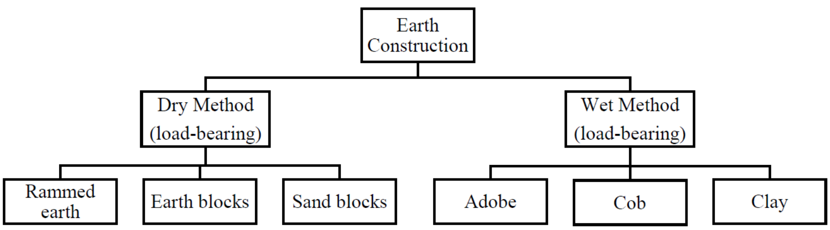


Figure 2. Suggested classification of earth construction by Gomaa et al. 2022 (28)

In another study, the production process of adobe blocks was interpreted as in the graphic below (Figure 3) (29). Although firing takes place in the process described in the graphic, it is not always applied in the production of adobe blocks and generally the sun drying process is sufficient for the adobe to gain strength. The application stages of adobe production together with the human factor can be seen in Figure 4.

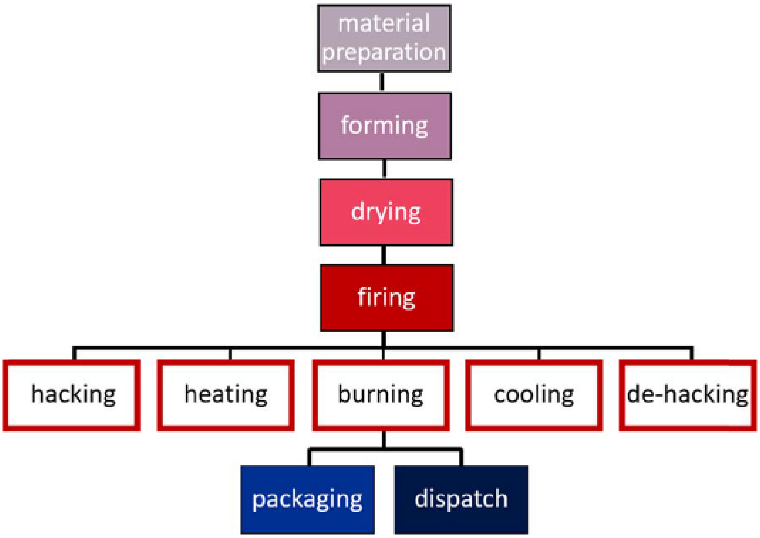


Figure 3. Production process of adobe mud bricks (29)

Figure 4. Production process of adobe mixture (29)

4. TECHNOLOGICAL SYSTEMS EMPLOYING ADOBE

The global and climatic crisis scenarios that came to the fore with the Anthropocene era caused future concerns all over the world. For a sustainable and livable world, the need to reconcile with nature and compensate for the damage done to it has become an opinion agreed upon by all branches of science. The discipline of architecture and building production practices is one of the areas that are discussed again in this process and "new" truths are sought. In this context, alternative uses of adobe, which can be easily accessed almost all over the world and which is still the basic building material of one-third of the buildings in the world, and its possibilities for use in technological systems with a contemporary approach are investigated. In this part of the research, the technological systems that are currently developed using adobe and earth-based materials are examined. Robotic systems and 3D printers, which are among the current technologies, are the areas where earth-based materials are used most intensively for building production purposes today with a digital design approach.

Recently, digitally manufactured earth construction systems are gaining popularity. This method uses one or more digital fabrication techniques. The use of digital fabrication techniques in construction has been increasing in the last 20 years, as a result of the search for more complex forms, less labor intensive and faster construction process (30). In general, digital fabrication and production processes are grouped as 2D and 3D techniques. 2D manufacturing processes include laser cutting technologies operating on a 2D axis, while 3D techniques include four categories: additive, subtractive, formative and assembly systems (Figure 5) (28).

(1) (2) (3) (4)

Figure 5. Types of 3DP techniques: (1) Additive, (2) Subtractive, (3) Formative, (4) Assembly (28)

These techniques use machines that can move in three or more axes (for example, industrial robotic arms) in the manufacturing process. Automated manufacturing had an intense attention in the field of construction and architecture in recent years, and as a result, there has been a significant improvement in 3DP technologies (31). Most of the digital earth construction applications are focused on 3D printing technology, just as seen in cement-based reinforced concrete construction applications (28). Figure 6 shows the production model and material rates used in digital earth-based construction applications used today.

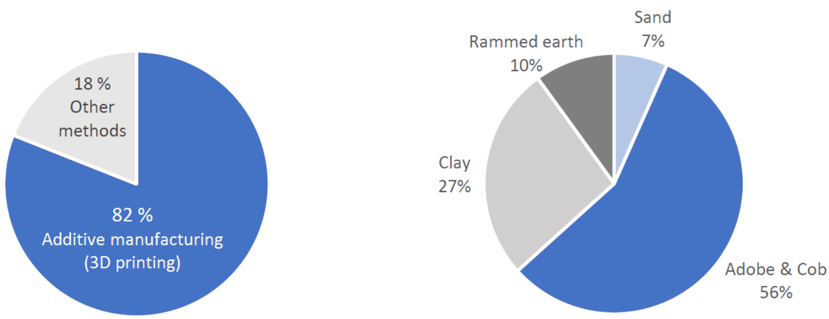


Fig 6- a.Percentage of fabrication methods. b. Percentage of construction methods. (28)

Digital manufacturing applications developed using earth-based materials have gained momentum in the last 10 years (Figure 7)

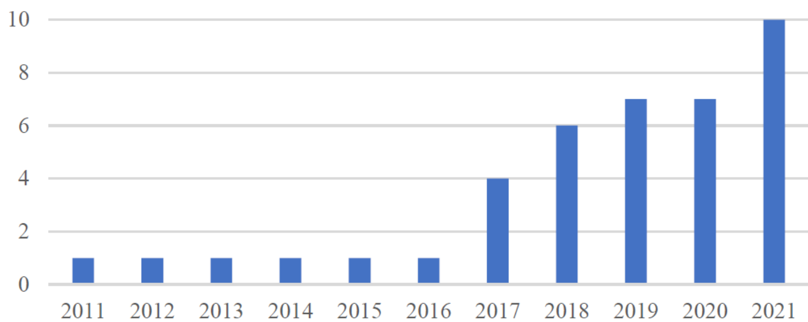
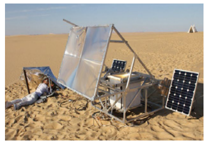
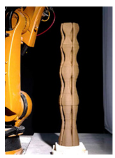
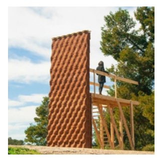
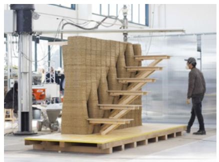


Figure 7. Number of recorded works on digital manufacturing of earth per year. (28)

Some of the important studies developed by digital production method (mostly robotic 3D printing) in recent years can be seen in the table below.

Table 1. Emerging earth based digital productions

Material Type	Year	Project	Image
	2011	Solar sintering of sand by Markus Kayser	 
	2012	Stone Spray Robot	  
	2015 (left) 2017 (mid) 2018 (right)	Pylos 3DP clay (left) TerraPer-for-ma (mid) Digital ado-be (right)	  

	2018	Earth house prototype by WASP	 
	2018	3D printing system of earth by WASP	 
	2019	3DP adobe wall with embedded staircase	  
	2021 (left) 2020 (mid) 2020 (right)	3DP adobe by Emergent Objects(left) Mud Fron-tiers-mid CasaCovida prototype (right)	  

5. CONCLUSIONS

Building production is an important practice that is affected by the resource consumption rate that has affected the whole world in recent years and the problems experienced due to its results. While the resources requ-ired to produce buildings are rapidly depleted in nature; artificial sources harm nature. In this context, there is a significant increase in the tendency towards materials that are the most accessible and most abundant in order to produce structures. When the materials used in building production in the past are examined, it is seen that earth based materials come first in terms of accessibility and harmony with nature. Adobe, which is a building material obtained by mixing the soil with various additives, stands out as a resource whose importance is understood and whose use is increasing in this sense. Adobe material is compatible with almost all the parameters of today's sustainability understanding. As one of the most suitable materials that can be used to produce sustainable buildings and ensure that these structures are passed on to future generations, adobe is often associated with rural areas; not preferred in urban areas.

Adobe is almost as old as human history and is one of the first materials used by human beings for building production. Adobe (30% of the existing building stock in the world is composed of mud-brick structures), which has still an important place in our building production practices for thousands of years, tends to regain its popularity, especially with the effects of the Anthropocene era, which it lost due to industrialization and modernism. Experimental applications regarding the use of adobe materials in digital robotic systems and 3D printing systems have increased especially in the last 10 years.

With the idea of combining low-cost and sustainable materials with emerging new technologies, a new industry is emerging day by day. The successful use of digital earth-based construction systems in different scales in the last 10 years, from simple forms to large-scale construction, has expanded the scope of digital manufacturing beyond less environmentally friendly materials such as reinforced concrete. The work done so far provides a roadmap that can bring digital earth construction closer to an industrial scale and narrow the gap between earthen material and contemporary digital practice. Considering the course of digital earth-based production systems that have developed rapidly in recent years, it is obvious that this technological building production practice will find a much more widespread application area in the near future. Although the technological uses of adobe material are discussed within the scope of the study, the questioning and development of similar digital production systems on different sustainable materials, their widespread use compared to the less environmentally friendly materials that are used intensively today, can be an effective method in reducing the damage caused by humanity to nature and compensating for the damage that has occurred. In a world where the damage to nature is increasing day by day with industrialization, there is an inevitable return to natural and sustainable materials. Perhaps this is the only way to leave a livable world to future generations.

