AN ANALYZE ON CONTRIBUTIONS OF COURTYARDS IN BUILDING IN TERMS OF SUSTAINABILITY IN ARCHITECTURE - AN EVALUATION ON EXAMPLES IN MARMARA REGION

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ABSTRACT

AN ANALYZE ON CONTRIBUTIONS OF COURTYARDS IN BUILDING IN TERMS OF SUSTAINABILITY IN ARCHITECTURE - AN EVALUATION ON EXAMPLES IN MARMARA REGION

The courtyard can be defined as a special space limited in architectural designs; however, the fact that courtyards are treated as a living space and their potential is recognized shows that they are more than just a void. From the ancient times, every society has created courtyards that reflect their religious beliefs, cultural and social experiences.

The fact that yard use has an important role in terms of sustainable architecture cannot be denied. According to the Brundland Report, sustainability is defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. In this context, the first part of this thesis examines the concept of sustainability in terms of its basic features and in the second part in terms of general and architectural features.

While the interior of the courtyard creates an outer space feeling, vegetation areas and micro-climatic environments in the structure of the courtyard create a common social space that is different from the external environment. In the third chapter, the concept of common space is examined and a detailed examination of the common spaces developed within the historical process is studied. In the fourth chapter, the definition of common space concepts at the building level was made and common exterior and interior spaces at the building level related to nature were examined while the common interiors were compared in terms of sustainability.

In the literature, there are many and various courtyard typologies. In this thesis, a typology has been made and a table has been developed by taking into consideration of the opportunities provided by the courtyards to the building in terms of sustainability. In the sixth chapter, 13 different commercial and educational structures in the Marmara Region and the contributions of courtyards to these structures were examined and evaluated in terms of sustainability.

ÖZET

AVLULU YAPILARIN SÜRDÜRÜLEBİLİR MİMARİYE KATKILARININ ANALİZİ - MARMARA BÖLGESİ'NDEKİ ÖRNEKLERİN DEĞERLENDİRMESİ

Avlular, mimari tasarımlarda sınırlanmış özel boşluk olarak tanımlanabilir; ancak avluların bir yaşam alanı olarak ele alınması ve potansiyellerinin fark edilmesi onların birer boşluktan fazlası olduğunu ortaya koymaktadır. İlkçağlardan itibaren her toplum, kendi dini inanışlarını, kültürel ve sosyal yaşantılarını yansıtan avlular meydana getirmiştir.

Avlu kullanımının, sürdürülebilir mimari açısından önemli bir rolü olduğu gerçeği yadsınamaz. Sürdürülebilirlik, Avrupa Birliği'nin Brundland Raporuna göre, "Geleceğin kendi ihtiyaçlarını karşılama yeteneğinden ödün vermeden bugünün ihtiyaçlarını karşılayan kalkınma" olarak tanımlanmıştır. Bu bağlamda "sürdürülebilirlik kavramı" temel özellikleri açısından, ikinci bölümde genel ve mimari anlamda irdelenmektedir.

İç mekanda dış mekan hissi yaratırken, bitkisel alanlar ile yapı içinde mikro-klimatik ortam oluşturan avlular; dış ortamdan farklı, doğa ile ilişkili bir ortak sosyal mekan sağlamaktadır. Üçüncü bölümde ortak mekan kavramı incelenerek tarihsel süreç içerisinde gelişen ortak mekanların detaylı incelenmesi yapılmaktadır. Dördüncü bölümde bina düzeyinde gelişen ortak mekan kavramlarının tanımlanması yapılıp, doğa ile ilişkili bina düzeyinde bulunan ortak dış ve iç mekanlar incelenip, ortak iç mekanların sürdürülebilirlik açısından karşılaştırılması yapılmıştır.

Literatürde avlu boyutları ön plana konarak hazırlanan çok ve çeşitli avlu tipolojisi bulunmaktadır. Bu tezde ise, avluların binaya sürdürülebilirlik açısından kazandırdığı olanaklar göz önüne alınarak bir tipoloji yapılmış ve bir tablo geliştirilmiştir. Bu tipoloji tablosunda yer alan kombinasyonlar dünyadan örneklerle desteklenmiştir. Altıncı bölümde de Marmara Bölgesi'nde bulunan 13 farklı avlulu ticari ve eğitim yapıları incelenerek avluların sürdürülebilirlik açısından bu yapılara sağladığı katkılar değerlendirilmiştir.

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LIST OF SYMBOLS/ABBREVIATIONS

^{o}	Degree
%	Percentage
m^2	Square meter
BREEAM	Building Research Establishment Environmental Assessment Method
CASBEE	Comprehensive Assessment System for Built Environment Efficiency
CEPAS	Comprehensive Environmental Performance Assessment Scheme for buildings
CGUB	Coefficient of Green Usage of Building
d	Depth
F	Form
h	Height
HK-BEAM	Hong Kong, Building Environmental Assessment Method
ITU	İstanbul Technical University
kWh	kilowatt hour
L	Length
LEED	Leadership in Energy & Environmental Design
m	Meter
C	Centigrade
R	Ratio
R&D	Research &Development
SBAT	Sustainable Building Assessment Tool
SBTool / GBTool	Green Building Tool
TPAB	Total Planted Area on Building
TFA	Total Floor Area
V	Volume
W	Weight
WGBC	World Green Building Council

1. INTRODUCTION

Since ancient times, the courtyards have been created with the need for personal space in outdoor areas, in order to protect from the climatic difficulties of the region and to create a comfortable living space. Courtyards, In addition to being a collector and a regulator regardless of the function of the building, the inner garden quality that provides the transition between the building units are supported by landscape designs and thus reveals the importance of personal outdoor space.

Structures for shelter and protection purposes have been protected from wind, solar radiation and negative external effects that change according to the environmental-climatic features by creating courtyards. Since ancient civilizations, courtyards are architectural elements between the elements that provide the most important effect. Amongst houses, mosques, churches, temples, palaces, public areas, education, commercial and health buildings; designs with courtyards are encountered. In the traditional Turkish architecture, courtyard buildings are quite common. The importance of residential life with a courtyard is seen in Diyarbakır, Mardin and Şanlıurfa.

The functional features of the courtyards are also used in the creation of architectural designs according to their intended use. In buildings where architectural aesthetics are emphasized, courtyards are the most important architectural component.

Decline of green areas by irregular urbanization and constructions has distanced people away from their natural environment. Whereas, the courtyards provide healthier living spaces by creating natural areas at the building level with functional, aesthetic and psychological effects. Therefore, this feature is very important in terms of sustainable architectural design that is developing, rapidly today, since the courtyard designs provide environmental and ecological benefits to both the structure and the users of the structure with courtyard. In this sense, the courtyards create good physical environments in terms of sustainability such as sunbathing, natural lighting, natural ventilation, indoor temperature control, microclimatic comfort.

When designing structures, it is necessary not to only meet the sheltering requirements of the people, but also to ensure, their health, safety and comfort in a user-focused manner.

Whether they are with hard floor or a natural soft floor, the courtyards create an outdoor space within the interior of the building for users and add sustainability to the building.

1.1. AIM OF THE RESEARCH

Today, sustainable buildings form the basis of many research topics in terms of the security of our future, both in engineering and architectural practice. In this context, the use of courtyards can provide many positive contributions to the sustainable lives of buildings. The aim of this thesis is to determine the variables that may be effective to evaluate the courtyards according to the sustainability criteria and to forward their contribution to sustainability by examining the commercial and educational structures of the courtyard which are actively used throughout the day in the Marmara Region.

1.2. SCOPE OF THE RESEARCH

The research is handled on the basis of courtyards as common interiors associated with nature. The scope of this study is to investigate the effects of sheltered outdoor spaces (courtyards) on the sustainability of the building in order to meet the decreasing natural area requirement. In order to examine the commercial and educational buildings in the Marmara Region, which include collective service functions throughout the day, 13 actively used buildings were selected.

The steps after the first part of the research are as follows.

In the second chapter, the definition and criteria of the concept of sustainability are explained in general and architectural terms in accordance with the literature researches.

In the third chapter, the definition of the concept of common space concept related to nature and its development in historical process have been examined by revealing the differences between them and different typological evaluations have been investigated.

In the fourth chapter, common spaces at the building context are explained. The effects of courtyard, atrium and compact structures on sustainability have been comparatively tabulated.

In the fifth chapter, the definition of the development, types and characteristics of courtyards in historical process is made and evaluated in terms of sustainability criteria. The evaluation of the importance of the open-air courtyards as the best outdoor space insurted into the building, the characteristics of the spaces, the types, the varieties in the literature are examined and the factors related to sustainability of courtyard typology are determined. The courtyard typology table was classified according to these factors.

The sixth chapter includes case studies. Commercial and educational structures of the courtyard, which are actively used throughout the day in the Marmara Region, were calculated according to Table 4.2 (Basic Positive Qualifications Table) in the fourth section and the results were evaluated.

1.3. RESEARCH METHOD

This study was started by examining literature sources, articles, theses, books, papers and information obtained from electronic media about the courtyards.

Then the research was carried out in the following stages:

- General and architectural investigation of sustainability
- To make comparison a courtyard with another associated with nature interior common spaces and tabulated to reveal the importance of the courtyard.
- Determining the sustainability gains of courtyards with determined control variables and tabulated.
- Preparing courtyard typology in terms of sustainability
- Explaining and examining the types of courtyard in typology with examples
- For the case studies, located in the Marmara Region is actively used 13 commercial and educational buildings with courtyards were selected. Analyzing the architectural projects of these buildings and analysis and evaluation the data according to the control variables determined in the table of sustainability gains of courtyards.
- As a result, electrical data of winter and summer seasons belonging to the best, middle and worst ones between examined structures, has been checked by using interviews and the conclusions are explained comparatively.

2. SUSTAINABILITY

Sustainability is an advanced concept that is necessary in every field of life to guarantee our future and to ensure the continuity today. In general, this concept will be explained in detail in 2.1 and 2.2 chapters.

2.1. BRIEF HISTORY OF SUSTAINABILITY

Sustainability term was first used in Human Environment Conference in Stockholm at 1972. After the conference, Stockholm environment declaration was signed. After this declaration, the Barcelona Contract was signed in 1976. The Brundtland Report published by the World Environment Commission in 1987 sets forth the definition of sustainability used today.

In this report, “Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs.”

The historical development of the concept needs to be searched for a more detailed examination of the developments in the time period since the beginning of sustainable development and the progress of the mentioned points.

In the early nineteenth and early twentieth centuries, the world was dominated by imperial and colonial relations, and countries in colonial status were obliged to meet the raw material needs of the imperial forces. Progress and modernization in the developed regions have been set as the main targets, and equality and social justice issues remain in the background. During the Great Depression, it was observed that policies carried out in developed regions such as Europe and the United States (USA) ignored the needs of the majority of people. This situation began to change considerably after the Second World War. The main objective of economic development policies has been to raise living standards and provide more goods and services to the expanding population. After the war, the International Monetary Fund, World Bank and the United Nations have been established for this purpose [1]. In the period after the Second World War, all efforts were directed to revive the collapsing economies and to seek development paths.

These policies, which have led to many environmental problems along with development and which are against the countries in the long term, have been replaced by an understanding of not only economic but also social, environmental and human factors. The rapid increase in the population and the need for more natural resources triggered concerns about this issue, provided a clearer understanding of the negative aspects of the current practices and demonstrated the necessity of taking measures globally. It's imperative that these changes occurred in the 1970s, gathered under the name "Sustainable Development", led to the emergence of a new development concept [1].

United Nations Stockholm Conference, 1972;

The concept of sustainable development related to the occurrence and development of a next step was administered for the first time in "United Nations Conference on the Human Environment" which was held in Stockholm in 1972.

United Nations Conference on Human Settlements (Habitat I), 1976;

Following the conference held in Stockholm, in 1976, the United Nations Human Resources Conference (Habitat I) was also held in Vancouver, Canada, to discuss the urbanization and housing problems of developing countries and possible [2]. Two years after this conference, the United Nations Center for Human Settlements (UNCHS) became operational.

The World Conservation Strategy (WCS), 1980;

Published in 1980, “the World Conservation Strategy” aims to ensure sustainable development by protection of living resources. The strategy, in which the concept of sustainable development has been used for the first time, has been prepared for three basic groups that are not completely separate from each other and suggest ways to be effective in achieving the goal of sustainable development. It is stated that achieving a sustainable society in the strategy is possible through the preservation of genetic diversity, the sustainable use of living resources and the sustainability of life processes [2].

Our Common Future (Brundtland Report), 1987;

It was recognized by countries that the steps taken until the 1980s on the way to sustainable development were inadequate and a serious organization was needed to serve this purpose. Cheap and environmentally harmful methods used by developing countries in order to keep up with rapid industrialization increased the awareness towards sustainable development. It is suggested that sustainable development consists of three main components in this report, which is concerned with ways of redistributing to developing countries and encouraging economic growth and at the same time achieving sustainable growth. These three components, defined as environmental protection, economic growth and social equality, constitute the three pillars of sustainability. If one of them is weak, the existing system is considered unsustainable [3].

Ecological sustainability,

- Consciously use the consumption of resources in the environment
- To reduce the production of hazardous wastes
- Using the all of waste materials by recycling beneficially
- Become aware of renewable resources and ensure recycling
- Ensuring benefits to ecological sustainability by reducing the use of harmful substances [4]

Economic sustainability,

- In order to support of local economies, producing of rich products in its territory for each country
- Performing investments and resources under ethical conditions
- Providing economical healthy living opportunities by making the pricing over real costs, getting rid of the need to pay extra for a healthy nutrition for people by this way [4]

Socially sustainability,

- Ensuring social equality in society
- Ensuring cultural and social integrity
- Improving living comfort and raising healthier generations
- Increase in the powers and capacities of societies [4]

Ecologic, economic and social growths are shown as triple profit chart to ensure sustainable development (Figure 2.1).

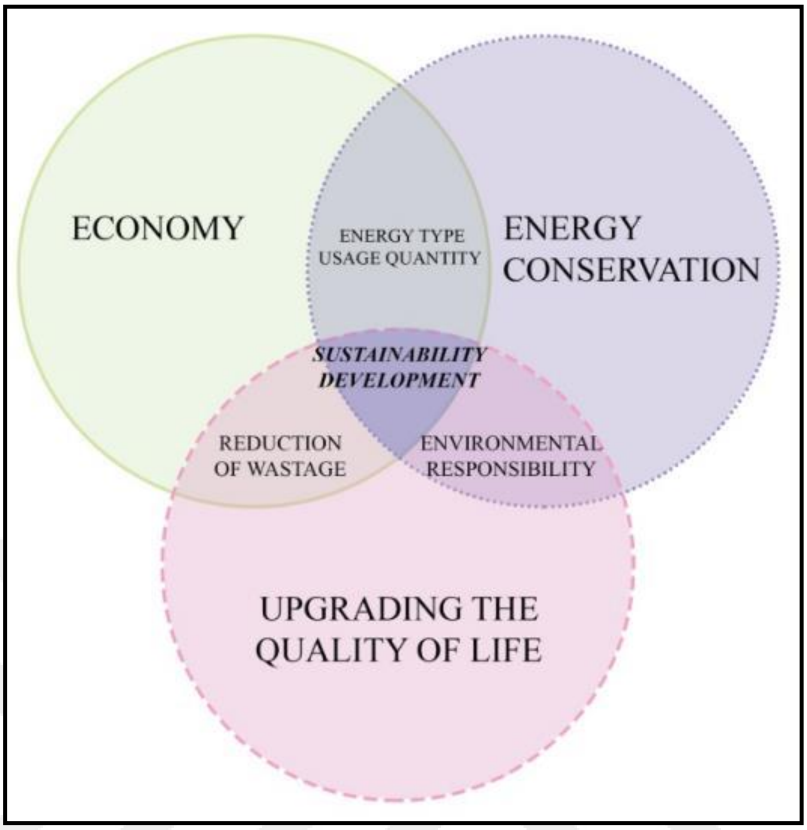


Figure 2.1. Development of sustainability [5]

United Nations Conference on Environment and Development (Rio Conference), 1992;

Twenty years after the UN Stockholm Environment Conference, 3-14 June 1992, the United Nations Environment and Development Conference was held in the city of Rio de Janeiro, Brazil, which 172 countries participated. During the conference a Declaration was made out with the aim of achieving the objectives set out in the conference. Contrary to the previous ones, this conference, which is also known as the World Summit, has been carried out not only with the participation of senior management, but also with the participation of all segments of the conference [6].