6. REFERENCES

[1] Tosun, E. (2017) Sürdürülebilirlik Bağlamında Ekolojik Kent Söylemi. Bolu Abant İzzet Baysal Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 17 (4).

[2] Olğun, T, N., Akyıldız, N. A., Ekici, B. B., Açıkgenç Ulaş, M., (2019) Doğal Yapı Malzemelerinin Sürdürülebilirlik Bağlamında Değerlendirilmesi: Kerpiç Malzeme Örneği, III. Uygulamalı Bilimler Kongresİ, Diyarbakır.

[3] Boyacıoğlu, C., (2017) Mimarlıkta Çevreci Yaklaşımların Antroposen Kavramı Bağlamında Tartışılması, İTÜ, Doktora Tezi.

[4] Rose, D., Dooren T., Chrulew M., Cooke S., Kearnes M., & O'Gorman E. (2012) Thinking through the environment, unsettling the humanities, Environmental Humanities, 1(1), 1-5.

[5] Swyngedouw, E. (2006) Metabolic Urbanization: The Making of Cyborg Cities. In N. Heynen, M. Kaika, E. Swyngedouw (Eds.), In the Nature of Cities: Urban Political Ecology and the Politics of Urban Metabolism (pp.21-40). Abingdon: Routledge.

[6] Crutzen, P. & Stoermer E. (2000) The anthropocene, Global Change Newsletter, 41, 17-18.

[7] Castree, N., (2014) The anthropocene and geography II: current contributions, Geography Compass, 8(7), 450-463.

[8] Davies, J., (2016) The Birth of the Anthropocene. Berkeley: University of California.

[9] İşeri, E. (2021) "Antroposen Çağında Doğu Akdeniz'de Enerji Güvenliğini Yeniden Düşünmek", Güvenlik Yazıları Serisi, No. 57.

[10] Rockström, J., Steffen, W., Noone, K. (2009) A safe operating space for humanity. Nature 461, 472–475

[11] Parlak Biçer Z. Ö., Yağmur, Y., Ergüneş, F., (2016) "Tarihi Ve Kültürel Miras Kapsamına Giren Alanların Sürdürülebilir Tasarım Kriterleri Açısından İncelenmesi Örnek Alan: Talas", IV. Çevre Tasarım Kongresi- Tarihi Çevrede Tasarım.

[12] Heathcote, K. A. (1995) Durability of earthwall buildings. Construction and Building Materials 9 (3):185–89.

[13] Houben, H., Guillaud, H., (1994) Earth construction: a comprehensive guide, 1st ed. Intermediate Technology Publications, London.

[14] Vega, P., A. Juan, M. I. Guerra, J. M. Morán, P. J. Aguado, and B. Llamas. (2011) Mechanical characterisation of traditional adobes from the north of Spain. Construction and Building Materials 25:3020–23.

[15] Fratini, F., R. L. Pecchioni, and U. Tonietti. (2011) The earth in the architecture of the historical centre of Lanezia Terme (Italy): Characterization for restoration. Applied Clay Science 53:509–16.

[16] Niroumand, H., M. F. M. Zain, and M. Jamil. (2013) A guideline for assenssing of critical parameters on Earth architecture and Earth building as a sustainable architecture in various countries. Renewable and Sustainble Energy Reviews 28:130–65.

[17] UNCED Bruntland Comission. Sustainable Design of Research Laboratories, Planning, Design, and Operation. 1987.

[18] Bui, Q. B., J. C. Morel, V. B. V. Reddy, and W. Ghayad. (2009) Durability of rammed earth walls exposed for 20 years to natural weathering. Building and Environment 44:912–19.

[19] Burroughs, S. (2008) Soil property criteria for rammed earth stabilization. J. Materials Civil Engineering 20 (3):264–73.

[20] Quagliarini, E., S. Lenci, and M. Iorio. (2010) Mechanical properties of adobe walls in a Roman Republican domus at Suasa. Journal of Cultural Heritage 11:130–37.

[21] Calabria, A. J., W. L. Vasconcelos, and A. R. Boccaccini. (2009) Miscrostructure and chemical degradation of adobe and clay bricks. Ceramics International 35:665–71.

[22] Torgal, P., and S. Jalali. (2012) Earth construction: Lessons from the past for future eco-efficient construction. Construction and Building Materials 29:512–19.

[23] Daudon, D., Y. Sieffert, O. Albarracín, L. G. Libardi, and G. Navrta. (2014) Adobe construction modelling by discrete element method: First methological steps. 4th International Conference on Building Resilience. Procedia Economics and Finance 18:247–54.

[24] Silveira, D., H. Varum, A. Costa, T. Martins, H. Pereira, and J. Almeida. (2012) Mechanical properties of adobe bricks in ancient constructions. Construction and Building Materials 28:36–44.

[25] Christoforo, E., A. Kylili, P. A. Fokaides, and I. Ioannou. (2016) Cradle to site Life Cycle Assessment (LCA) of adobe bricks. Journal of Cleaner Production 112 (Part 1, January 20):443–52.

[26] Calatan, G., A. Hegyi, C. Dico, and C. Nircea. (2016) Determining the Optimum Addition of Vegetable Materials in Adobe Bricks. Procedia Technology 22:259-65. Engineering,

[27] Sharma V., Vinavak H. K., Marwaha B. M. (2015) Enhancing sustainability of rural adobe houses of hills by addition of vernacular fiber reinforcement. International Journal of Sustainable Built Environment 4(2)

[28] Gomaa, M., Jabi, W., Soebarto, V., Xie, Y. M. (2022) Digital manufacturing for earth construction: A critical review, Journal of Cleaner Production, Volume 338.

[29] Dalkılıç, N., Nabikoğlu, A., (2017) Traditional manufacturing of clay brick used in the historical buildings of Diyarbakir (Turkey), Frontiers of Architectural Research, Volume 6, Issue 3, Pages 346-359,

[30] Soto, B.G. De, Agustí-juan, I., Hunhevicz, J., Habert, G., Adey, B. (2018). Productivity of digital fabrication in construction: cost and time analysis of a robotically built wall. Autom. Constr. 92, 297–311.

[31] Geneidy, O., Ismaeel, W.S.E., Abbas, A. (2019) A critical review for applying three-dimensional concrete wall printing technology in Egypt. Archit. Sci. Rev. 0, 1–15.

BÖLÜM 5

URBAN MORPHOLOGY AND ENERGY-EFFICIENT DESIGN[1]

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1. Introduction

The second wave of the Industrial Revolution led to significant transformations, such as the growth of industry and the expansion of cities. Since then, architectural design has encountered difficulties due to the growing demand for buildings, resulting in the development of unsustainable structures. This research focuses on the worldwide effects of the changes that began during this time, including rural-urban migration and environmental and infrastructural issues in urban areas. It also highlights the importance of energy-efficient design criteria within the framework of sustainable urbanization goals. The second wave of the Industrial Revolution led to mass migration from rural areas to cities worldwide. This wave of migration has increased the need for housing and infrastructure systems in cities and led to unplanned urbanization and environmental problems. This process has increased the population density in cities and the demand for essential services such as infrastructure, housing, transport, and energy. That required a transformation of urban planning, design, and energy policy. That has necessitated reshaping of urban planning, design, and energy policies. Energy efficiency plays a critical role in achieving sustainable urbanization goals, especially given the share of cities in energy consumption and greenhouse gas emissions. Hence, energy efficiency stems not only from the design of buildings but also from transportation systems, infrastructure projects, and the organization of public spaces. Most of the world's population currently live in cities in 2023, and this trend will continue to increase until 2050 (Figure 1). Prioritizing energy efficiency and environmental awareness is essential to attain sustainable urban development objectives.

This study can provide policy implications to shape the future roadmap of urbanization and sustainability efforts. This century-long change in urbanization, as seen in Figure 1d, tends to affect Turkey as well. The percentage of the population in urban areas, which was 25.5% in 1951, is estimated to increase to 86% in 2050. Migration to cities, especially from rural areas and other countries, together with the economic policies implemented, can be the reasons for the rapid increase in the urbanization rate in Turkey after 1980. The exponential growth of urbanization has been the driving force behind economic growth. This growth is evident in major cities such as Istanbul, Ankara, Izmir, Antalya, and Adana. These cities have become dynamic centers of productivity. They have grown with industrialization, technological innovations, and advancements in the field of education. However, this increase in the urban population has led to a housing shortage and environmental problems. The environmental impacts of urbanization, expressed in increased pollution, threaten both the natural environment and public health (Emir et al., 2022). Additionally, the rural population relative to the urban population in Europe has declined, but the urban population rate will the total population rise to 83.7% in 2050 (Figure 1b).