United Nations Conference on Human Settlements (Habitat II), 1996;

At the Rio Conference, the concept of sustainable development has been examined in a broader context and the relation between the fields of economy, environment and management were discussed. Four years later, in the documents of the United Nations

Conference on Human Settlements held in İstanbul, attention was drawn to the relationship between the concept and the human settlements [7].

Rio +5 Conference, 1997;

At the Rio +5 Conference held in New York City from March 13 to March 19, 1997, participants from different parts of the society were included in order to prevent the sustainability concept from being kept in theory and to increase its applicability [7].

United Nations World Summit on Sustainable Development (Johannesburg Summit), 2002;

The World Conference on Sustainable Development, which was a decade after the Rio Conference and which had been left behind for ten years, has been prepared for a long period of preparation. In this process, a series of meetings were organized in 2001, in regional and global level, until June 2002, in preparation for the summit [8].

United Nations Conference on Sustainable Development (Rio + 20 Conference), 2012;

The city of Rio de Janeiro hosted a conference on sustainable development twenty years after the Rio Conference in 1992. The United Nations Conference on Sustainable Development (UNCSD), organized by the UN between 20-22 June 2012, is known as the Rio +20 Conference and its main objectives are; taking sustainable development related to previously arranged assessment of the conference can be summarized as sustainable renewal of political commitments made related to the development and addressing new problems from occurring [9].

G20 Antalya Summit, 2015;

The G20 Summit, in which the world's 20 largest economies are participated and has been established to represent as much of the global trade as possible, evaluating the issues that come into prominence globally and making recommendations and commitments to resolve the problems. G20 summit was hosted in Turkey in 2015. G20 countries, which represent 90% of the world economy and 80% of the trade in economic size, are of global importance [2].

Figure 2.2. United Nations sustainable development goals [10]

Sustainable development’s goals are;

- Combining two groups that are Economy and ecology into one and to offer resources to use of today’s and tomorrow’s generations;
- Protection of basic ecologic balance and life support system, genetic versatility and spaces with ecosystems;
- Renewing growth, having growth speed under control, enriching natural resource’s basis, taking economy and environment into consideration while deciding, re-conducting technological developments,
- Increasing of harmony with human and nature [11].

2.2. SUSTAINABILITY IN ARCHITECTURE

Generally, structures that use economic and renewable energy, minimize fossil fuel consumption and unpolluted the environment are considered sustainable. They are also called green structures due to their ecological features.

Sustainable structures do not pollute the environment during construction, operation and destruction. At the same time, they use water, energy, waste and material resources in the most appropriate way (Figure 2.2) [12].

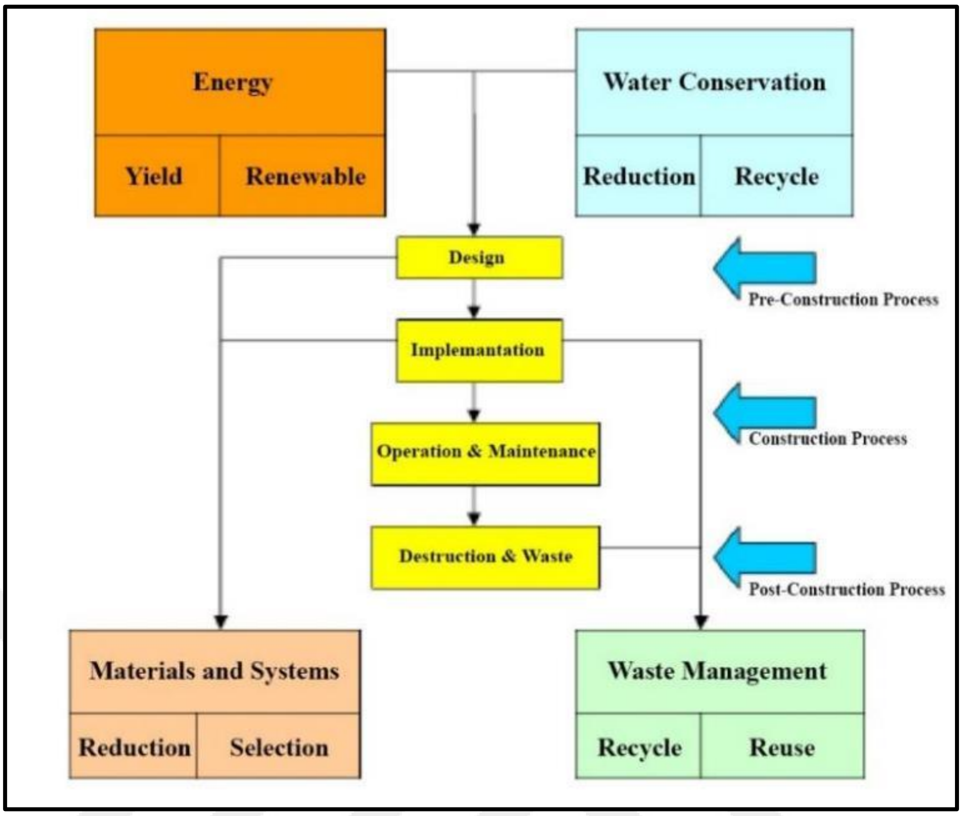


Figure 2.3. Lifetime flow chart for buildings [13]

There are certain criteria when designing sustainable structures. These are as follows,

- Proper volume organization should be done to minimize energy losses. This organization is essential to get maximum advantage of solar orientation. Considering summer and winter conditions this solar direction should be the "optimum direction" that varies according to the latitude of the region. This solar direction may also overlap with the suitability for wind utilization and ventilation [5].
- Design of building shell should be designed by choosing the most suitable material according to the climate.
- The inclination and direction of the land to be built is very important in terms of microclimate. Climatic features such as air flow, solar radiation, and humidity provide energy saving by making natural air conditioning in the building.
- Effective landscape design greatly reduces heating and cooling energy costs. The variety of trees used plays a big role. For example, it is possible to provide cooling

in summer months with natural shading by placing broadleaved and decidious trees in winter around the structure.

- For material selection, local, renewable, recyclable durable products which are present in the environment and used at low energy levels should be preferred.
- When designing a water efficient structure, it is essential to keep the amount of water to a sufficient level in order to use low-consumption installations and tools, to collect and use rain water, to convert wastewater, and to provide adequate care to the landscape.
- It is essential to be avoided from the construction at fertile soils for agriculture, areas full of biodiversity and forested areas. Furthermore, the damage to the soil should be minimized by reducing the areas where the building would be built along with providing designated firm ground for parking lots and the pedestrian paths.
- Designs should be made to protect the natural habitats of plants and animals [4].

The criteria mentioned so far about sustainability in architecture have accelerated the concept of certification for sustainable buildings.

Certification systems aim to define the green building by creating general and valid measurement standards, to develop a holistic building design method, to recognize environmental leadership in the building sector, to encourage green competition, to transform the building market by increasing consumer awareness of the benefits of green buildings [14].

In addition to BREEAM which emerged in the UK, LEED in the US and DGNB in the Germany. There are lots of sustainable building certification systems like, SBTOOL (GBTOOL) which emerged in Canada but is an international system, HK-BEAM and CEPAS used in Hong Kong, SBAT in South Africa, Green Star in Australia and CASBEE used in Japan. While the purpose of these certification systems is to initially establish a system specific to each country by considering its own local standards, climatic data and living conditions, countries that do not have their own assessment system depending on these two systems have international recognitions have begun to adopt LEED, BREEAM and DGNB certification systems [15]. Today, it has been begun to use SBTOOL in many countries which are member of the World Green Building Council (WGBC) in accordance with local standards in addition to BREEAM, LEED and DGNB systems. Figure 2.4 summarizes the evaluation criteria and certification levels of these certification systems.

	BREEAM Communities	LEED - ND	DGNB - NSQ
Title	Building Research Establishment Environmental Assessment Method (for) Communities	Leadership in Energy and Environment Design - Neighborhood Development	German Sustainable Building Council - New City Districts (Deutsche Gesellschaft für Nachhaltiges Bauen - Neubau Stadtquartiere)
Logo	breeam	U.S. GREEN BUILDING COUNCIL LEED USGBC	DGNB
Developer	Building Research Establishment (BRE)	U.S. Green Building Council (USGBC)	German Sustainable Building Council (DGNB)
Country of origin	United Kingdom	United States of America	Germany
Release	2009	2009	2011
Groups of Criteria	- Climate & Energy - Resources - Place Shaping - Transport & Movement - Community - Ecology & Biodiversity - Business & Economy - Buildings	-Smart Location & Linkage - Neighborhoods Pattern & Design - Green Infrastructure & Buildings - Innovation & Design Process - Regional Priority Credits	- Ecological Quality - Economical Quality - Sociocultural & Functional Quality - Technical Quality - Process Quality
Rating System	Outstanding Excellent Very Good Good Pass	Platinum Gold Silver Bronze	Gold Silver Bronze

Figure 2.4. Rating systems [16]

Ecological and sustainable architectural design table (Table 2.2) which summarizes the general explanations mentioned above related to sustainability in architecture has been developed.

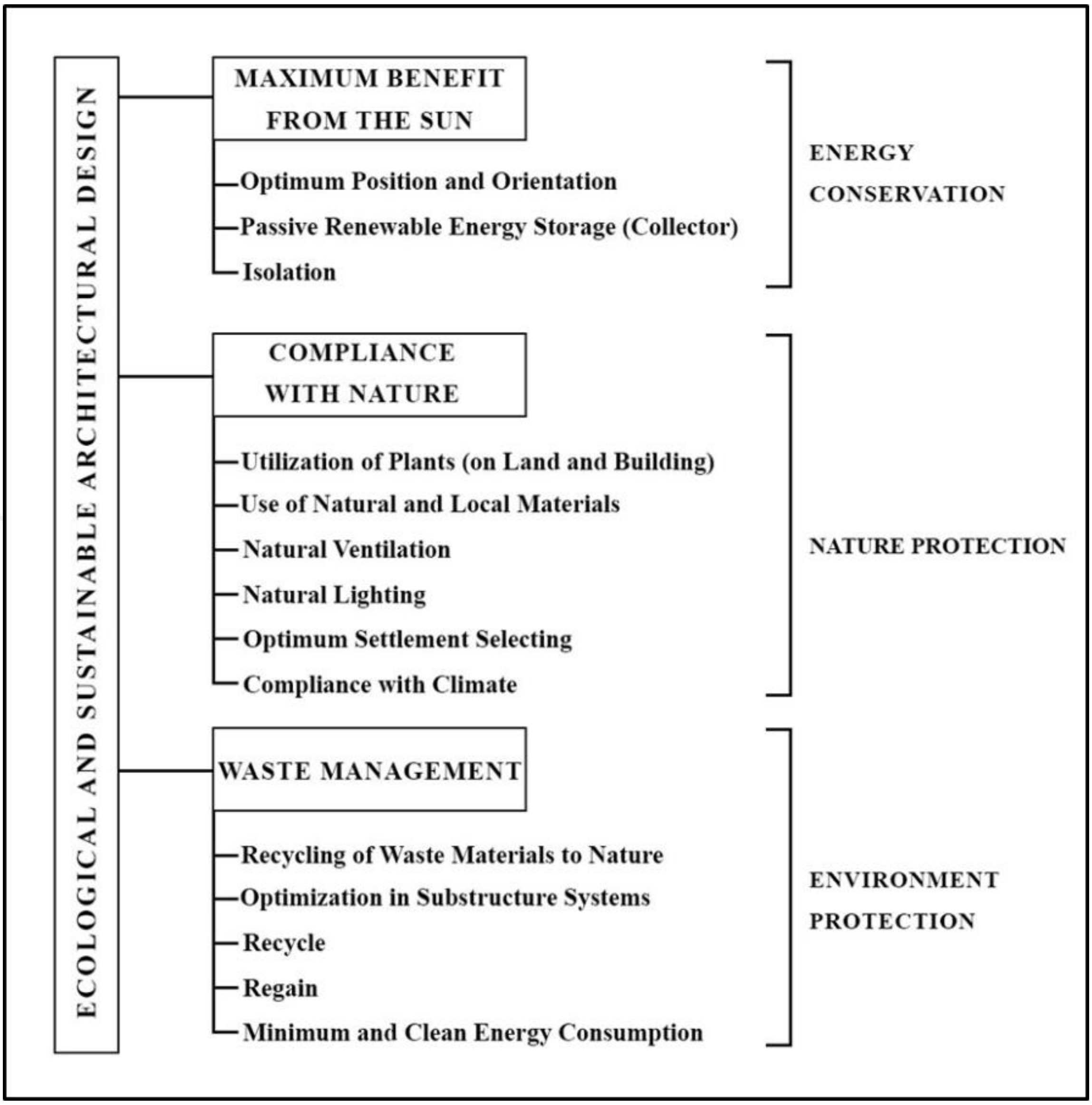


Figure 2.5. Ecological and sustainable architectural design [5]

3. GENERAL COMMON SPACE CONCEPT AND DEVELOPMENT IN HISTORICAL PROCESS

Common spaces have been created in order to meet the needs of communities to be together and to meet. These spaces have constantly changed and improved depending on the social, economic and urban characteristics of the period. They vary according to cultural differences. There are places where people from various groups and qualities can use together without discrimination.

Common spaces can be examined in two groups as common outdoor spaces and common interior spaces. With the industrial revolution, many problems have arisen such as the crowding of cities over their capacities, the emergence of various environmental matters and the negation of the urban conditions. The approach of shifting the common life to interior has been developed for the purpose of protection from these conditions [17].

3.1. GARDEN AND INNER GARDEN

Garden; *“A piece of land is the art of arranging with nature elements such as plants, water, stones"* [18].

Gardens are vegetative common outdoor spaces designed by humans, using natural materials, cultivated and spatially varying. Seasonally, they present a visual difference according to the weather conditions and the diversity of the landscape items. They are places that change with time and live with people.

The combination of nature and art has kept the link between man and nature together throughout history. Each culture varied according to the power of the gardening period, power, philosophy, and religious belief.

When the historical process of garden art is examined, it is seen that civilizations have existed since its foundation. Hence, research is shed not only about design and human-nature relations but also about the properties, values, habits of periods, how they meet spatial needs according to climatic conditions, and aesthetic values [19].