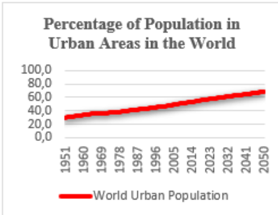

Figure 1a: Urban population in the World as a percentage of the total population (World Urbanization Prospects, United Nations, 2018)

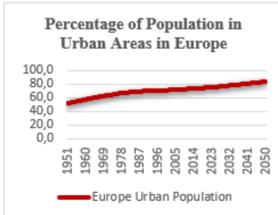

Figure 1b: Urban population in Europe as a percentage of the total population (World Urbanization Prospects, United Nations, 2018)

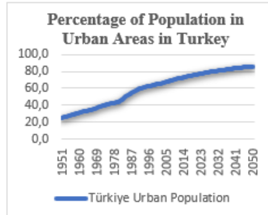

Figure 1c: Urban population in Turkey as a percentage of the total population (World Urbanization Prospects, United Nations, 2018)

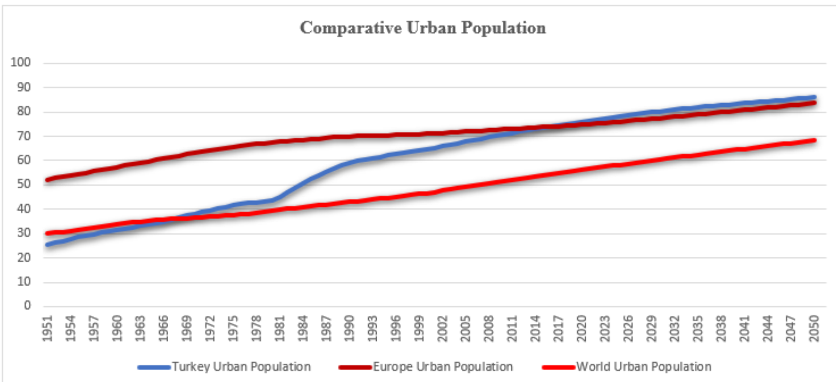

Figure 1d: Comparison of Urban Populations in the World, Europe, and Turkey (1951-2050) (World Urbanization Prospects, United Nations, 2018)

Figure 1: Figure 1(a,b,c) shows the urban population in the World, Europe, and Turkey as a percentage of the total population and Figure 1(d) shows the Comparative Assessment (World Urbanization Prospects, United Nations, 2018).

The rapid process of urbanization poses challenges such as limited access to essential services like healthcare and education, as well as quality and sustainable accommodation and infrastructure services. Although rapid urbanization is associated with increased economic growth, it also exacerbates economic disparities across different regions of the world (Badur & Sohag, 2023). Additionally, energy consumption in urban areas contributes to greenhouse gas emissions, given that cities are hubs of economic and social activities. In developed countries, buildings in urban areas are responsible for a significant portion, ranging from 20% to 40%, of total final energy consumption (Pérez-Lombard, Ortiz, and Pout, 2008). Thus, the nexus between cities and energy is fundamental, considering that urban settlements, covering only 2% of the Earth's surface, account for all consumption (Madlener & Sunak, 2011). In light of these issues, this study aims to explore the sustainability and energy efficiency of architectural designs from a morphological perspective. Methodologically, it highlights the integration of energy-efficient elements in urban planning processes and emphasizes the role of natural resources like sunlight, groundwater, surface water, and wind in architectural design, drawing from an extensive literature review. Following the introduction, the study delves into a comprehensive literature review. This section first discusses urban morphology and its various components, exploring different schools of thought within this field. It traces the evolution of morphology as a fundamental aspect of urban studies, detailing how different schools approach urban fabric and analyze the historical development of cities. Subsequently, the interplay between urban morphology and energy is examined, followed by an analysis of the relationship between sustainability and energy-efficient design. The section aims to assess the impact of urban morphology on the past, present, and future of cities within the context of sustainability and energy-efficient design. The literature review section concludes by discussing the significance of natural resources such as sunlight, groundwater, surface water, and wind in architecture and urban planning. Finally, the study presents its conclusions and provides recommendations for policymakers.

2. Literature Review

2.1. Urban Morphology

The term 'morphology' was first proposed by Johann Wolfgang Von Goethe at the end of the 18th century and used to mean "the science that deals with the essence of forms." Goethe (1952) stated that morphology involves examining the physical shape of living beings and works of art (Wilkinson & Academy, 1953). In this context, Goethe aimed to establish a connection between the external form of an organism or artistic piece and its internal structure, defining the internal components of each other. Additionally, Goethe viewed both external and internal forms as the result of formation and change. In many studies, however, urban morphology is defined as "the pattern of land use within a town" (Helm & Robinson, 2002).

For a better understanding of urban morphology, the essential elements that define the physical form of cities are critical. Urban form can be divided into various elements, such as urban fabric, streets, plots, and buildings, each playing a distinct role in shaping the urban landscape. Urban fabric, as defined by Karl Kropf, represents the finer texture of the city. These textures vary significantly between different cities and even between different parts of the same city, influenced by historical, cultural, and geographical factors. In addition, the street system and its interaction with parcels and buildings form the structure of urban morphology. Streets are places for movement and the intersection of public and private spaces, shaping the daily experiences of urban dwellers. The configuration, hierarchy, and connectivity of streets and their relationship with adjacent plots and buildings define the rhythm and scale of urban spaces. Whether the grand boulevards of Paris or the streets of Siena, streets encompass the diversity of urban life and reflect broader social, economic, and cultural dynamics. Understanding these elements together provides a comprehensive view of urban morphology, which is essential for analyzing existing urban textures and guiding future urban development (Oliveira, 2018). In addition, Karl Kropf defined urban morphology in four broad approaches, each reflecting a different view of form: spatial analytical, configurational, process typological, and historical-geographical. The spatial analytical approach uses various models to understand the complex structures of cities, while the configurational approach examines the spatial structures of cities and their effects on movement. The process typological approach, through the work of architects Saverio Muratori and Gianfranco Caniggia, aims at an in-depth understanding of urban formations and their historical evolution. In contrast, M.R.G. Conzen's historical-geographical approach explores towns' geographical structure and development over time, examining in detail their physical and functional components and revealing how urban form and function are intertwined.

Despite originating as a biological discipline, morphology's broad applicability allowed it to be utilized in various fields, including urban studies in Central Europe in the late 1800s. The systematic study of urban forms began more than a century earlier with the research work of German geographers (Oliveira, 2018). In the first three decades of the twentieth century, the center of morphological research remained in Germany. In the 1930s, however, German urban geography shifted from focus to function rather than form. Italian architects made the main contributions to the history of urban morphology in the mid-twentieth century. The formulation and development of a process typological approach by Saverio Muratori, followed by Caniggia and Maffei, followed in the footsteps of Saverio Muratori in a series of studies on urban morphology. In their research, they argued that maps reflect the volume of structures and the parts of urban organisms. According to Caniggia and Maffei, there are two different forms of urban texture: basic and specialized. From the 1960s onwards, the work of German immigrant MRG Conzen became a central reference in British geography (Conzen, 2004). Conzen (2004), in his view, states that cities are the property of communities and represent valuable cultures.

For this reason, he argues that urban morphology should be considered together with city history. Moudon (1997) According to this, there are similarities in the theoretical infrastructure of the schools of France, England, and Italy. Although these three schools originate from different languages and disciplines, they agree on making the city's physical fabric analyzable. They also state that the urban fabric can be reduced to three essential physical elements. These three essential physical elements are listed: parcels, open spaces, and streets. Moudon also suggests that urban fabric analysis can be carried out at different levels. He defines these levels as building-parcel, building-block-street, city, and region. They also believe that the urban fabric can only be understood through its history, given that city elements can change or transform (Ağırbaş, 2016; Moudon, 1997).

The morphological characteristics of the urban built environment include the physical components of urban space. These features are mainly related to 'urban form' and 'urban layout' (Carmona et al., 2003). While 'urban layout' is expressed in terms of the dimensions and forms of building blocks and the street pattern, 'urban form' is defined by the relationship between individual buildings and each other in urban settlements. Elements such as building layout, heights, setback distances, and building volumes are components of the urban form (Ünlü, 2006). An essential element for discussions on urban morphology was the formation of the 'International Seminar on Urban Form' (ISUF) in the mid-1990s. After three meetings in Lausanne between 1994 and 1996, the first open conference was held in Birmingham in 1997. Since then, ISUF has promoted the organization of regular annual conferences and the publication of the journal 'Urban Morphology'. Another essential element is the 'International Symposium on Spatial Syntax' (ISSS). The meeting started in London in 1997 and was organized every two years. Since 2010, researchers and practitioners have mainly published in the Journal of Space Syntax. Urban morphology, however, works at a scale not usually recognized by other disciplines. While other disciplines usually focus on the city as a whole or individual buildings, urban morphology deals with groups of buildings, different zones, and other components other than buildings. It, therefore, has the potential to fill a gap for research at different spatial scales (Oliveira, 2018)

2.2. Urban Morphology and Energy

This sub-section aims to elaborate on the role and importance of urban structures on energy use and the environment through urban morphology. In light of various academic studies and research, this framework discusses how urban form can be a critical factor in sustainability, energy efficiency, and environmental sensitivity. In addition, the relationship between urban structures and energy use has been central to urban planning and architectural design in recent years. Since most energy consumption takes place in urban areas, the design of cities is of great importance for energy efficiency. This chapter also discusses the effects of urban form on energy demand, its potential to reduce energy consumption, and design strategies for doing so in the context of the literature. In addition, regarding environmental impacts, urban design and configuration are critical in reducing greenhouse gas emissions and improving air quality. Characteristics of urban form, such as reducing the heat island effect, providing natural ventilation, and maximizing sunlight, directly impact environmental performance. This sub-section details the principles and practices of sustainable urban design in this context.

In recent years, there has been a growing awareness of the importance of urban form in terms of its social, economic, and environmental dimensions in cities. Therefore, urban morphology has gained an important role in discussions on cities' past, present, and future. The urban morphology approach has the potential to provide innovative solutions to make our cities more sustainable, functional, and livable. To assess urban structural form, the relationship and arrangement of floor area and building volume, thermal characteristics of the building fabric, and settlement patterns are essential in determining the overall development efficiency. Such factors will help designers and policymakers and provide a method of understanding the energy-related characteristics of urban structural form. This approach leads to questioning one of the most precise indicators of the thermal efficiency of structural efficiency, the floor area-to-surface area ratio. This ratio gives an idea of the spatial efficiency of the enclosed space. However, it does not consider differences in the thermal properties of the building material or the impact or direction of solar gains. The floor area-to-surface area ratio can be modified by introducing basic thermal transmittances to account for differences in the building material. However, as a formal efficiency indicator, it is only suitable for blocks performing in private mode. While this metric considers heat loss from the block, it does not consider solar gains or the resulting thermal balance.