Egyptian Civilization, between 4000 and 5000 BC, was settled in the Nile Valley and they built monumental gardens, geometric and symmetrical frescoes and terraces and the most magnificent gardening examples of the past.

The most well-known example of the Mesopotamian Civilizations, made up of fertile soil between the Dicle and the Euphrates, is the Hanging Gardens of Babylon. The terrace is made up of gardens. It is observed that this tradition is maintained in the following years.

Figure 3.1. The Hanging Gardens of Babylon [20]

Roman Empire were interested in agriculture and they designed irrigation systems. According to their religious beliefs, the gods have humanized and reduced everything to a human dimension. Sacred landscapes, god sculptures, water items were made to show gratitude to the gardens as it was believed that the gods were in everyday life.

With the collapse of the Roman Empire in the Middle Ages and the conventions becoming the center of cultural life, the experience here has contributed to the development of horticulture and agriculture. These gardens, where plants and flowers were grown for vegetables, fruit, medicine, were surrounded by high walls for creating an isolated environment on the outside. Nowadays, remains of mosaics and ornaments can be found from those times.

In the Renaissance period, the garden art began in Florence and reached reached its most magnificent period in Rome. The gardens are partially symmetrical around the central axis.

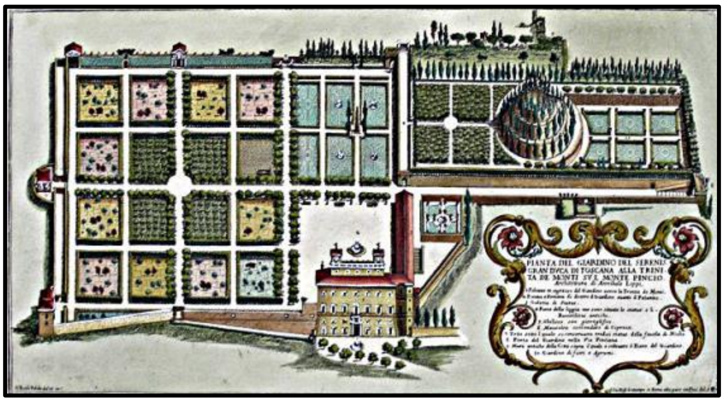


Figure 3.2. Villa Medici, Florence [21]

The Baroque gardens began by being influenced by the Renaissance gardens. The Early Baroque garden art is designed with the geometric scheme of Renaissance and colorful flowers. The design principles of the Baroque gardens are putting the architectural garden in the forefront by emphasizing the infinity of the conception of space in a whole, and planning with diversity, simplicity and detail.

A second pavilion and a greenhouse are located on the other end of the garden passing through the central axis of the mansion. There are wooden roads, water items, canals, terraces, and tree paths intersecting with sculptures around this axis. These gardens are called French gardens.

Figure 3.3. Vaux-le-Vicomte, France [22]

Another concept of garden art is the English garden, which emerged in response to French gardens. It is supported by emotionally created structures that are randomly designed to reflect the nature as it is. These constructions are artificial ruins, new gothic monk houses (loneliness), reed structures (simplicity), bridges and temples.

Figure 3.4. Stourhead Gardens – Wiltshire [23]

The influence of religious beliefs in Far East gardens is quite high. Especially in China and Japan, inner garden art developed. Different kinds of arts have emerged. For example, Ikebana (flower arrangement art) and Bonsai (art of trimming trees in pots with special techniques trimming and dwarfing appeared in the 7th century.) Stone, gravel and mosaic stones are used as floor covering. The garden has water features, bridges, arbors, garden pagodas. It is surrounded by high stone and walls. There is a rectangular pool along with channels. They regard the gardens as a part of love of nature.

Figure 3.5. A garden in the Far East [24]

Figure 3.6. Ryōan-ji Gardeni, Kyoto [25]

In the 20th century and nowadays, the concept of garden is seen as an element that supports architectural units. In Turkish gardens naturalness is in the foreground. Among its characteristics are short walls that can be easily seen outside, and a series of long cypress trees on the floor to hide these walls. The plants inside are naturally grown species. The garden is influenced by the ancient beliefs of the Turks. It is meant to be living within the zenith of viewing the garden and it is possible to see this thought in the widespread use of arbors. The water element is used as it is in other gardens, but it is not visual yet functional and can be in the form of a fountain, well or pool [26].

Interior Gardens are designed with a certain purpose and quality concern in the structure and are arranged with different kinds of plants depending on the demand. Inner gardens are living organisms of enclosed spaces [27].

The disappearance of natural areas, cities and everyday life together with the widespread urbanization have increased the interest on natural area and human - nature relations. With the rise of modern buildings outdoors, people's desire for nature has increased steadily. As a return to nature in the name of sustainability, interior gardens have begun to be designed intensely [27].

Man needs nature both physiologically and psychologically. While the internal gardens provide this, the plants and water used to make it home to other species as well as humans.

3.2. ATRIUM

Doğan Hasol discribes the atrium as "an opening in the middle of the old Roman houses, all parts of the house open, courtyard around the portico" [18].

It is called the closed hollow volume which extends over all floors, not less than 5 meters away from the two opposite sides, in which the two or more layers are opened as a common volume [28].

Early atrium is distinct from today's atrium. They are classified according to the type of vaulted roof enclosures that surround the open middle area and are interior spaces that create a sense of presence in the outdoor space to meet the needs such as natural lighting, rainwater collection [17].

There are 5 varieties of lodge cover types which are the criteria for early atrium classification. They are Etruscan (Tuscan), Corinth (Corinthian), Four Columns (Tetra Stylon), Roof Surface Sloped (Displuviatum), and Central Spaces Covered by the Roof (Testudinatum).

The Etruscan (Tuscan) style is the type of roof that provides rain water from the roof gutters from the corners of downwardly inclined courtyard walls to the intersection of the beams.

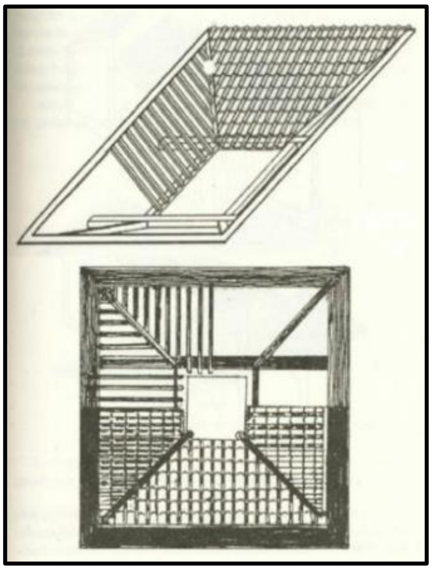


Figure 3.7. Tuscan style atrium plans [29]

In the Corinthian (Corinthian) style, the beams and roof openings are equally flattened. But the beams are pulled in at a certain distance and joined with peristyle columns.

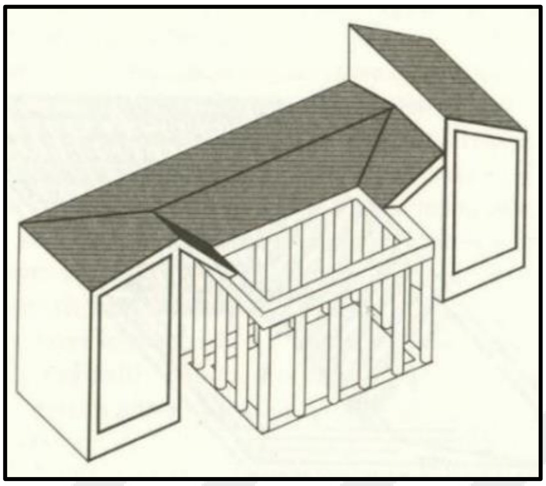


Figure 3.8. Corinthian style atrium [29]

The four-column (Tetra-Stylon) style is the atrium roof type, which is carried by four columns. Corner columns provide stability. As the loads are evenly distributed, the beams are lifted from the load and pressure.

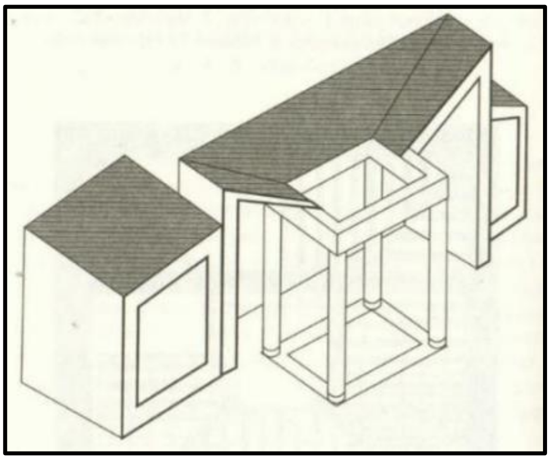


Figure 3.9. Tetrastylon style atrium [29]

The Roof Surface is composed of displuviatum style, beams supporting the roof, and channels located from the outside to the inside, helping to collect the rain water. But this disrupts the structure of the wood and the wall.

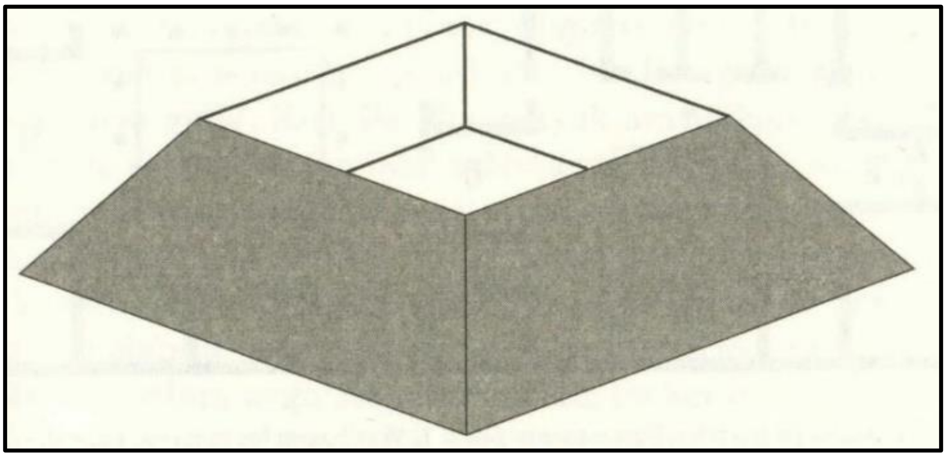


Figure 3.10. Displuviatum style atrium [29]

Testudinatum Style is used in situations where the common space is not too large and there are large rooms on the upper floors [29].

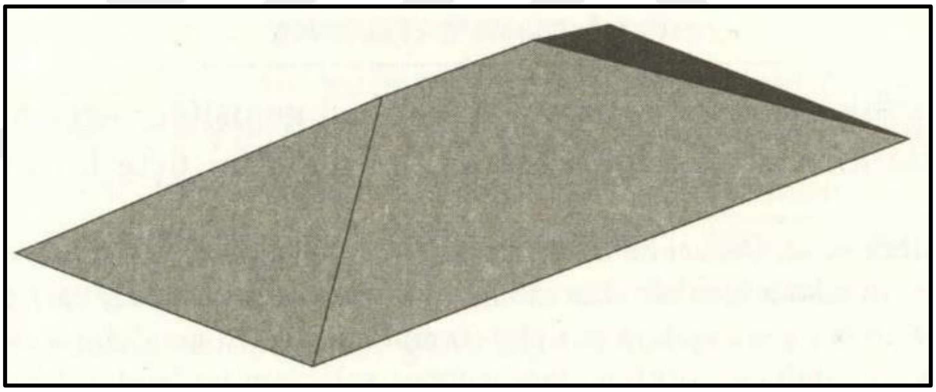


Figure 3.11. Testudinatum style atrium [29]

With the use of glass and steel technology developed after the Industrial Revolution, central spaces - large central spaces - were built which were closed, covered by larger openings and protected from climatic conditions [17]. The first and the most striking examples of the period were built in England and France. These examples are Galerie Des Machines, designed by Joseph Paxton in London in 1851 and Crystal Palace (Figure 3.12) in 1889, designed by Dutert in Paris in 1889. These designed constructions were built for the World Fair [17].

Figure 3.12. Crystal Palace, London [30]

Figure 3.13. Galerie Des Machines, Paris [31]

In 1967, The Hyatt Regency Hotel in Atlanta was designed by John Portman as the first modern example. The hotel's rooms open onto a one-way corridor overlooking twenty floors of transparent twin-roofed atrium. This structure has created a prototype of atrium hotel designs. Not only is the hotel functional but also office, shopping center, health care, culture and education and multifunctional design [17].

Figure 3.14. Atlanta Hyatt Regency Hotel [32]

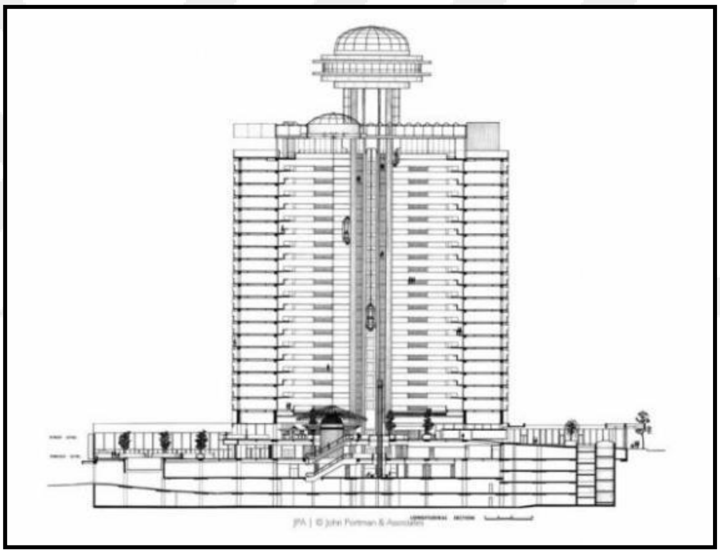


Figure 3.15. Atlanta Hyatt Regency Hotel section [33]

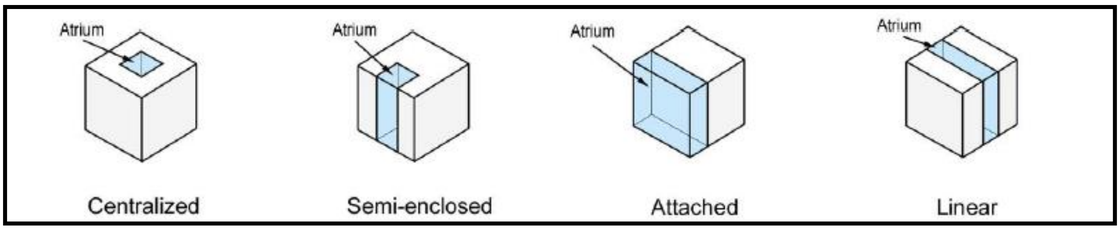


Figure 3.16. Basic atrium styles [34]

Nowadays, the atrium creates a common space by providing natural lighting and controlled climatic environment to indoor spaces with different designs. According to the desired effect and the type of structure to be used, atriums can be constructed as centralized, semi-enclosed, attached and linear. According to the necessity of the special plant varieties used in the interior, water items and appropriate furniture according to the function of the design is completed.

3.3. COURTYARD

Doğan Hasol defines the definition of the courtyard as *"the open space in the middle of a building or building group, the surrounding area is closed"* [18].