A review of the relevant literature in this framework reveals that studies generally focus on the relationship between urban morphology, sustainability, and energy efficiency. For example, the study of Lyons, Kenworthy, and Newman (1990) aims to quantitatively assess the impact of urban structures on vehicle pollution in the Perth metropolitan area of Western Australia. In this study, the city was divided into six different zones using an ecological approach, and representative driving cycles were obtained, taking into account factors such as socioeconomic status and activity intensity. The findings show that urban form and air pollution are related to vehicle use, but land use sprawl away from the city center will not reduce emissions. Instead, the importance of public transportation is emphasized.

Moreover, Anderson, Kanaroglou, & Miller (1996), aim to investigate the urban form, energy use, and the environment. By examining the effects of urban form on energy and the environment, their study argues that effective policy interventions cannot be designed without better information on individual travel choices. It also emphasizes that the generation of urban emissions and the impact of urban form on this is relatively weak. Furthermore, Haines (1986), examines the relationship between urban form and energy use, comparing the energy efficiency of three different spatial configurations of urban systems. The study addresses the conflicting consequences of multicore structuring and sprawl on energy efficiency and finds that multicore structuring is the most energy-efficient urban form. While this suggests that energy may be a relatively weak determinant of urban form, it discusses the future role of energy in urban form.

Additionally, the study of Holden (2004) examines the link between physical urban planning and household energy consumption and discusses the principle and practice of sustainable urban development. The findings show that high density and short distances favor sustainable urban development. Moreover, the findings highlight that single-family and large houses in sparsely populated areas consume more energy. Besides, the study of Howard et al. (2012) aims to estimate the demand for energy use in the building sector in New York City. This study aims to understand the dynamics of energy use depending on building function and quantifies intensities modeled with energy use data in New York City. The findings show that office buildings are large electricity consumers and that waste heat can reduce energy losses when located next to them. This study develops a spatial energy consumption model to enable energy reduction measures. In addition, Manesh, Tadi, & Zanni (2012) investigate the relationships between urban morphology and energy consumption and offer new design principles for the sustainable reshaping of cities. By focusing on urban morphology and energy consumption, this study aims to examine the city's complex system with a holistic approach. It highlights the essential differences between the city's total energy consumption and proposes a simulation method to promote sustainable urban transformation.

Moreover, de Casas Castro Marins and de Andrade Roméro (2013) demonstrate and evaluate the potential of integrated planning of urban morphology, urban mobility, buildings, and energy efficiency. The study is based on developing and applying a methodology for energy modeling. The study highlights the importance of strategies such as building volumes, geographical orientations, and the design of urban corridors to reduce energy consumption in buildings, as in the case of Agua Branca in Sao Paulo, Brazil. The study emphasizes that the potential for energy efficiency is high, especially in urban transport, and that public transport should be prioritized over individual transport. Ko (2013) examines the impact of urban form on residential energy consumption. The study focuses on climate-appropriate design principles and factors affecting residential energy consumption. The results found that multi-family houses use less energy and that afforestation contributes to energy savings. The study also suggests that planning guidelines should further emphasize the importance of energy-efficient urban form variables.

Sarralde, Quinn, Wiesmann, & Steemers (2015) investigate the relationship between the physical form of residential areas and energy efficiency. This statistical analysis examines urban morphology scenarios in London, showing how urban form variables can be regulated to optimize the solar radiation of roofs and facades. The study provides recommendations on design strategies to increase solar energy potential. Moreover, Cerezo Davila, Reinhart, & Bemis (2016) focus on developing building energy efficiency strategies. This simulation and statistical analysis study aims to estimate citywide energy demands by building building energy models in Boston. The study presents model outputs that can influence energy policy decisions across the city. Ma & Cheng (2016) conducted a study to estimate the intensity of building energy use at the urban scale. Using GIS and data mining methodology, the study aims to estimate the energy use intensity of multi-residential buildings in New York City.

Furthermore, the study emphasizes the importance of feature engineering and GIS integration. Tsirigoti and Bikas (2017) examine the relationship between urban morphology and energy efficiency in Greek cities. This simulation study shows that urban morphology factors significantly impact energy efficiency. Recent studies have confirmed the compact city theory. Murshed, Duval, Koch, & Rode (2019) analyze energy use due to vertical mobility in Asian cities. The study investigates the impact of building forms and uses on energy consumption for vertical mobility. The results show that vertical mobility is essential in thoroughly assessing the energy balance.

Additionally, Mouzourides, Kyprianou, Neophytou, Ching, & Choudhary (2019) examine the relationship between building energy demands and city breathability. This analysis shows a strong relationship between energy demand and city breathability using multi-scale analysis methods. This study emphasizes the importance of designing for energy demands in urban planning. The study of Loeffler, Österreicher, & Stoeglehner (2021) examines the energy implications of urban morphology for a new urban development area in Vienna. The study shows how passive design measures can improve the energy efficiency of buildings by using simulation and statistical analysis methods.

Furthermore, the study emphasizes the importance of densification and thermal insulation of the building envelope. Ovalı & Delibaş (2016) examines Kayaköy regarding sustainable architecture. The research assesses Kayaköy's environmental, socio-cultural, and economic sustainability through on-site observation and analysis techniques. Furthermore, it suggests that the architectural features of the settlement could serve as a model for contemporary architecture.

2.3. Sustainability, Energy Efficient Design

In this section, we analyze the relationship between sustainability and energy-efficient urban design. Specifically, we discuss the concept of sustainability and the role of energy-efficient design in urban planning, drawing from evaluations of studies in the literature. We also examine the effects of energy-efficient design on the built environment, urban form, and energy efficiency of buildings, thus shedding light on current approaches and strategies in sustainable development and energy performance.

The concept of "sustainability" emerged from the final report of the United Nations Conference on the Human Environment held in Stockholm in 1972. This concept has been shaped by the intensive efforts of the UN and other international organizations (Çorbacı and Ertekin, 2018). The principles outlined in the Stockholm Declaration emphasize sustainable development by establishing the relationship between economic development and the environment. One of the principles calls for environmental education to protect the environment. The definition of sustainable development in its current sense emerged with the "Our Common Future" report published by the United Nations World Commission on Environment and Development (WCED) in 1987. Sustainable development is defined as a process that sustains improvements in the current situation while considering the interests of future generations (Badur, Yılmaz, & Sensoy, 2023; Bozlağan, 2010; Günerhan & Günerhan, 2016). The overarching framework regarding the principle of sustainability, known as the "sustainable urbanization" approach, encompasses fundamental issues such as growth regulation, land use planning, urban design, housing, transportation, environmental protection and restoration, energy and material use, green architecture and settlement, equity, environmental justice, economic development, and population (Baytok, Z.G., 2012).

Recently, the urban morphology approach has gained significance in sustainability and energy efficiency discussions. The realization that buildings contribute significantly to global carbon dioxide emissions has reignited discussions on building and urban design methods. Dense, mixed-use, pedestrian-oriented, and transit-based urban forms have emerged as sustainable and energy-efficient in the literature (Newman and Kenworthy, 1989; Calthorpe, 1993; Banister, 2011; Beatley, 2012). Despite preferences for less dense urban forms, the negative consequences of low-density and segregated land uses are gradually diminishing the effectiveness of this approach. Such urban forms negatively impact both the economy and the environment by promoting reliance on individual vehicles (Filion, 2008). Conversely, active modes of transportation such as walking, cycling, or public transit, including buses, bus rapid transit, light rail, and subway, have more positive implications in terms of energy efficiency and environmental pollution (Farr, 2011).

"Energy-efficient design" entails creating buildings and urban layouts that minimize energy consumption while providing comfortable living or working conditions in architecture. This concept is becoming increasingly important in the face of climate change as cities expand and become centers of global energy consumption, primarily based on fossil fuels (Mangan and Koçlar Oral, 2020). The study underscores the critical relationship between urban geometry and building energy performance, highlighting the need for integrated planning and design that incorporates climate data, urban geometry, and building attributes from the outset. Such integration aims to optimize energy use in urban areas, achieve sustainable development, and mitigate the impacts of climate change. By demonstrating how settlement patterns and building forms significantly influence energy efficiency, the research suggests that detailed analyses of urban geometries informed by future weather data can reveal optimal configurations that reduce energy consumption and carbon emissions. In conclusion, the study on Istanbul's new settlement patterns underscores the need to anticipate and adapt to a changing climate, advocating a forward-thinking approach to urban planning and building design, and calling for its wider application to other regions, particularly those facing rapid urbanization and significant climate change impacts. Moreover, energy-efficient design in urban development focuses on creating building and block configurations that significantly reduce energy consumption while maintaining functionality and comfort. Such design considerations include the shape, size, orientation, and location of urban blocks relative to each other. In addition, the mix and distribution of floor areas, the thermal properties of building materials, and their utilization also play crucial roles in determining the energy efficiency of a block. Urban planners and architects can identify the most energy-efficient arrangements by employing strategies that optimize sunlight exposure and analyzing seasonal sunlight variations as well as the surface area-to-floor area ratios. These methodologies aim not only to reduce immediate energy consumption but also to guide progressive redevelopment to promote sustainable urban environments over time (Rickaby, 1987).

The relationship between urban fabric and energy efficiency emerges as a critical area of study within this framework. Urban fabric, comprising the physical layout and material composition of urban forms, directly affects the energy performance of buildings and blocks. By studying the configurations and thermal behavior of existing urban blocks, researchers can identify energy inefficiencies and propose improvements. For example, altering urban land uses or densities can impact energy demands, and adjustments to building orientation or distances between buildings can increase solar gain in winter while reducing overheating risks in summer. This detailed research extends beyond individual buildings to provide recommendations on the broader urban scale and energy dynamics, enabling more nuanced and effective urban planning decisions (Rickaby, 1987).

Energy-efficient design in urban planning also involves the strategic use of space and resources to reduce energy consumption and increase sustainability. The relationship between urban fabric and energy efficiency is critical in contemporary urban planning. Dense urban textures often lead to increased energy demand due to limited natural light and ventilation, necessitating careful design interventions. In this context, innovative utilization of side setbacks from buildings, traditionally underutilized spaces in urban environments, is significant. By repurposing these spaces for activities that encourage social interaction and commercial engagement, cities can enhance their vitality and aesthetic appeal while adhering to energy efficiency standards. For example, the transformation of bypass areas in Seoul into vibrant semi-public spaces contributes to urban regeneration and energy efficiency by optimizing land use and fostering community engagement. Lee et al. (2021) demonstrate how Seoul's urban planning initiatives have addressed challenges such as reducing the need for artificial lighting and cooling by organizing side setbacks to ensure adequate sunlight and air circulation. According to the study, the adaptive reuse of these spaces for commercial purposes demonstrates a pragmatic approach to integrating energy efficiency with economic and social vitality, showcasing the potential for urban fabrics to positively influence energy consumption patterns.

2.3.1. The Role of the Sun in Planning within the Scope of Energy-Efficient Design

Today, the increasing demand for energy resources and growing environmental concerns are driving the energy sector towards a more sustainable and efficient future. In this context, energy-efficient design plays a crucial role in planning processes, aiming to minimize negative environmental impacts by optimizing the use of various resources. This sub-section examines the key role that solar energy, in particular, plays in energy-efficient design. Solar energy is distinguished as a clean, unlimited, and renewable resource. Photovoltaic systems, which generate electricity directly from sunlight, and thermal energy systems, are recognized as the cornerstones of energy-efficient design. This design approach aims to harness solar energy to meet the energy needs of buildings, thereby enhancing environmental sustainability. Consequently, this sub-section explores how solar energy can be integrated into the planning process of buildings and the benefits this integration can provide within the framework of relevant literature.

Ebenezer Howard, Frank Lloyd Wright, and Le Corbusier had distinctly different conceptions of ideal urban planning (Segal & Fishman, 1979). Urban planning is heavily influenced by concepts such as Howard's "garden city model," Le Corbusier's "shining city model," and Wright's "expansive city model," highlighting the diversity of approaches. This diversity emphasizes the need to strike a balance between proposed land uses and energy efficiency for 21st-century cities (Amado, Poggi, & Amado, 2016). According to Bektas Ekici & Aksoy (2011), proper heating and cooling design is one of the most effective methods to reduce energy costs in buildings. Consequently, the design parameters affecting energy-demanding buildings are summarized (Table 1). These parameters encompass both physical environmental and artificial design aspects. Physical environmental parameters, such as hourly outdoor temperature, solar radiation, and wind direction/speed, directly influence the thermal performance of a building. Temperature fluctuations determine the demand for heating or cooling systems, while solar radiation affects daylighting and passive solar gains. Wind factors impact ventilation and can contribute to heat loss or gain. In terms of artificial design, factors like building form factor, transparency ratio, orientation, thermo-physical properties of building materials, and distance between buildings shape energy demand. Building form and orientation influence solar exposure and airflow, transparency ratio affects natural lighting, and material properties determine insulation and heat absorption capabilities. Furthermore, the distance between buildings affects airflow, shading, and microclimate, all contributing to the overall energy efficiency of a building. Therefore, a comprehensive consideration of these design parameters is crucial to optimize the energy performance and sustainability of a building.

Table 1: Design Parameters Affecting Building Energy Requirements (Bektas Ekici ve Aksoy, 2011)

Physical environment parameters	Artificial design parameters
Hourly outdoor temperature (°C)	Building form factor
Solar radiation (W/m2)	Transparency ratio
Wind direction and speed (m/s)	Orientation
	Thermo-physical properties of building materials
	Distance between buildings

In response to the increasing priority of energy conservation in developed countries Pacheco, Ordóñez, & Martínez (2012), aim to contribute to the ongoing discourse by providing a comprehensive review of building design criteria that can effectively reduce energy demand for heating and cooling in residential buildings. Their study highlights the significant impact of design elements on the total energy demand by rigorously examining parameters such as building orientation, shape, façade system, passive heating and cooling mechanisms, and shading. Thus, the study reveals the most suitable options for energy-efficient residential buildings. The study's findings

demonstrate the importance of sustainable design in reducing energy requirements, the cost-effectiveness of implementing energy-saving measures at the project design stage, and the benefits throughout the entire life cycle of a building. The study also highlights the dynamic nature of building design, demonstrating the need for adaptive insulation systems and the superiority of mobile shading devices. Furthermore, the study examines the optimization of solar panel performance by evaluating orientation and tilt angles and provides specific recommendations based on seasonal variations. The study of Salat (2009) analyzes the energy consumption and CO_2 emissions associated with the existing building stock in Paris, France, considering various factors including urban morphology, architectural archetypes, construction technologies, energy systems, and occupant behavior. Through a comprehensive case study covering 96,000 buildings, the research compared various environmental metrics of Paris' urban fabric with thermal energy consumption in residential buildings. The study reveals the impact of urban morphology and building typology on energy efficiency in different areas of Paris, focusing on key metrics such as building shape factor and passive volume. In addition, the study offers a perspective on the complex interplay of morphologies, typologies, energy systems, and behaviors, separating energy efficiency and CO2 emissions related to heating mode and occupant behavior from those linked to urban form and construction technology. The findings provide valuable insights for optimizing urban form regarding density, building configuration and morphology. The study concludes that the developed energy consumption assessment method can be a practical tool for urban planning and management by helping optimize the parameters affecting energy consumption.

The climate-based design aims to take measures against negative factors and utilize positive factors to increase user comfort and reduce energy consumption. Annual climatic analyses are required to assess the performance of the building. It is also essential to consider design principles in different climatic zones, such as cooling in hot climates and temperature differences during the day in arid climates. Designs suitable for all seasons are possible by adopting an environmentally friendly approach, considering regional climate data (Goulding, Lewis, & Steemers, 1992; Günel, 2015).

One of the most widely used climate classification maps is the one developed by Wladimir Köppen and updated by Rudolf Geiger in 1961. Climate classification is used in various fields such as geography, hydrology, agriculture, biology, education, and climate and climate change studies. In this context, a new digital Köppen-Geiger climate classification map for the second half of the 20th century presented in Figure 2, based on the most recent data provided by the Climate Research Unit of the University of East Anglia and the Global Precipitation Climatology Center of the German Meteorological Service. Bölük (2016) focuses on the Köppen Climate Classification applied to the climate of Turkey. The study uses grid-based world climate classification maps based on data from the Global Precipitation Climatology Center and the University of East Anglia Climate Research Unit. The main objective is to identify the climate types in Turkey in line with the Köppen system. The findings show that the most widespread climate type in Turkey is the Cs with Mediterranean climate characteristics, accounting for 65.1% of the country's climate (Figure 3). Other identified climate types include arid (BS), temperate with year-round rainfall (Cf), and cold winter climates (Df, Ds). However, the study concluded that although the Köppen classification effectively shows the boundaries of climate types globally, it is unsuitable for Turkey compared to other classification methods. Moreover, it emphasizes the dynamic and complex nature of climate classification and the need for continuous updates in the context of climate change.

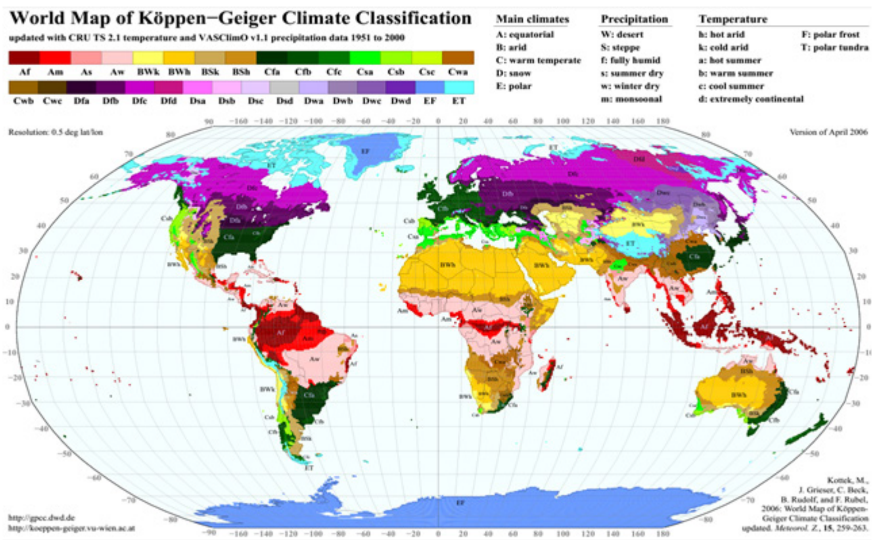

Figure 2: World Map of Köppen-Geiger Climate Classification (Kottek, Grieser, Beck, Rudolf, & Rubel, 2006)

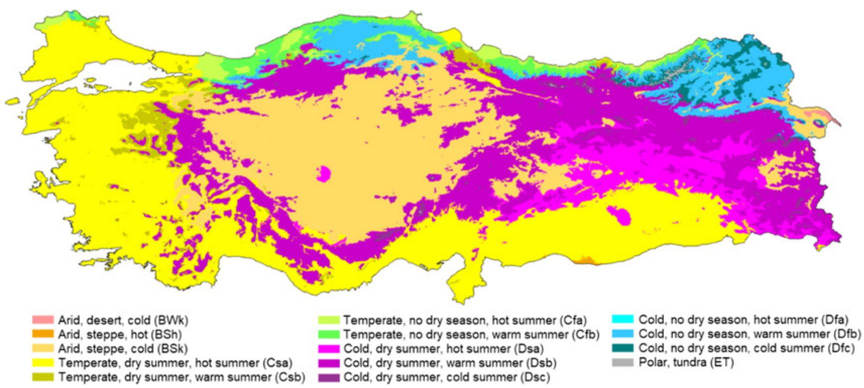

Figure 3: Climate of Turkey according to Köppen Climate Classification (Beck et al., 2018)