Courtyard is called the building section which has different shapes in the open-top traditional architecture surrounded by sections of the buildings or walls, with a short edge of not less than 5 meters [35].

Humans designed the need for protection and accommodation according to climatic conditions by searching for different solutions. It is an example of these solutions in the courts. Starting from the ancient times, this solution provides safety and protection from harsh climatic conditions. We come across different types of courtyards in different parts of the world. (Figure 3.17)

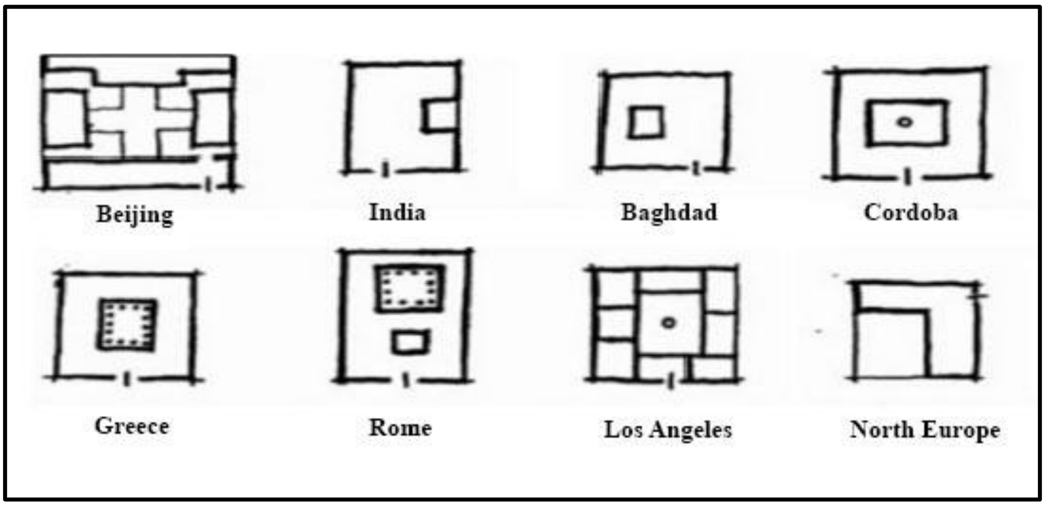


Figure 3.17. Examples of different types of courtyards around the Globe [36]

Each period has its own design features. The needs of the courtyard from ancient and today's needs are not the same. In ancient times, single-storey courtyards in Africa have prototyped courtyards [37].

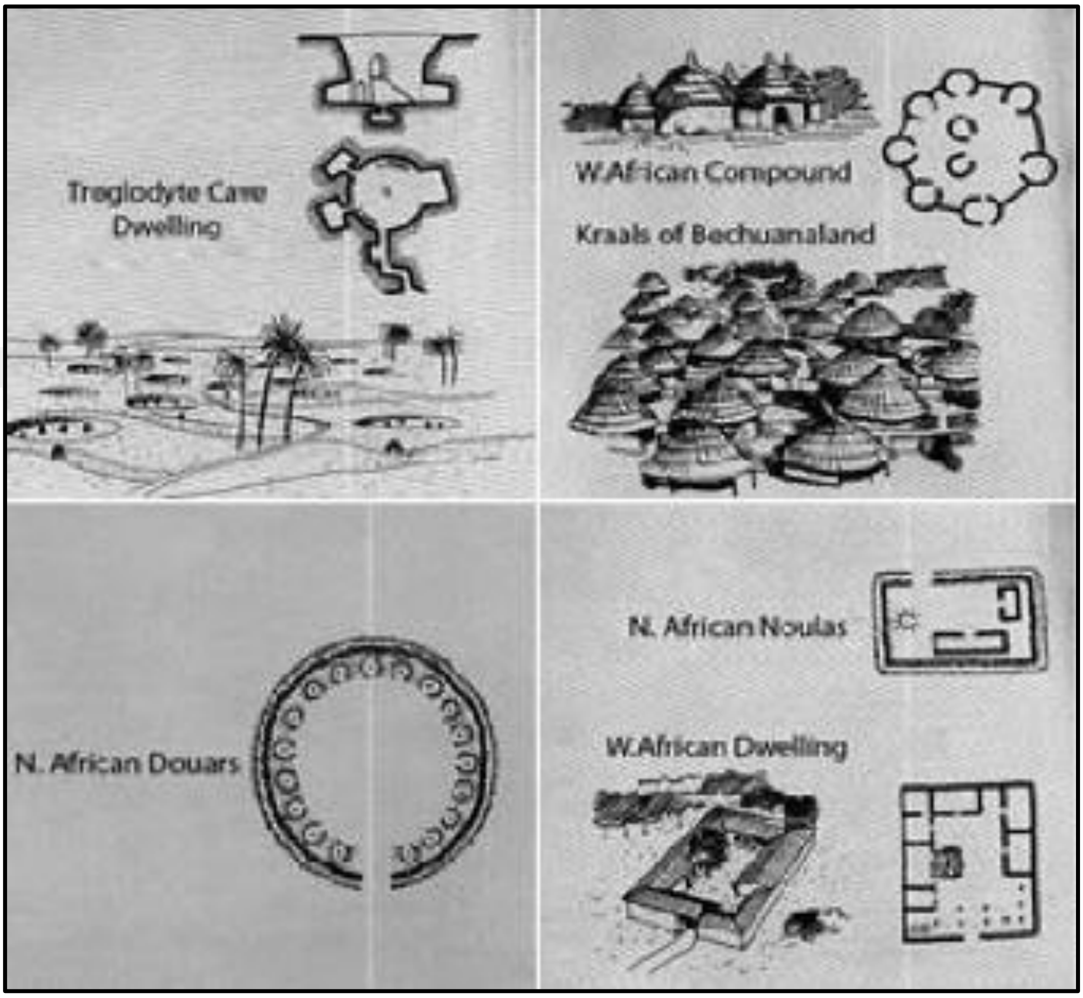


Figure 3.18. African courtyards in ancient times [38]

In the plans of the Courtyard in Mesopotamia; the ground floor consists of rooms around the central courtyard [39].

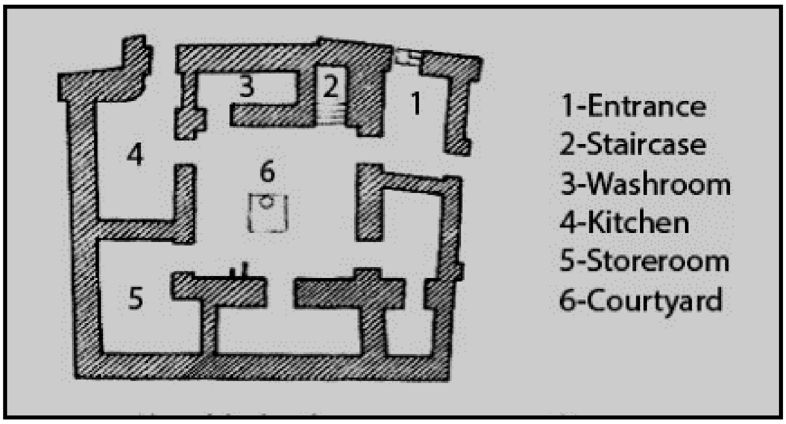


Figure 3.19. Mesopotamian courtyards [39]

The courtyards in China were built with faith, meditation, Yin-Yang philosophy and confidentiality [38].

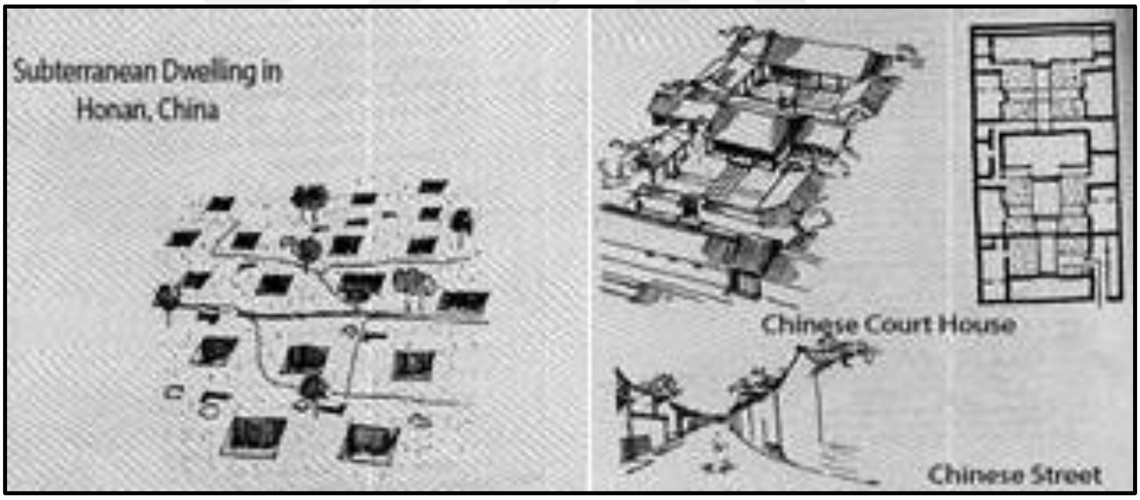


Figure 3.20. Chinese courtyards [38]

In the classical period courtyards, design was the main purpose. Atrium and courtyard were used together in Roman architecture. Personal spaces were created on the outside [39]. Designed peristyle style courtyard in Greek architecture. Over time, the atrium and peristyle style have been used together [40].

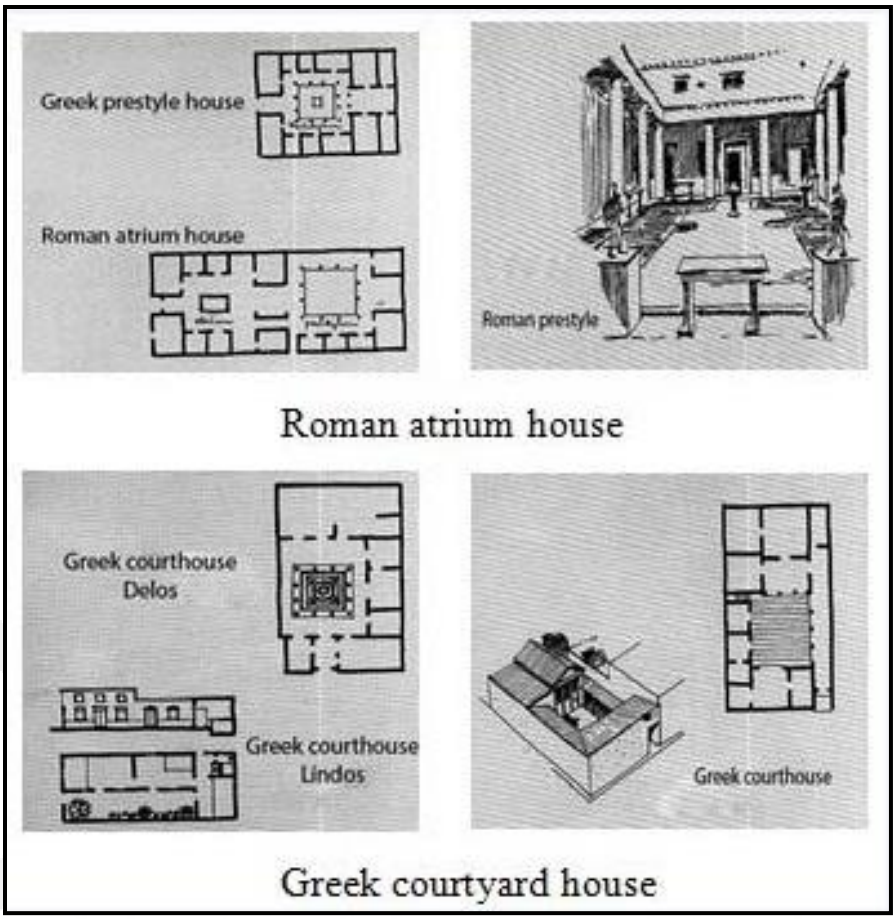


Figure 3.21. Roman and Greek courtyards [38]

The "avula", synonymous with the courtyard, was given to the open courtyards in front of the ancient Greek houses. This space, which is called "the courtyard" in the Homer Period, refers to an open top of the houses. At that time there were two such courtyards in every house. There are rooms for men's use around them, and rooms for women for the other. This order is also present in Roman houses. But one of these courts was called "atrium" (men's use) and the other was called "peristhylium" (women's use). Besides these, the courtyards are defined according to their place or functions in the structures [41].

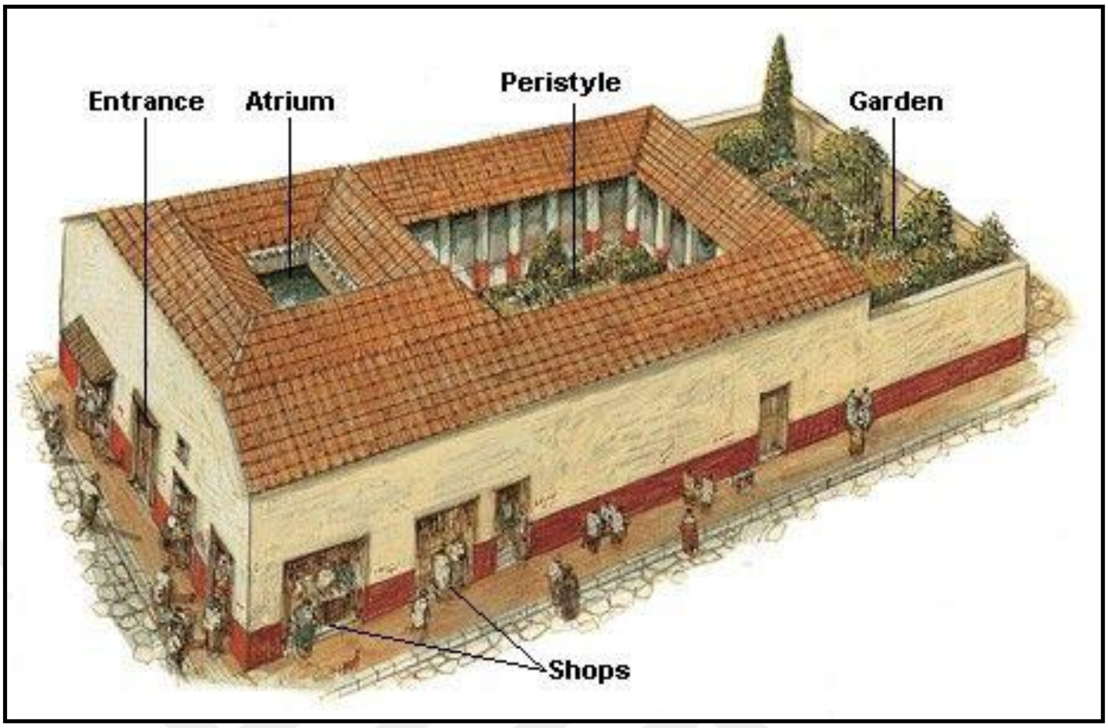


Figure 3.22. Roman villa [42]

During the Middle Ages Early Christian era, the central peristyle courtyard was the common venue where the meetings were held. The use of the "water" element in this courtyard was for worship. Those who came to worship were first to wash their hands in this water and then enter the church [40].

During the medieval Islamic period, the social status of the person in the outside world was minimized, and privacy and secrecy were taking place [38].

Spanish architecture, on the other hand, was influenced by Roman architecture and helped to develop the courtyard by performing outdoor activities in the courtyard [43].
Today's courtyards are used as architectural elements. Measures and different methods are being used to increase the efficiency of courtyard use [44]. The courtyards are used in every building function and form a common space.

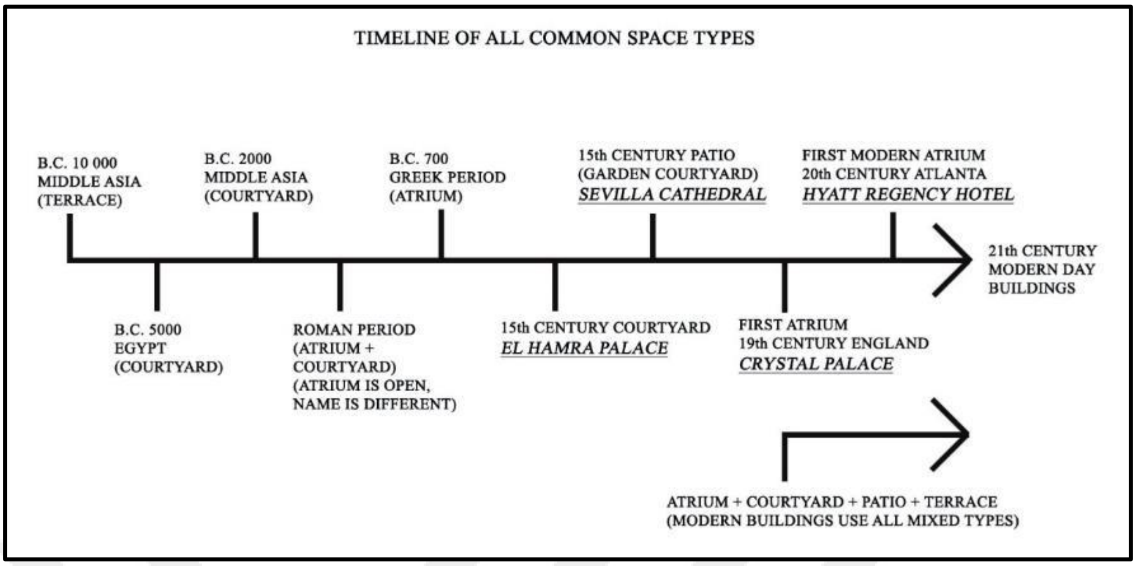


Figure 3.23. Timeline of all common spaces
(Constitute by Author)

4. THE CONCEPT OF COMMON SPACES ON THE BUILDING

The concept of common space at and around the building can be defined as the areas that everyone in the building can use. For example, the places where a number of users simultaneously use such as conference rooms, meeting rooms, halls, vertical and horizontal circulation areas can be given as examples for these places. Common spaces can be found outside and inside the building, which can be designed with different functions, can be converted into places associated with the nature and spaces arranged with plants. The gardens can be found around the building as common areas and create a natural habitat and have a positive effect both ecologically and psychologically. The internal and external common spaces at the building will be described in sections 4.1. Common Exterior Spaces Associated with Nature on the Building and 4.2 Common Interior Spaces Associated with Nature on the Building.

4.1. COMMON EXTERIOR SPACES ASSOCIATED WITH NATURE ON THE BUILDING

In buildings, common outdoor spaces appear as a courtyard, terrace, balcony and garden, as shown in Figure 4.1 and 4.2 these spaces are on different levels and places in the building and in a sense, they are the common exterior spaces of the building. Those areas are directly related to nature, but their floors are harsh except for the gardens. When desired, planting with pots can be provided. In other words, those areas are common external areas associated with the outside of the building and controlled.

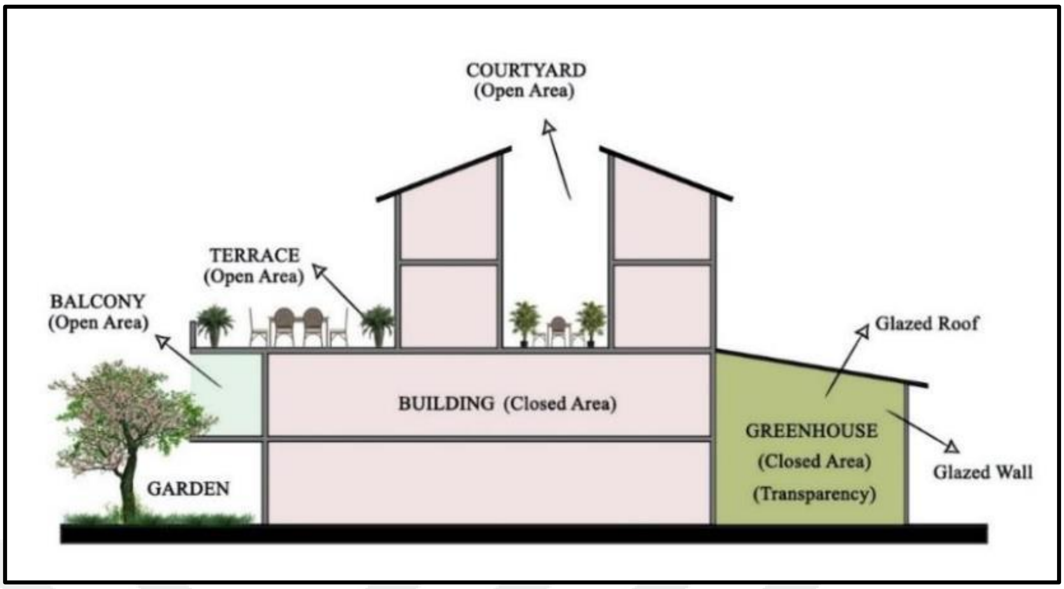


Figure 4.1. Open spaces in low storey buildings
(Drawing by Author)

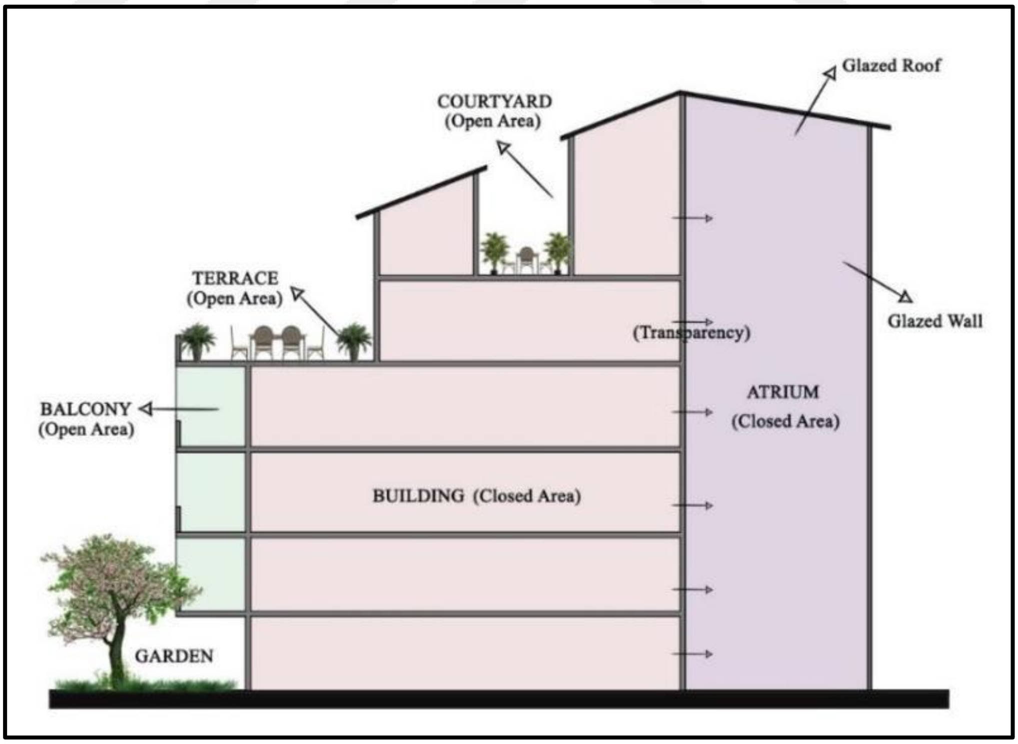


Figure 4.2. Open spaces in high storey buildings
(Drawing by Author)

4.2. COMMON INTERIOR SPACES ASSOCIATED WITH NATURE ON THE BUILDING

The courtyard, atrium and greenhouse as shown in Figure 4.1 and 4.2, are common interiors associated with nature in building. However, only the courtyards between these places are directly related to nature in building while atrium and winter gardens are indirectly related with nature. Therefore, courtyards are kinds of spaces taken inside of building of common outdoor spaces associated with nature. When the common spaces associated with nature are taken into the building, the concepts of quality and belonging become more subjective. As input and output controls can be applied, controlled areas can be created in external environment. These places can be used in different seasons because of designed with firm or natural ground and ensured suitable climatic environment.

4.3. COMPARISON OF COMMON INTERIOR SPACES ASSOCIATED WITH NATURE IN TERMS OF SUSTAINABILITY

In order to be able to make these comparisons, the benefits of the common interiors in the structure in terms of sustainability criteria will be revealed first. Later, it will be compared through a table of different common interiors according to the benefits.

The benefits of common interiors to the building in terms of sustainability criteria, within the framework of the opportunities provided by common outdoor spaces are:

- Insolation
- Natural ventilation
- Wind control
- Noise Control
- Air pollution control
- Outdoor planting
- Natural lighting
- Compliance with nature
- Indoor temperature control
- Microclimatic comfort
- Improved outdoor comfort

In Table 4.1, a comparison between courtyard and the atrium buildings and compact building has been shown by considering the similarities of positions in the building. Courtyard and atrium buildings have common interior spaces associated with nature; but compact building does not have any common interior spaces associated with the nature. As can be seen from this table, the benefits of the courtyards to the building in terms of sustainability criteria are 1/3 of the atrium and 1/2 of the compact building.

When the opportunities that there are not in the interiors of building, but provided from the external environment are taken into the building inside, they bring important benefits to the building in terms of the sustainability criteria laid down in Chapter 2. When the issue is addressed in this direction; the outside environment is regarded as a common space for the users, and the idea of creating a common outside space in the structure arises. In this context, in the thesis study, the concept of "common outside space inside building" which is taken into the structure as the external environment qualification has been developed. From this point of view, courtyards and inner gardens can be described as common interiors of building, rich in outdoor qualities. Therefore, the concepts of "courtyard" and inner garden which are explained in Chapter 3 come to the forefront in terms of the sustainability criteria set out in Chapter 2.

Inner gardens, on the natural ground, can be kept equivalent to large size courtyards. For that reason, the inner gardens will be treated as a courtyard type.

Consequently, generally in this study, the contribution of courtyard to the sustainability in terms of design will be examine and other common non-courtyard spaces of structure shown in Figures 4.1 and 4.2 will be excluded from the research topic.

Table 4.1. Assessment of physical properties of outdoor spaces in buildings according to sustainability criteria

(Constitute by Author)

Common outdoor spaces in buildings / Benefits	COURTYARD	ATRIUM	COMPACT*	SUSTAINABILITY CRITERIA	REFERENCES
Insolation	+ + +	+	+	A,B,D	Ahmed, Gadi , 2013, Karagüler, 1994
Natural Ventilation	+ + +	+	+	A,B,D,E	Yaşa, 2017, Karagüler, 1994
Wind Control	+ + +	+ + +	+ + +	A,D,E	Zamani, Taleghani, Hoseini, 2011, Karagüler, 1994
Noise Control	+ +	+ + +	+ + +	B,E	Yang, 2013, Saxon, 1983, Karagüler, 1994
Air Pollution Control	+ + +	+ + +	+ +	A,B,D,E	Reynold, 2002, Saxon, 1983, Karagüler, 1994
Outdoor Planting	+ + +	-	-	A,B,C,D,E	Reynolds, 2002, Karagüler, 1994
Natural Lighting	+ + +	+ +	+	B,D	Taleghani, 2014, Karagüler, 1994
Compliance with Nature	+ + +	+	+	A,B,C,D,E	Reynolds, 2002, Karagüler, 1994
Indoor Temperature Control	+ +	+ + +	+ + +	A,D	Taleghani, 2014, Karagüler, 1994
Microclimatic Comfort	+ + +	+ +	+	A,E	Salur, 2016, Karagüler, 1994
Improved Outdoor Comfort	+ + +	+	-	A,B,C,E	Karagüler, 1994
Total Qualifies	**31**	**20**	**17**		

+ + + Well Qualified, + + Qualified, + Less Qualified, - Unqualified

A) Climate Comfort, B) Naturality, C) Human Scale – Life quality, D) Economical Life
E) Environmental Control

*** COMPACT:** Building with window and door openings only without common spaces associated with nature.

4.3.1. The Significance of the Courtyard

The courtyards have always existed in the historical process. It is an architectural element which is made for the purpose of creating thermal comfort and has different usage purposes today. It is used as a planning element in architecture and urban scale. In one hand, these small structural open spaces are used for the functions of planning, organizing providing closure and being a transition element. On the other hand, they have functional importance with the attribution of climate regulation, defense and introversion. It connects the different places in the building with natural ventilation and lighting and creates the outside space which is taken into the building. Courtyards are the only common interior spaces associated with the nature as directly. Therefore, as explained in the previous chapters, their contribution to the sustainability of building is much higher than the other interiors associated with nature. That's why; their importance is high as well. The courtyards vary according to the type of flooring, climate, design and use of materials.

In order to provide visual and spatial continuity, openings must be found in the planes surrounding the area. The closeness of the space varies according to the aspect ratio, the layout and the number of the courtyard. The direction of the space, the light axis, the light quality, the landscape and the movement within it affect the element of this closure.

The courtyards, also used as transition elements, have different effects according to their location.

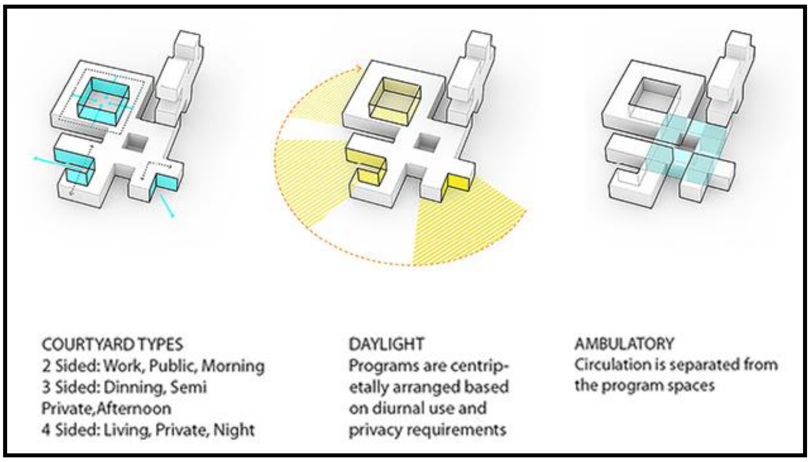


Figure 4.3. Common spaces [45]

The building is limited to its exterior surfaces. With the formation of the courtyard, the transparency of the inner parts of the structure and the expansion of the restricted space surfaces (window, door blanks, etc.) are ensured. Internal and external integration are ensured, and the functions in the space are transported to the outer space and the sheltered outdoor space directly related to the nature in the building. In other words, it is a common space where the outdoor conditions of the courtyards and the interior conditions are combined.