Amado, Poggi, & Amado (2016) propose a new urban planning approach that promotes energy efficiency and sustainability by addressing the problem of urban sprawl, which is directly linked to global energy consumption. The current urban planning paradigm fails to deliver energy-efficient cities, leading to overdependence on fossil fuels. A theoretical model and its practical application are introduced that challenges conventional notions of energy efficiency locally. In contrast to standard approaches, the proposed energy-efficient city model adopts a cellular, self-sufficient structure that emphasizes redesigning existing urban areas and strategic planning for new expansions. The main focus is reducing electricity consumption and promoting the widespread integration of solar energy and smart grids. The study aims to improve global energy performance by estimating energy consumption patterns and solar energy potential in new and existing urban areas. The detailed guidance framework for urban planning supports optimizing, adapting and developing energy-efficient cities, highlighting the critical role of promoting sustainable urban planning practices. This research contributes to a better understanding of urban development pathways and the strategic inclusion of energy efficiency in cities through urban planning on a global scale.

2.3.2 The Role of Groundwater and Surface Water in Energy-Efficient Design Planning

Energy-efficient design encompasses not only the optimization of energy resources but also the management of water resources. In this context, the significant role of groundwater and surface water in planning for energy-efficient design stands as a decisive factor in the success of sustainable energy policies and projects. Groundwater is directly linked to crucial components such as cooling systems and geothermal power plants used in power generation. Furthermore, the reliance of hydroelectric power plants on water resources significantly influences the water-demand balance in energy production. Surface water also holds significance in the planning of energy production areas and infrastructures for renewable energy sources like wind and solar energy. This section delves into how groundwater and surface water can be strategically considered in planning for energy-efficient design and the roles these resources play in realizing sustainable energy projects. Additionally, it highlights the positive impacts of effective water resource management on the security, resilience, and environmental sustainability of energy systems.

Ahmad, Jia, Chen, Li, and Xu (2020) conducted a detailed study examining the intricate interrelationship between water and energy. The study sheds light on the multifaceted demands for water across various sectors at both local and regional levels. It addresses societal needs for water in diverse areas including housing, commerce, industry, recreation, aquaculture, hydropower generation, and agricultural activities. Moreover, it emphasizes the variability of energy demands across communities, spanning from urban centers to provinces or states. Notably, the study underscores the critical role of energy in urban water systems, encompassing processes such as water supply, treatment, transmission, distribution, wastewater collection, treatment, recycling, and discharge to natural waterways. This complex phenomenon is commonly referred to as the water-energy nexus, depicted in Figure 4.

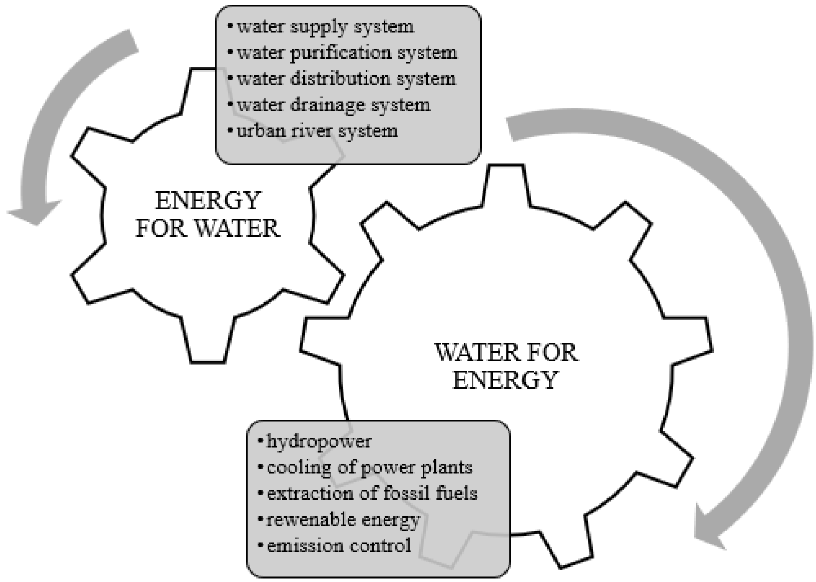

Figure 4: Overview of the Water-Energy nexus and its connections for different purposes (Ahmad vd., 2020)

To comprehensively analyze the water-energy cycle and the roles of groundwater and surface water in planning, it is crucial to understand water security, water demand, and policymakers' arrangements for several reasons. Firstly, the natural environment plays a critical role in supplying water for human needs, bearing a significant share of water stress as a silent stakeholder in water resources. Secondly, cities and local as well as national governments must prioritize water monitoring, efficiency, and production to address more frequent and severe droughts and manage an increasing water footprint. In this context, it is imperative to curtail water demand and incentivize the private sector and households to invest in water-efficient and reusable solutions. Rainwater harvesting systems have proven effective for this purpose. However, the capacity to scale up supply through mechanisms such as disinfection and treatment varies across countries due to geographical and economic factors.

Water security remains a concern in several countries, with escalating regional impacts stemming from hygiene and health crises, urban migration, displacement, and involuntary migration (Global Risks Report 2023). Additionally, metrics such as the Water Scarcity Index, based on per capita availability of renewable fresh surface water and groundwater, provide insights into potential water availability per capita without considering existing water infrastructure or economic use. The Water Intensity Use Index, expressing surface water and groundwater withdrawals as a percentage of the internal renewable water resources available for a region, further illuminates water utilization trends. As of 1995, approximately 41% of the world's population, or 2.3 billion people, resided in water-stressed river basins (FAO Water Reports 35, 2010).

Predicting future demand trends with certainty poses challenges. Burek et al. (2016) estimate a continued global increase in water demand by about 1% per year, projected to rise by 20% to 30% by 2050. Geographical variations in water demand evolution are pronounced, with Asia expected to remain the largest water consumer globally, particularly in terms of agricultural water use. Significant demand growth is anticipated in West, East, and Southern Africa, as well as South and East Asia. Notably, India and China lead in water demand at the country level, while Sub-Saharan Africa experiences rapid domestic demand growth. Several countries, including those in the Arabian Peninsula, North Africa, Cyprus, Armenia, Uzbekistan, Afghanistan, and Pakistan, already face water scarcity conditions, with the number of people living in severe water scarcity projected to increase by 2050 (Burek et al., 2016). Moreover, a study conducted by the FAO-American University in Beirut utilizes scenario development tools to explore various food, water, energy, and health alternatives. The study highlights the necessity of multi-sectoral stakeholder engagement and intergovernmental cooperation to achieve multiple objectives optimally. Furthermore, it recommends exploring land reclamation, marginal land use, and agroforestry options, as well as improving crop yield potential and breeding technologies (The United Nations World Water Development Report, 2023).

2.3.3 The Role of Wind in Planning within the Scope of Energy-Efficient Design

Understanding the effects of wind on urban form and structure is essential for improving energy efficiency and creating comfortable outdoor spaces. Analyzing how wind speed, direction, and behavior affect the urban space can provide valuable design recommendations. This aspect of the subject is elucidated by reviewing relevant literature. In this subsection, studies focusing on wind analysis techniques, integral to the energy-efficient design process, are evaluated. Although factors like the effect of wind are widely used in industrial design, they have not yet become a standard in architecture. Integrating performance criteria such as wind through simulations can enhance the environmental adaptability of buildings (Kormaníková et al., 2018). The aim of this subsection is to summarize the literature on the development of wind analysis techniques and their performance in various applications. By discussing the effects of wind on architecture and urban design, and how these effects can be utilized as positive design elements, a comprehensive understanding is achieved. Wind analysis emerges as a critical tool to enhance not only the aesthetic and functional aspects of architecture and urban design but also their environmental performance. These analyses offer crucial insights for making buildings and cities more sustainable and energy-efficient, with applications ranging from building envelope design to urban planning.

The related literature primarily focuses on the development of wind analysis techniques, the effect of wind on building design, the impact of urban geometry on wind flow, and the adverse effects of wind speeds on pedestrian comfort. For instance, Nirmal (2017) examines how local climatic elements, particularly wind, influence building design, leading to different architectural styles in various regions. The study emphasizes the synergistic relationship between architecture and engineering, highlighting how architecture can integrate wind into design to benefit buildings. Similarly, Rajagopalan, Lim, and Jamei (2014) study the Urban Heat Island (UHI) effect in Muar, Malaysia, focusing on how urban geometry affects wind flow and the UHI. The research suggests that optimizing urban regulations based on thermal comfort is crucial for mitigating the UHI effect. Castro, Burry, and Burry (2015) concentrate on the development of wind analysis techniques such as Computational Fluid Dynamics-Performance Drawing Tools (CFD-PST) to support architects in the initial design phase. The study underscores the increasing integration of wind analysis in architecture to enhance urban comfort.

Moreover, studies in the literature address energy-efficient design issues. Bughio et al. (2021) investigate the impact of passive energy efficiency measures on reducing internal temperature and cooling energy demand in a building in Karachi, Pakistan. Ratković et al. (2015) present a holistic evaluation of low-power design techniques in computer systems, emphasizing the importance of a comprehensive approach to achieve significant savings in power and energy. Shi et al. (2016) analyze energy-efficient design optimization techniques, discussing various approaches and challenges in real-world applications.