These sheltered outdoor spaces allow the individual to be abstracted from his intense activities in everyday life, resting, having time and dreaming. The courtyards create a garden atmosphere depending on the design and an extra living space that separates spaces and provides privacy.

The spaces can not only meet people's need for protection. People need psychological environments as well as physical environment in order to survive healthy individual life. Individual experiences, social relations, working environment, and the necessary moral environment provide a great positive impact [46].

The preference of local materials in building construction contributes to sustainability both as a cultural reflection and in the usage process. The prevalence of hedonistic structures varies according to climate regions.

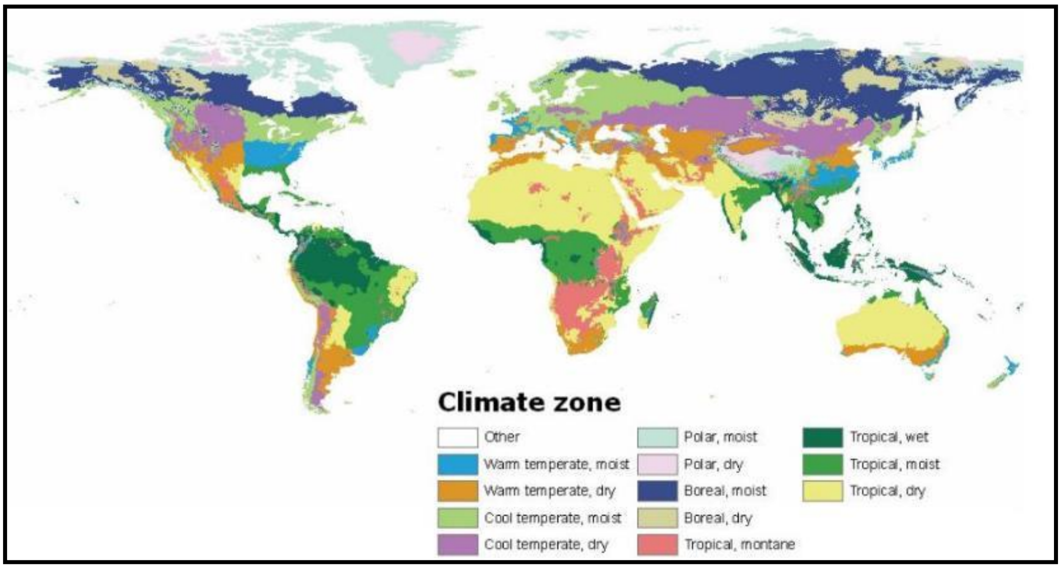


Figure 4.4. Climate zones [47]

The Hot-Dry Climate Zones are located at 20° and 35° latitudes on the globe. The temperature is the highest at 45°C and the lowest at 25°C. Humidity and precipitation are very low. Moisture deficiency and seasonal winds can cause sandstorms [48]. In hot-dry climate regions, when the sun is controlled in the right-handed courts, the water content and moisture content can be increased to the desired level. According to other climate regions, the courtyards used in the hot-dry climate regions are large. In large courts, daylight is provided more and the place causes radiation gain. Shaded and moist environment is created with the used water items and plants. As the north facing façade will be cooler than the south façade, the courtyards constructed in this direction constitute the ideal temperature environment for this climate region. The openings on the southern side are larger and larger openings on the north are very few. While openings are preferred at minimum because the eastern face of the structure receives more sunlight, the openings of the western face require more sunlight and heat than the eastern face [44, 49]. In Eastern parts of Turkey courtyards hold importance on daily life.

Figure 4.5. Iran, Yezd [50]

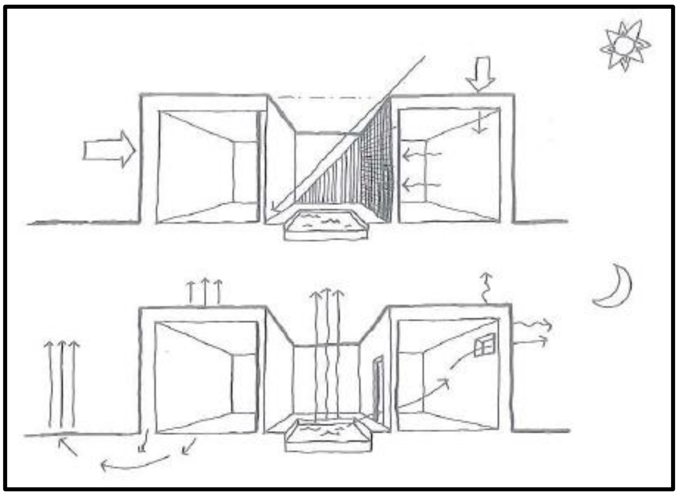


Figure 4.6. The main thermal elements [48]

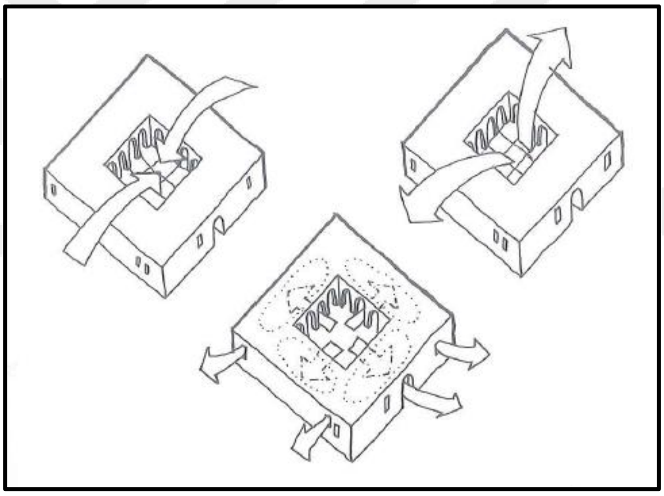


Figure 4.7. The diurnal thermal regimes [48]

Cold Climate Zones are located at 55° latitudes on the globe. The average temperature is the highest -15 ° C in winter and the lowest -40° C in winter. The temperature in summer is not more than 10° C [48]. In cold climates, courtyard proportions are smaller in order to minimize heat loss. We are trying to create a compact structure. Maximum sunlight, minimum air circulation is utilized. Cold climate zones are located in the north. Benefiting from daylight is provided from the southern cephalopod. The gains and losses on the eastern and western fronts are equal, so use rates are equal. As a landscape, leafy trees can be planted, but in this climate region, the use of plant in the courtyard is not common [44, 49].

Figure 4.8. Stockholm, Sweden [50]

Temperate Climatic Zones are located at 30° and 55° latitudes on the globe. The temperature is approximately 25 ° C. The lowest in winter is -15°C. Seasonal temperature changes lead to overheating in summer and excessive cooling in winter [48]. In temperate climatic regions, there is no mention of a single type of courtyard, since sudden changes in weather conditions are not observed. There is no need for moisture values expected from water items and landscaping, and temperature and humidity rates are sufficient for the climate itself. Wide and frequent openings are preferred in temperate climate regions. These openings will provide cross ventilation and eliminate the need for more air conditioning [44, 49].

Figure 4.9. Granada, Spain [50]

Tropical Climate Zones are located at 0^o and 25^o latitudes on the globe. Temperature values do not exceed 35^oC during the day and 20^oC overnight. The humidity is quite high. Precipitation is often seen intensely [48]. In tropical climatic regions, radiation gain is the least desirable. The courtyards have to make a refreshing effect with the cross flow of air to the space. Wind speed and direction determine the positioning of the courtyards. As the humidity is high in tropical climatic regions, landscaping and water surfaces are not needed, preferably depending on the courts. Floor height in courtyard buildings is over and narrow compared to other climates. Due to the excess of openings, the wind flow creates a cooling effect. In addition, long parapet applications are being made to reduce radiation gain.

Figure 4.10. Malasia [50]

Figure 4.11. Samples of courtyards in different building types in Malaysia [51]
(a) Courtyard in Melaka townhouses; (b) Courtyard in a renovated terrace house, Bangsar; (c) Courtyard in a restored 18th century Melaka shophouse; (d) Courtyard in British council complex, Kuala Lumpur; (e) Courtyard in the University Putra Malaysia, Serdang

In summary, the courtyards organize the spaces, gain the identity of the space, provide the harmony between the space and the person, create the external effects of the interior, establish the plant - human relationship, and function as the divider for the functions overlapping each other. Heating and ventilation factors can be provided by natural means with courtyards, with the colorful plants used in the building, it creates a livable environment both for the human and psychologically.

4.3.1.1. Sustainable Attribution of Courtyard Buildings

These qualifications can be explained in the following way in terms of sustainability in accordance with the benefits provided by common interiors.

Insolation: The courtyard constructions are the ones that collect the total solar radiation according to the other constructions. Outside space in the structure shows high performance in terms of natural energy storage due to the fact that the surface of building shell increases. The sun comes at different angles, depending on the location, with the latitude and longitude of the courtyard. The angle of sunrise varies depending on the openness rates of the constructions.

Natural Ventilation: Ventilation of a building inexpensively, ecologically, only due to natural air movements is very important in terms of sustainability. Natural ventilation reduces the need for artificial ventilation and conditioning to save money. Cross natural ventilation is provided by taking wind from the structural cavities (window, door) and courtyard openings. Natural fresh air can be provided in courtyard, while natural air is provided only from the windows because of the closed space in the atrium and compact structures [52].

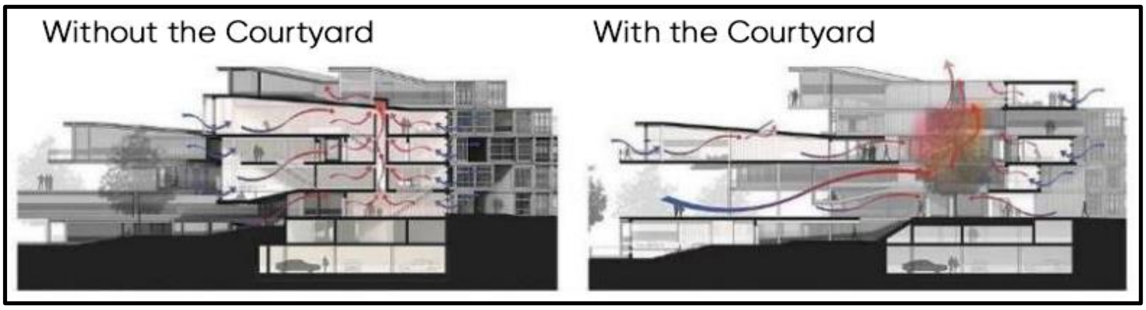


Figure 4.12. Natural ventilation [53]

Since the early ages, designers have used natural air movements for two basic needs, such as removing dirty and humid air, and providing personal thermal comfort and conditions [54].

For example, traditional Korean architecture is usually located on the foothills. The mountains are very influential on the speed and direction of the wind. Korea in mountainous regions benefits from the influence of traditional architectural mountains and responds to seasonal climate changes. Constructions are protected against cold winds in winter. In addition, moderate winds are required due to summer and high temperatures. Moreover, structures must be protected from strong winds, such as typhoons. So, the Koreans place their buildings on the slopes of the mountains. Despite the windless summer weather, in traditional Korean architecture, the application of various techniques, produces a resultant wind. The Korean style courtyard is located at the front edge of the "madang" structure. Madang; white clay is a hollow empty field. There is no tree here, with a small garden in the corner or a small pond. The back of the building is associated with the mountains. The backyard contains trees, flowers and plants. In sharp daylight a temperature difference between the backyard and the front courtyard occurs. The temperature of the front courtyard exposed to daylight is higher than the backyard, which is green with trees and flowers. The temperature difference between the front and back of the build results in local current conduction. This is the method of natural phenomenon from the heat flow [55, 56].

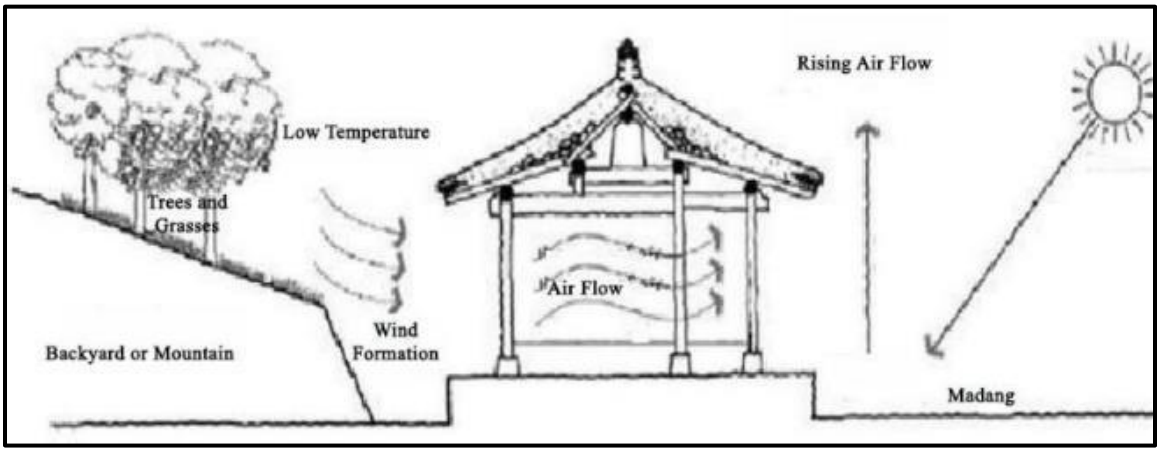


Figure 4.13. Traditional Korean natural ventilation [55]

One of the traditional architectural buildings in Morocco, which is called Kasbash, is also known as the "Kasr". Kasbash's especially used in the hot-arid regions of North Africa, surrounded by high mud-brick walls. Kasbashes are very high and have very small windows; they are built very close to each other. The town houses several of these houses known as "kasr". Kasbashes have the qualities to comply with the harsh hot-dry climates. Indeed, the main purpose of these structures is to protect the inhabitants and animals from extreme sunlight. The most important aspect of Kasbash plan is planning with a large courtyard facing inward. The courtyards have great precaution in the climatic control. The houses have three outer walls to prevent facades from being exposed to heat. Each Kasbash has a thermally highly effective surface volume ratio. Since most walls are shared by neighbouring houses, only the roof surfaces are exposed to the sun. Their closeness to each other, surrounded by the streets, plays an important role in passively cooling the house. In the shaded areas (the streets) the stored cold air is pushed through the courtyard by convection and then ascends out of the house. This helps keep the house cool during the day [55, 56].

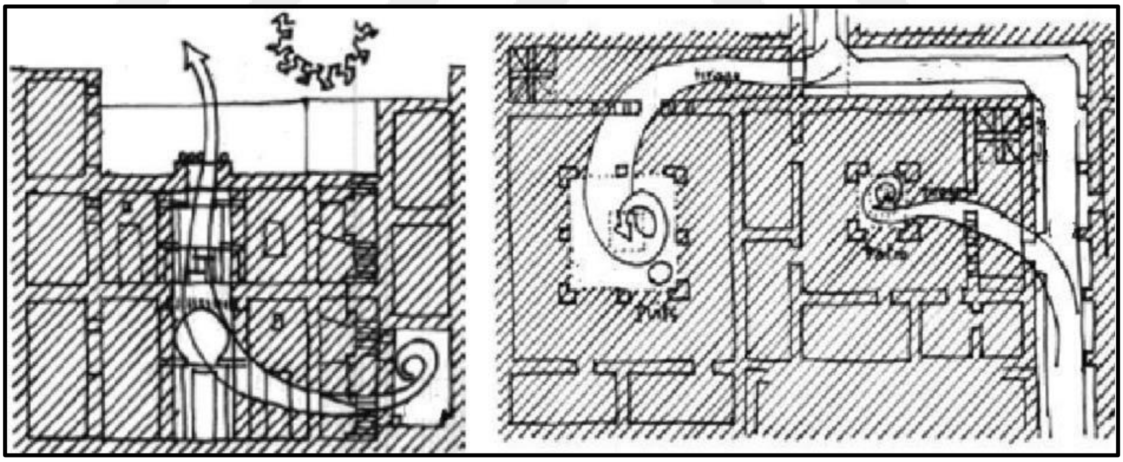


Figure 4.14. Traditional Moroccan natural ventilation [55]

Wind Control: The exterior walls of structure consist of a courtyard area and a secluded area. With this area, the effective wind effect on the outside is reduced. The plants are highly effective in terms of wind prevention and guidance potential. The effects of plants on wind control depend on their layout as much as their species [58].

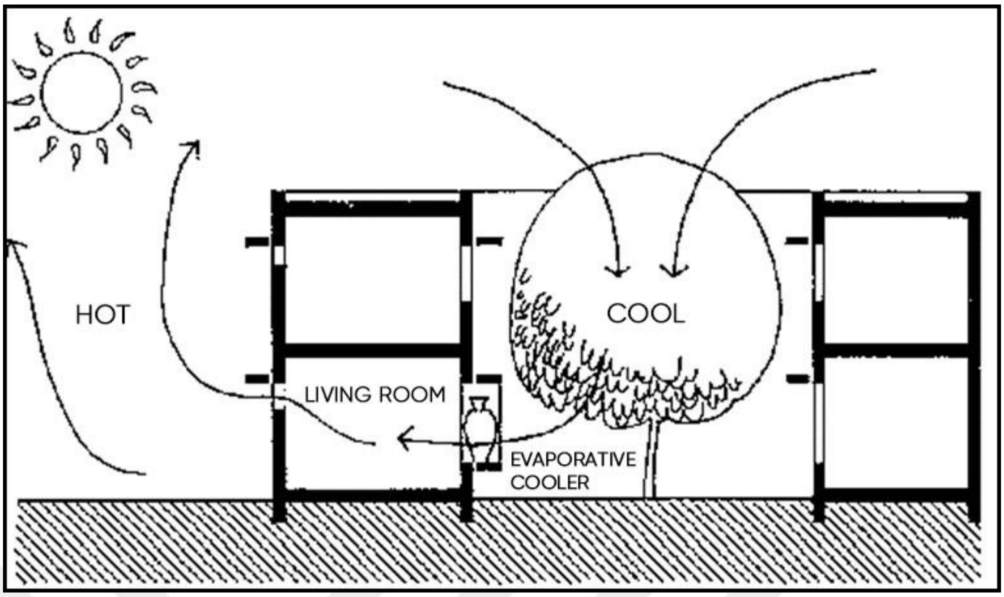


Figure 4.15. Wind control [36]

Noise Control: The outer wall of the bellows serves as insulation, greatly reducing the noises on the outside. In order to provide noise control inside the courtyard, the results of the investigations are as follows;

- Use of sustainable acoustic materials on the sides of the building instead of the ground
- Soil, leaf surfaces and plant arrangements at different heights absorb high frequency sound energy, so the floor must be covered with soil or another layered floor covering
- Planting should be done both on the facade and on the ground
- Use of outdoor furniture for sound distribution and breakage; it is very useful in terms of noise control [59].

Air Pollution Control: Factors such as uncontrolled city growth, concrete use, fossil fuel use, and diminishing green spaces create air pollution. The air is filtered through new ventilation systems in compact and atrium structures to prevent partial pollution. In the courts, the isolated area of the building's wall is partially protected from air pollution.

Outdoor Planting: The plants are considered as architectural elements. By using the different characteristics of the various plants used in the courtyard, habitable, functional and aesthetically sustainable spaces are created for plants. Air pollution, noise, wind control, natural green space requirement (such as soil) can be provided by courtyards with planting. The interior spaces are providing both a comfortable environment and an outside space (such as garden) effect is created in. Every season a different atmosphere is provided by the transformation of plants. With the smell of flowers, the opportunity to live in natural life is provided.

Natural Lighting: Outdoors in the courtyards, natural lighting is benefited directly from diffuse solar radiation. Providing natural lighting to the illuminated place contributes to sustainability by reducing the energy consumption caused by artificial lighting. While the atrium is partially sun-lit with transparent glass roofs, the compact buildings are lit only by the sun reflected from the window. By using water elements, more illumination is obtained by reflection. Natural enlightenment has psychological effects on humans as well as physical characteristics such as energy saving, improvement of healthy environment and improvement of spatial quality. It improves the performance of the staff working in offices, increases the success rates of the students in schools, increases the sales rates in the service sector and increases the quality in industry and industrial facilities.

Compliance with Nature: The growth of cities, the increase of artificial environments, the decrease of green space-natural environment, the deterioration of human-nature relationship, the more time people spend in closed areas, the deterioration of ecological urban climate, the need for soil-nature are greatly reduced.

Indoor Temperature Control: Each climate has different characteristics. The courtyard protects you from the effects of outside by creating a secluded interior space in challenging winter conditions. According to the researches and measurements made, the temperature difference between indoor and outdoor can be felt. It is cool in summer and provides a warmer winter environment. Heat and humidity control can be provided by the landscape and water items used.

Microclimatic Comfort: *"It's a climatic event that happens in a small area defined by boundaries"* [44]. Microclimate can be controlled when the parameters such as width, height, height, material are designed according to the climate. When the courtyard structure typologies and literature studies are examined, it is found that the courtyard has the most effective microclimatic comfort. But this comfort differs according to the climatic conditions.

During the winter season, the inner surfaces of the courtyard store heat throughout the day with the sun's rays becoming more oblique. This heat is transmitted to the interior in the evening hours and provides the necessary thermal comfort during the night. There is very little change in the courtyard temperature when the outside temperature shows a decrease in the air temperature. Thermal changes occur on the floor of the courtyard. Since the northern part of the courtyard will be under the influence of radiation during the winter season, indoor winter areas are located to the north of the building.

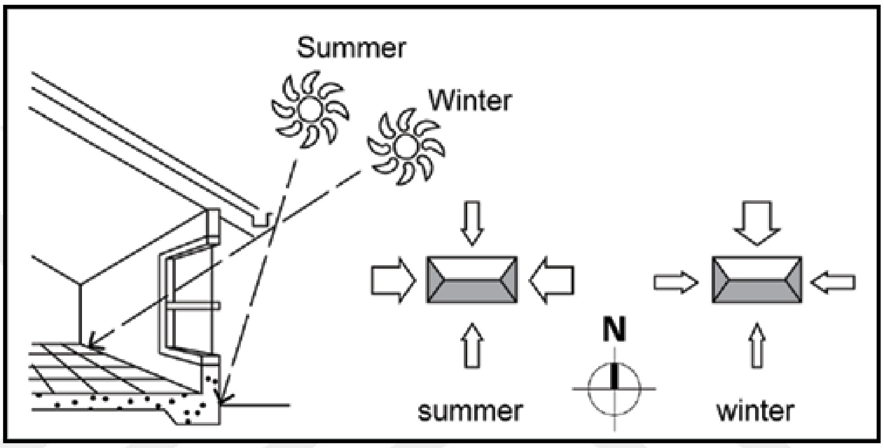


Figure 4.16. Sun orientation [60]

It is only the radiation of the open and semi-open spaces expected in the summer period. It is easier to control the obtained radiation by not accessing the closed space. Due to the controlled heat accumulation and cross ventilation, a lower temperature value is obtained in the courtyard than in the outdoor environment. The air current is taken in and the micro flow balance is provided by this current reaching the courtyard [44, 61].

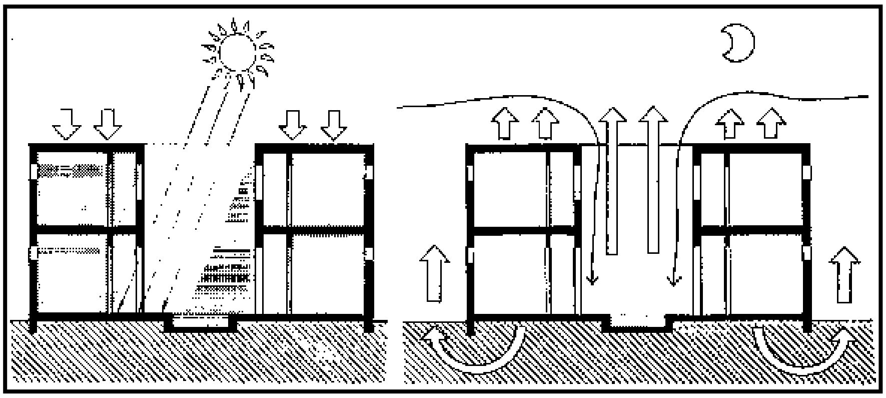


Figure 4.17. Summer day in the courtyard (Left) and night (Right) air movements [36]

Improved Outdoor Comfort: The courtyards can create a sheltered, improved environment outside the boundaries of the building that is free from adverse effects such as strong winds, noise and dust that may occur in the outside environment, but which can benefit from positive effects such as natural ventilation, natural lighting and an isolated environment in the common living area. In other words, courtyards, eliminating the disadvantages of the external environment are a location inside a building can benefit from the positive effects.

4.3.1.2. Basic Positive Qualifications of Courtyard in terms of Sustainability

The main positive qualities of courtyards are Maximum Utilization in Passive Solar Energy and Wind Energy, Compliance with Nature and Improved Outside Comfort. Control criteria of these properties and standard criteria of these variables are determined and tabulated in Table 4.2. This table will be used in the calculations to be made in Section 6 and the comparisons will be made on the basis of standard criteria.

Maximum Utilization in Passive Solar Energy: As the area and length of the facades facing the maximum solar area increase, more space of the building can benefit from the sun. The southern facade (Northern Hemisphere) is the facade with maximum sunshine throughout the year. For this reason, this utilization will increase as the ratio of the southern façade of the courtyard surrounded by buildings and the south façade of the building is increased. In addition, the air movement between the cold and hot directions (north-south directions) will increase, thus increasing the possibility of natural ventilation. In passive buildings, maximum passive sunbathing is provided only through the windows located on the facade of this building. Therefore, the increase in courtyard openings is important in ensuring good sunbathing. However, this opening is controlled by the ratio of the perpendicular depth of the courtyard to the north wall height of the courtyard (Figure 4.18)

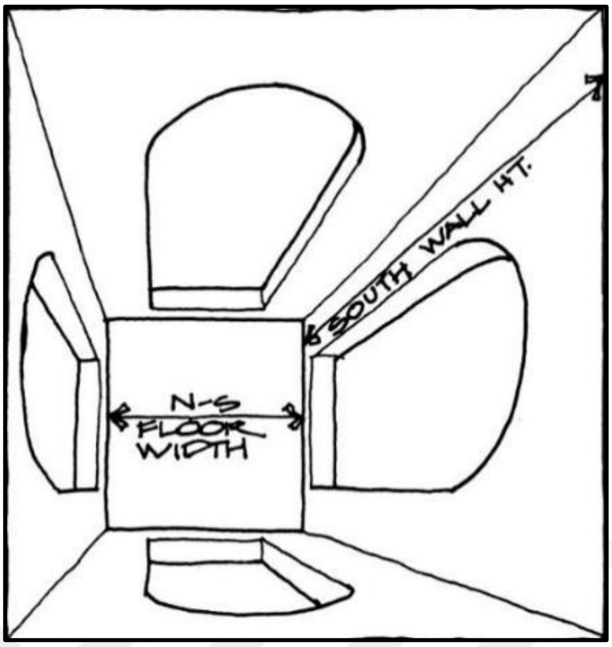


Figure 4.18. A high solar index indicates [62]

Table 4.2. Critical obstruction angles for different latitudes [48]

Latitude	**Critical Obstruction Angle**
Up to 40^o	40^o
40^o to 45^o	35^o
45^o to 50^o	30^o
50^o to 55^o	25^o
55^o to 60^o	22^o
Over 60^o	20^o

This rate is the minimum 2 (40^o North Latitude), at noon will allow the winter sun to get the most from the lower level of radiation (Figure 4.19). Sunbathing and natural lighting should have a sufficient effect, to benefit from the heating effect of the winter sun and to provide natural ventilation.

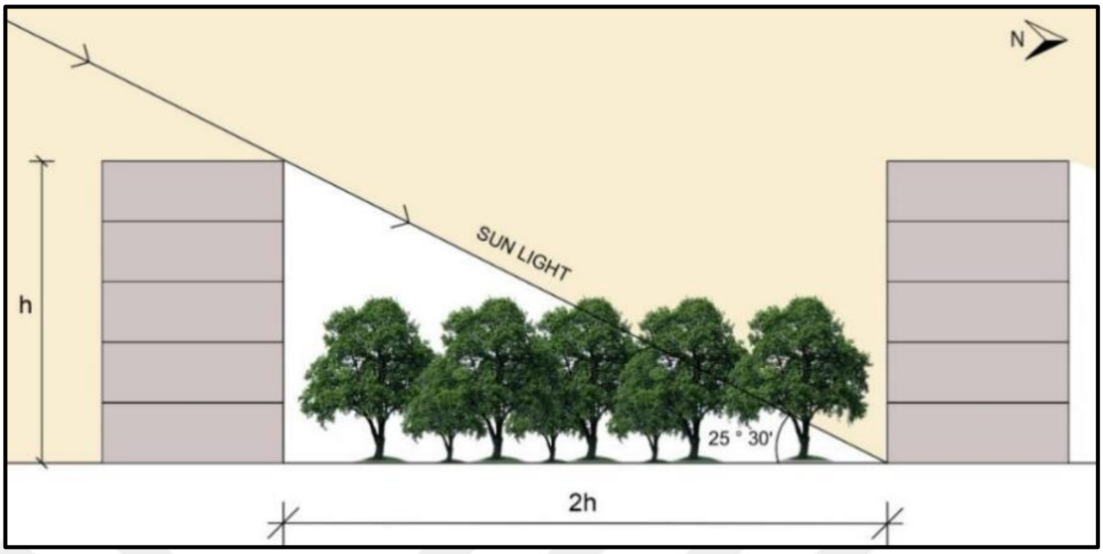


Figure 4.19. Sun light orientation [5]

Maximum Utilization in Wind Energy: The air flow within the yard is divided into three types as slip flow, wake-up flow and isolated roughness flow. The flow classification depends on the interaction of the downstream flow with the stream adjacent to the yard. When the main current strikes the body, a stagnation point is created on the wind's face and then the current divides it into four parts. The first flow wall is parallel to the wind and forms a vortex close to the ground. The second stream deflects upwardly above the building and then forms a re-bonded separation point and circulation on the roof due to separation and reconnection occurs. The other moves towards both sides of the building and forms two separate separation points and then joins the wind side. The isolated roughness flow is found in the case of **a shallow courtyard (h / d = 0.1 ~ 0.2)** where the distance between the courtyard is sufficient to prevent any interference. **In large courtyards (0.3 < h / d <1.0),** it causes the circulation flow by connecting with the flow on the wind side. With a further decrease in **width (h / d > 1.5)**, the flow of circulation will increase, which means that most of the flow does not enter the courtyard, and this is the last flow type that flows through [52, 63, 64].