Furthermore, studies in the literature focus on various dimensions of Building Information Modeling (BIM) based on energy efficiency. Wong, Wong, and Nadeem (2011) examine the development of BIM guidelines and implementation strategies in Hong Kong and the USA. Chong, Lee, and Wang (2017) explore how BIM can be used for sustainability assessments in the construction industry. Shen, Shen, and Sun (2012) propose a BIM-based method for simulating and evaluating user activities to enhance designer-user communication and improve design solutions' quality and quantity of feedback.

3. Conclusion and Policy Implication

This study aims to evaluate the relationship between energy-efficient design and urban morphology. In the comparison of the urbanization rates of Europe, the World, and Turkey, which is the target of the study, it is understood that the urbanization rate in Turkey is much higher than the rate of the World and Europe, especially in the period between 1980 and 2020. Through a detailed literature review, it is examined how these data can be integrated into strategic approaches to energy efficiency in urban areas, and the results of this integration are evaluated. The research reveals three main findings. First, given the complexity of urbanization's impact on energy demand and the environment, energy-efficient design is crucial to achieving sustainable urbanization. Integrating urban morphology with energy-efficient design emerges as a critical strategy in this respect. This integration involves optimizing building layout, transportation planning, land use considerations, and environmental factors to increase energy efficiency and overall energy consumption in cities. Second, energy-efficient urban design offers long-term economic benefits by contributing to cost savings. By implementing energy efficiency measures, cities can reduce operating expenses and increase economic sustainability, thus making sustainability more attainable. Third, focusing on utilizing natural resources such as sun, groundwater, surface water, and wind in energy-efficient design planning can determine their availability for sustainable projects and reduce environmental impacts.

In light of these findings, the study provides several policy recommendations. First of all, it is necessary to integrate energy efficiency and sustainability principles into urban planning processes. This integration should be considered for both new construction and renovation of existing buildings. Furthermore, policymakers should promote the effective use of renewable energy sources such as solar, water, and wind, which is in line with the sustainability goals of energy-efficient design, by ensuring cooperation between different sectors in urban planning processes. Finally, policymakers should develop policies that encourage the effective use of environmental data in design processes. These policies, which facilitate informed and data-based decision-making in urban planning and design, can enable a more efficient and information-based approach to sustainable urbanization.

4. References

Ağırbaş, A. (2016). *Avangart tasarım süreci için kent morfolojisi kısıtlayıcıları ile bir simülasyon modeli* (doctoral Thesis, Mimar Sinan Güzel Sanatlar Üniversitesi). Mimar Sinan Güzel Sanatlar Üniversitesi. http://acikerisim.msgsu.edu.tr/xmlui/handle/20.500.14124/1274

Ahmad, S., Jia, H., Chen, Z., Li, Q., & Xu, C. (2020). Water-energy nexus and energy efficiency: A systematic analysis of urban water systems. *Renewable and Sustainable Energy Reviews*, *134*, 110381. https://doi.org/10.1016/j.rser.2020.110381

Amado, M., Poggi, F., & Amado, A. R. (2016). Energy-efficient city: A model for urban planning. *Sustainable Cities and Society*, *26*, 476-485. https://doi.org/10.1016/j.scs.2016.04.011

Anderson, W. P., Kanaroglou, P. S., & Miller, E. J. (1996). Urban Form, Energy and the Environment: A Review of Issues, Evidence and Policy. *Urban Studies*, *33*(1), 7-35. https://doi.org/10.1080/00420989650012095

Badur, M. M., & Sohag, K. (2023). Does trade integration reorient income inequality? Evidence from the post-soviet countries / M. Mesut Badur and Kazi Sohag. *Management & Accounting Review (MAR)*, *22*(2), 331-353.

Badur, M. M., Yılmaz, E., & Sensoy, F. (2023). Do corruption and inequality shape sustainable development? Evidence from the post-soviet countries. *International Journal of Social Economics*, *51*(1), 115-132. (world). https://doi.org/10.1108/IJSE-01-2023-0065

Banister, D. (2011). Cities, mobility and climate change. *Journal of Transport Geography*, *19*(6), 1538-1546. https://doi.org/10.1016/j.jtrangeo.2011.03.009

Baytok, Z.G. (2012). *Sürdürülebilir kentsel gelişme ve neoliberal politikaların sürdürülebilir kentsel gelişime etkisi: Kurtköy bölgesi örneği* (Masters Thesis). Bahçeşehir Üniversitesi, Fen Bilimleri Enstitüsü, İstanbul.

Beatley, T. (2012). *Green Urbanism: Learning From European Cities*. Island Press.

Beck, H. E., Zimmermann, N. E., McVicar, T. R., Vergopolan, N., Berg, A., & Wood, E. F. (2018). Present and future Köppen-Geiger climate classification maps at 1-km resolution. Scientific Data, 5(1), 180214. https://doi.org/10.1038/sdata.2018.214

Bektas Ekici, B., & Aksoy, U. T. (2011). Prediction of building energy needs in early stage of design by using ANFIS. *Expert Systems with Applications*, *38*(5), 5352-5358. https://doi.org/10.1016/j.eswa.2010.10.021

Bozlağan, R. (2010). Sürdürülebilir Gelişme Düşüncesinin Tarihsel Arka Planı. *Journal of Social Policy Conferences*, (50), 1011-1028.

Bölük, E. (2016). *Köppen İklim Sınıflandırmasına Göre Türkiye İklimi*. Araştırma Dairesi Başkanlığı Klimatoloji Şube Müdürlüğü: T.C. Orman ve Su İşleri Bakanlığı Meteoroloji Genel Müdürlüğü. Geliş tarihi gönderen T.C. Orman ve Su İşleri Bakanlığı Meteoroloji Genel Müdürlüğü website: https://www.mgm.gov.tr/FILES/iklim/iklim_siniflandirmalari/koppen.pdf

Bughio, M., Khan, M. S., Mahar, W. A., & Schuetze, T. (2021). Impact of Passive Energy Efficiency Measures on Cooling Energy Demand in an Architectural Campus Building in Karachi, Pakistan. *Sustainability*, *13*(13), 7251. https://doi.org/10.3390/su13137251

Burek, P., Langan, S. J., Cosgrove, W., Fischer, G., Kahil, T., Magnusziewski, P., … Wiberg, D. A. (2016). *The water futures and solutions initiative of IIASA [International Institute for Applied Systems Analysis]*. Geliş tarihi gönderen https://hdl.handle.net/10568/82758

Calthorpe, P. (1993). *The Next American Metropolis: Ecology, Community, and the American Dream*. Princeton Architectural Press.

Carmona, M., Heath, T., Oc, T., & Tiesdell, S. (2003). Urban Spaces-Public Places The Dimensions of Urban Design. Oxford Architectural Press. - References—Scientific Research Publishing. (t.y.). Geliş tarihi 03 Mart 2024, gönderen https://www.scirp.org/reference/ReferencesPapers?ReferenceID=1845560

Castro, R. A. M., Burry, M., & Burry, J. (2015). *Wind analysis in the early design stage: An empirical study of wind visualisation techniques for architects*. Geliş tarihi gönderen https://www.semanticscholar.org/paper/Wind-analysis-in-the-early-design-stage%3A-an-study-Castro-Burry/12dbdcb3ec37c99325151e970ad14da0aeb38127

Cerezo Davila, C., Reinhart, C. F., & Bemis, J. L. (2016). Modeling Boston: A workflow for efficiently generating and maintaining urban building energy models from existing geospatial datasets. *Energy*, *117*, 237-250. https://doi.org/10.1016/j.energy.2016.10.057

Chen, Q. (2006). Wind in Building Environment Design. Içinde L. Glicksman & J. Lin (Ed.), *Sustainable Urban Housing in China: Principles and Case Studies for Low-Energy Design* (ss. 100-115). Dordrecht: Springer Netherlands. https://doi.org/10.1007/978-1-4020-4786-2_6

Chong, H.-Y., Lee, C.-Y., & Wang, X. (2017). A mixed review of the adoption of Building Information Modelling (BIM) for sustainability. *Journal of Cleaner Production*, *142*, 4114-4126. https://doi.org/10.1016/j.jclepro.2016.09.222

Conzen, M. R. G. (2004). *Thinking about Urban Form: Papers on Urban Morphology, 1932-1998*. Peter Lang.

Çorbaci, Ö., & Ertekin, M. (2018). *Sustainable Green Campuses*. Geliş tarihi gönderen https://avesis.erdogan.edu.tr/yayin/ef575cef-7169-4186-978a-78076138b314/sustainable-green-campuses

de Casas Castro Marins, K. R., & de Andrade Roméro, M. (2013). Urban and Energy Assessment from a Systemic Approach of Urban Morphology, Urban Mobility, and Buildings: Case Study of Agua Branca in Sao Paulo.

Journal of Urban Planning and Development, *139*(4), 280-291. https://doi.org/10.1061/(ASCE)UP.1943-5444.0000149

Emir, F., Philip, L. D., & Sertoglu, K. (2022). Assessing the influence of urbanization and energy on carbon emissions of Turkey: Evidence using the new RALS analysis. *Environmental Science and Pollution Research*, *29*(38), 57905-57917. https://doi.org/10.1007/s11356-022-19953-x

FAO Water Reports 35. (2010). Geliş tarihi 08 Mart 2024, gönderen https://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1508052/

Farr, D. (2011). *Sustainable Urbanism: Urban Design With Nature*. John Wiley & Sons.

Filion, Y. R. (2008). Impact of Urban Form on Energy Use in Water Distribution Systems. *Journal of Infrastructure Systems*, *14*(4), 337-346. https://doi.org/10.1061/(ASCE)1076-0342(2008)14:4(337)

Global Risks Report 2023. (t.y.). Geliş tarihi 08 Mart 2024, gönderen World Economic Forum website: https://www.weforum.org/publications/global-risks-report-2023/

Goethe, J. W. von. (1952). *Goethe's Botanical Writings ; Translated by Bertha Mueller*. University of Hawaii Press.

Goulding, J. R., Lewis, J. O., & Steemers, T. C. (1992). *Energy Conscious Design: A Primer for Architects*. Batsford for the Commission of the European Communities.

Günel, Ö. (2015). *Sürdürülebilir Bina Tasarımında İklim Verilerinin Değerlendirilmesi* (Fen Bilimleri Enstitüsü). Fen Bilimleri Enstitüsü. Geliş tarihi gönderen http://hdl.handle.net/11527/10308

Günerhan, S. A., & Günerhan, H. (2016). Türkiye İçin Sürdürülebilir Üniversite Modeli. *Mühendis ve Makina*, *57*(682), 54-62.

Haines, V. A. (1986). Energy and Urban Form: A Human Ecological Critique. *Urban Affairs Quarterly*, *21*(3), 337-353. https://doi.org/10.1177/004208168602100304

Helm, J., & Robinson, A. (2002). *GCSE Geography for AQA Specification B*. Heinemann.

Holden, E. (2004). Ecological footprints and sustainable urban form. *Journal of Housing and the Built Environment*, *19*(1), 91-109. https://doi.org/10.1023/B:JOHO.0000017708.98013.cb

Howard, B., Parshall, L., Thompson, J., Hammer, S., Dickinson, J., & Modi, V. (2012). Spatial distribution of urban building energy consumption by end use. *Energy and Buildings*, *45*, 141-151. https://doi.org/10.1016/j.enbuild.2011.10.061

Ko, Y. (2013). Urban Form and Residential Energy Use: A Review of Design Principles and Research Findings. *Journal of Planning Literature*, *28*(4), 327-351. https://doi.org/10.1177/0885412213491499

Kormaníková, L., Achten, H., Kopřiva, M., & Kmeť, S. (2018). Parametric wind design. *Frontiers of Architectural Research*, *7*(3), 383-394. https://doi.org/10.1016/j.foar.2018.06.005

Kottek, M., Grieser, J., Beck, C., Rudolf, B., & Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated. *Meteorologische Zeitschrift*, *15*(3), 259-263. https://doi.org/10.1127/0941-2948/2006/0130

Lee, J., Lee, J., & Je, M. (2021). Guidelines on Unused Open Spaces between Buildings for Sustainable Urban Management. *Sustainability*, *13*(23), 13482. https://doi.org/10.3390/su132313482

Loeffler, R., Österreicher, D., & Stoeglehner, G. (2021). The energy implications of urban morphology from an urban planning perspective – A case study for a new urban development area in the city of Vienna. *Energy and Buildings*, *252*, 111453. https://doi.org/10.1016/j.enbuild.2021.111453

Lyons, T. J., Kenworthy, J. R., & Newman, P. W. G. (1990). Urban structure and air pollution. *Atmospheric Environment. Part B. Urban Atmosphere*, *24*(1), 43-48. https://doi.org/10.1016/0957-1272(90)90008-I

Ma, J., & Cheng, J. C. P. (2016). Estimation of the building energy use intensity in the urban scale by integrating GIS and big data technology. *Applied Energy*, *183*, 182-192. https://doi.org/10.1016/j.apenergy.2016.08.079

Madlener, R., & Sunak, Y. (2011). Impacts of urbanization on urban structures and energy demand: What can we learn for urban energy planning and urbanization management? Sustainable Cities and Society, 1(1), 45–53. https://doi.org/10.1016/j.scs.2010.08.006

Manesh, S. V., Tadi, M., & Zanni, F. (2012, Mayıs 7). *Integrated sustainable urban design: Neighbourhood design proceeded by sustainable urban morphology emergence*. 631-642. Ancona, Italy. https://doi.org/10.2495/SC120532

Mangan, S. D., & Koçlar Oral, G. (2020). Impacts of future weather data on the energy performance of buildings in the context of urban geometry. *Cogent Engineering*, *7*(1), 1714112. https://doi.org/10.1080/23311916.2020.1714112

Moudon, A. (1997). Urban Morphology as an emerging interdisciplinary field. *Urban Morphology*, *1*, 3-10. https://doi.org/10.51347/jum.v1i1.3860

Mouzourides, P., Kyprianou, A., Neophytou, M. K.-A., Ching, J., & Choudhary, R. (2019). Linking the urban-scale building energy demands with city breathability and urban form characteristics. *Sustainable Cities and Society*, *49*, 101460. https://doi.org/10.1016/j.scs.2019.101460

Murshed, S. M., Duval, A., Koch, A., & Rode, P. (2019). Impact of Urban Morphology on Energy Consumption of Vertical Mobility in Asian Cities—A Comparative Analysis with 3D City Models. *Urban Science*, *3*(1), 4. https://doi.org/10.3390/urbansci3010004

Newman, P. W. G., & Kenworthy, J. R. (1989). Gasoline Consumption and Cities: A Comparison of U.S. Cities with a Global Survey. *Journal of the American Planning Association*, *55*(1), 24-37. https://doi.org/10.1080/01944368908975398

Nirmal, V. (2017). Wind and Architecture: Design to the flow. *International Research Journal of Engineering and Technology*. Geliş tarihi gönderen https://www.academia.edu/74854937/Wind_and_Architecture_Design_to_the_flow

Oliveira, V. (Ed.). (2018). *Teaching Urban Morphology*. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-76126-8

Ovalı, P. K., & Delibaş, N. (2016). Yerel Mimarinin Sürdürülebilirliği Kapsamında Kayaköy ün Çözümlemesi. *Megaron Dergisi*, *11*(4), 515-529. https://doi.org/10.5505/megaron.2016.44711

Pacheco, R., Ordóñez, J., & Martínez, G. (2012). Energy efficient design of building: A review. *Renewable and Sustainable Energy Reviews*, *16*(6), 3559-3573. https://doi.org/10.1016/j.rser.2012.03.045

Pérez-Lombard, L., Ortiz, J., & Pout, C. (2008). A review on buildings energy consumption information. *Energy and Buildings*, *40*(3), 394-398. https://doi.org/10.1016/j.enbuild.2007.03.007

Rajagopalan, P., Lim, K. C., & Jamei, E. (2014). Urban heat island and wind flow characteristics of a tropical city. *Solar Energy*, *107*, 159-170. https://doi.org/10.1016/j.solener.2014.05.042

Ratković, I., Bežanić, N., Ünsal, O. S., Cristal, A., & Milutinović, V. (2015). Chapter One—An Overview of Architecture-Level Power- and Energy-Efficient Design Techniques. İçinde A. R. Hurson (Ed.), *Advances in Computers* (C. 98, ss. 1-57). Elsevier. https://doi.org/10.1016/bs.adcom.2015.04.001

Rickaby, P. (1987). *An Approach To The Assessment Of The Energy Efficıency Of Urban Buılt Form*. https://doi.org/10.1016/B978-0-408-00891-4.50007-5

Salat, S. (2009). Energy loads, CO2 emissions and building stocks: Morphologies, typologies, energy systems and behaviour. *Building Research & Information*, *37*(5-6), 598-609. https://doi.org/10.1080/09613210903162126

Sarralde, J. J., Quinn, D. J., Wiesmann, D., & Steemers, K. (2015). Solar energy and urban morphology: Scenarios for increasing the renewable energy potential of neighbourhoods in London. *Renewable Energy*, *73*, 10-17. https://doi.org/10.1016/j.renene.2014.06.028

Segal, H. P., & Fishman, R. (1979). Urban Utopias in the Twentieth Century: Ebenezer Howard, Frank Lloyd Wright, and Le Corbusier. *Technology and Culture*, *20*(4), 815. https://doi.org/10.2307/3103653

Shen, W., Shen, Q., & Sun, Q. (2012). Building Information Modeling-based user activity simulation and evaluation method for improving designer–user communications. *Automation in Construction*, *21*, 148-160. https://doi.org/10.1016/j.autcon.2011.05.022

Shi, X., Tian, Z., Chen, W., Si, B., & Jin, X. (2016). A review on building energy efficient design optimization from the perspective of architects. *Renewable and Sustainable Energy Reviews*, *65*, 872-884. https://doi.org/10.1016/j.rser.2016.07.050

The United Nations World Water Development Report 2023. (2023). Geliş tarihi 08 Mart 2024, gönderen https://unesdoc.unesco.org/ark:/48223/pf0000384655

Tsirigoti, D., & Bikas, D. (2017). A Cross Scale Analysis of the Relationship between Energy Efficiency and Urban Morphology in the Greek City Context. *Procedia Environmental Sciences*, *38*, 682-687. https://doi.org/10.1016/j.proenv.2017.03.149

Ünlü, T. (2006). *Kentsel Mekânda Değişimin Yönetilmesi*. Geliş tarihi gönderen https://open.metu.edu.tr/handle/11511/50988

Wilkinson, E. M., & Academy, B. (1953). *Goethe's Conception of Form*. G. Cumberlege.

Wong, A. K. D., Wong, F. K. W., & Nadeem, A. (2011). Government roles in implementing building information modeling systems: Comparison between Hong Kong and the United States. *Construction Innovation*, *11*(1), 61-76. https://doi.org/10.1108/14714171111104637

World Urbanization Prospects, United Nations. (2018). Geliş tarihi 01 Mart 2024, gönderen https://population.un.org/wup/?_gl=1*6w6nmq*_ga*MTUwODU2MDg4NC4xNzA5MjMwMDg4*_ga_TK9BQL5X7Z*MTcwOTIzMDA4OS4xLjEuMTcwOTIzMDA5My4wLjAuMA