Compliance with Nature: "Coefficient of Green Usage in Buildings" (CGUB) has been described as the main control variable of the plant usage on the buildings which change depends on the types of environments. CGUB values for every type of environments are approximately as follows:

- CGUB: 0.50 for most inconvenient environments,
- CGUB: 0.40 for inconvenient environments,
- CGUB: 0.30 for convenient environments,
- CGUB: 0.20 for most convenient environments.

According to CGUB values suitable for the district types to provide, the Total Plant Area on Building (TPAB), which is stated as the herbal area on the building, its parcel is becoming easy thanks to the courtyards. This value is necessary in terms of increasing the conservation of energy, economy and quality of life because of it optimizes the use of plants in the building.

Therefore, the role of the planted ground area of the courtyard in the buildings with the courtyard to the level of the Total Plant Area on Building (TPAB) at the building level is gaining importance. In particular, the courtyard provides a great opportunity to ensure that the total plant area at the building level has the minimum share of TPAB on the natural ground. Because the total plant area of the building level is calculated by multiplying the CGUB coefficient, the Total Floor Area (TFA) beside the amount on building floors, the minimum TPAB value calculated by CGUB in the amount of the natural ground in the land must be ensured. For this reason, the high level of soil level of the ground floor of the courtyards is an important factor in terms of ensuring sustainable qualities.

The suitability of these variables, the structure of the region where the structure of the total number CGUB out by multiplying the result with the Total Floor Area (TFA) is located by the ratio of the total number of plants within the structure [5, 58].

Improved Outside Comfort: When the cities are viewed from a bird's-eye view, the structures of different sizes appear to resemble a texture. All of these structures have similar shapes, but the similarity in courtyard buildings depends on the size of the courtyard. These dimensions characterize the courtyard's width, height and depth. Therefore, there is a ratio (or proportions) with the representation of one size of courtyards to the other.

By comparing the results of different forms, sun and winter protection in the summer in case of a rectangular heat recovery ratio (2:1) shows the highest value. Square and rectangular form ratio (3:1) is considered appropriate than others. Moreover, the square shows that both the facades and the courtyard itself are well illuminated.

It provides an improvement in the angle of rotation 90 °, sun protection in summer and heat gain in winter and 60 ° rotation angle applied to the triangle. The results obtained in this case are stronger than the triangular ones.

1:1 ratio square-shaped courtyard type; is the most appropriate rate in terms of gathering. The longer the rectangular form and the higher the proportions, the greater the possibility of being collected the movement of the space and the effect of sun and wind [49, 65, 66].

Table 4.3. Basic positive qualifications table

(Constitute by Author)

BASIC POSITIVE QUALIFICATIONS	CONTROL VARIABLES			OPPORTUNITIES FOR SUSTAINABILITY	SUSTAINABILITY CRITERIA IN ARCHITECTURE
	VARIANT	STANDART CRITERIA	REFERANCE		
MAXIMUM UTILIZATION IN PASSIVE SOLAR ENERGY	* The Perpendicular Depth of the Courtyard to the South (d) / The Height of the North Wall of the Courtyard (h)	**$d / h \geq 2$	J.REYNOLDS (2001)	1. The natural lighting of the spaces is increasing. 2. Max. Solar space heating is increasing the possibility of benefiting from the effects of winter sun due to increased fronts. 3. Natural ventilation possibility is increasing.	1. Natural Renewable Energy Use 2. Improving the Quality of Life 3. Economic Solution Processes
MAXIMUM UTILIZATION IN WIND ENERGY	Ratio (R) = The Height of the Wall (h) / The Courtyard Short Edge Depth (d)	$R = h / d$ $0.3 \leq R \leq 1$	HALL et. al. (1999)	1. Natural ventilation possibility is increasing. 2.. Natural air conditioning is provided. 3. Cold wind, noise etc. A protected external environment is provided that is free of adverse environmental influences. 4. The common living space where the users can come together.	1. Natural Renewable Energy Use 2. Improving the Quality of Life 3. Economic Solution Processes
COMPLIANCE WITH NATURE	Total Planted Area on Building (TPAB) is depend on the size of green area on the buildings connected to the “Coefficient of Green Usage in Buildings (CGUB)”	$TPAB \geq CGUB \times TFA$	S.KARAGULER (1994)	1. Natural life is growing with plants. 2. Microclimatic conditions are provided naturally. 3. Visual comfort is provided.	1. Natural Renewable Energy Use 2. Improving the Quality of Life 3. Economic Solution Processes
IMPROVED OUTDOOR COMFORT	The Long Edge of the Courtyard / The Short Edge of the Courtyard = Form (F)	$R = 1 \leq F \leq 2$	MUHAISEN & GADI (2005) TABESH & SERTYESILISIK (2016)	1. The common living space where the users can come together, which they have formed together. 2. It enables joint activities. 3. Cold wind, noise etc. A protected external environment is provided that is free of adverse environmental influences.	1. Improving the Quality of Life

As the control variables grow, the courtyard's efficiency in sustainability is increasing.

* For the northern hemisphere. (In general, the "direction of the sun" direction for the South direction "North wall" is used in the "barrier wall".)

** For 40 ° North Latitude.

5. COURTYARD TYPOLOGY

Courtyards can differ according to their different qualities. Different types of courtyard can be made according to criteria such as climate, form, size, wall height enclosed. The explanations of the main typologies in the literature based on different criteria from the past to the present are made in chapter 4.1 Courtyard Typology in Literature.

5.1. COURTYARD TYPOLOGY IN LITERATURE

The position of the courtyards on the building, the size and the height of the walls surrounding the courtyard are shown in the Petruccioli Typology in Figure 5.1 and 5.2. The courtyards in the building which are narrow and wide in terms of wall heights surrounding the courtyard are shown in Figure 5.3 in the John Reynolds typology. In Figure 5.4 Günter Pfeiferand Per Brauneck typology is based on the shape of the courtyard according to the shape of the building.

5.1.1. Atillio Petruccioli Typology

In Petruccioli typology, the location of the courtyards on the building was created by the size of the courtyard, wall heights surrounding the courtyard and the development of combinations of these factors. There are 5 different combinations in this typology. Contents of these combinations: A; in one storey courtyard typology process B; development of multi-story typology process in residential houses and commercial buildings, C; examples of multi-storey, courtyard dwellings with combination of interior balconies, D; the development of courtyard structures on additional building modules in the plan; E; simultaneous variations of the courtyard house are adaptations of previous types [67, 68].

In this thesis, sections A and D of the typology of Petruccioli were taken as an example.

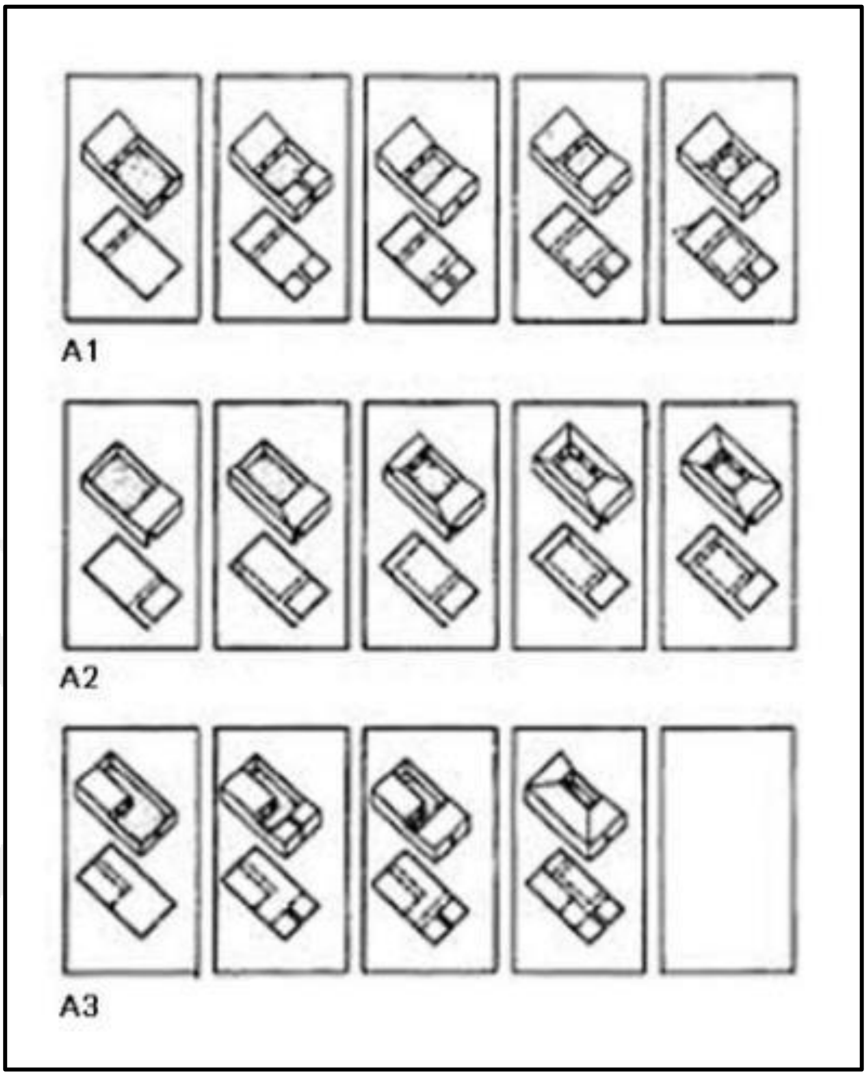


Figure 5.1. Petruciolli typology A series [67]

Figure 5.1 section A, in the boundaries of land within the boundaries of the entry of single-storey buildings were considered in terms of the upper coverings. In A1, different forms of the main entrance and the courtyard formed by the closeness to the building opposite to the road are shown. A2, exiting the courtyard by passing through the structure of the main entrance and the road A3, in the plan scheme is considered to be a long structure with a single layer enclosed courtyard wall [67, 68].

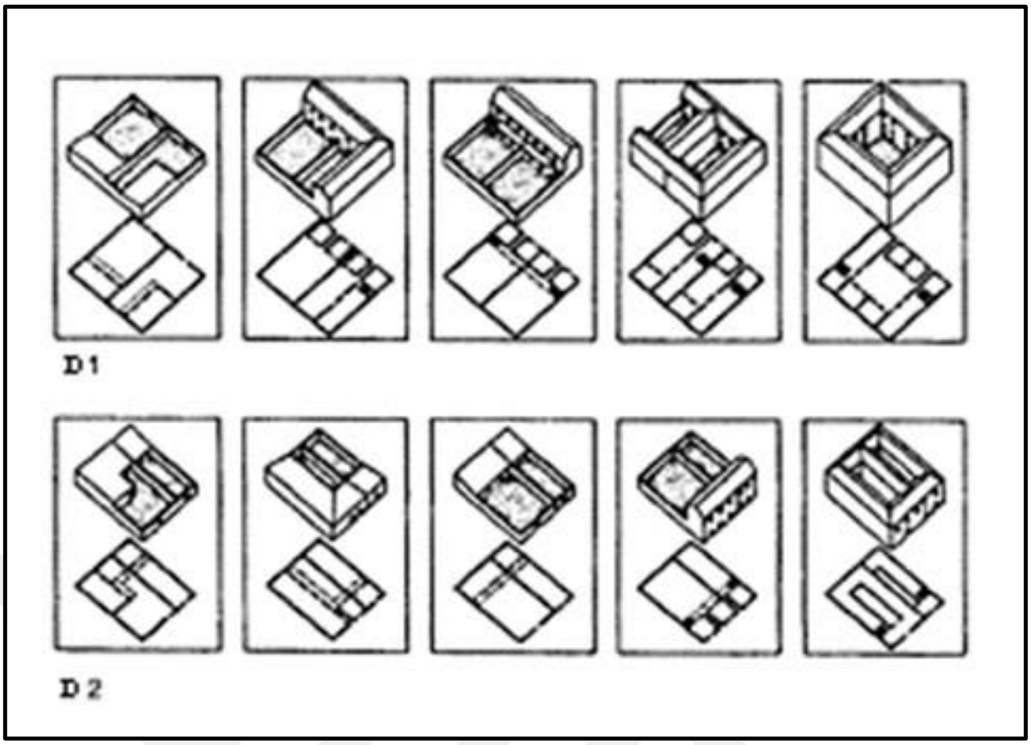


Figure 5.2. Petruciolli typology D series [67]

In section D in Figure 5.2., combinations of the structure and to develop a courtyard on additional modules in the building plan is shown. The building modules were built in different directions and height and the courtyard was formed [67, 68].

5.1.2. John Reynolds Typology

The ground floor-top floor relationship helps to determine the degree to which a yard looks in or out. The shallower the courtyard (the greater the aspect ratio), the clearer the sky or plants are framed by the fringes of the roof and a panoramic view is obtained. Deeper walls (smaller aspect ratio) emphasize walls and their openings (such as windows, doors) rather than sky. In a large and shallow courtyard, there is a collection of water with a generally sunny plant; in the narrow, deep courtyard, the voices are echoing and constant shadow dominates [62].

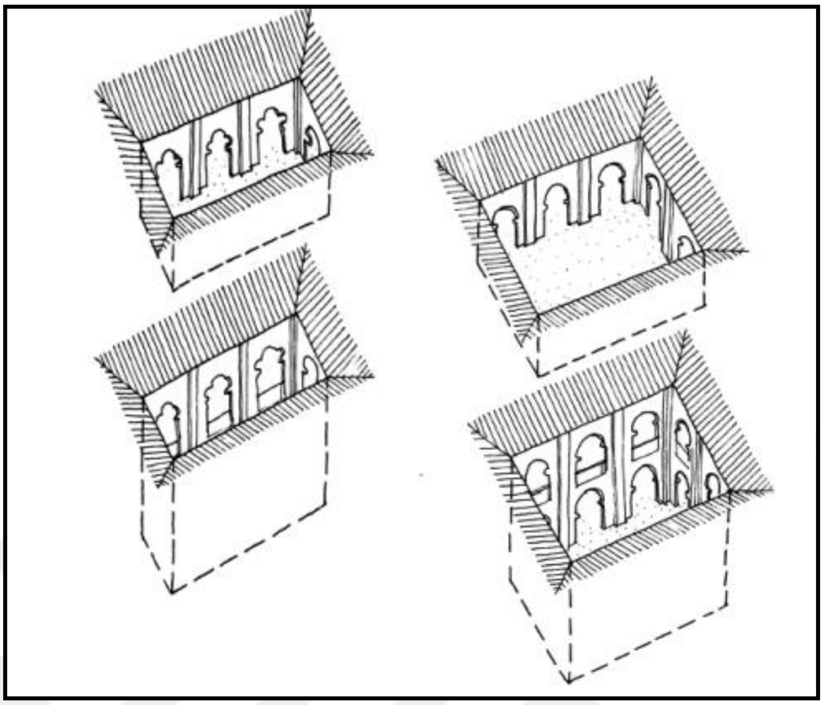


Figure 5.3. John Reynolds, courtyard type combinations [62]

5.1.3. Günter Pfeiferand Per Brauneck Typology

In Günter Pfeiferand Per Brauneck Typology, the priority is determined by the location and rate of the courtyard. The daylight coming to the structure becomes the determining factor and accordingly the direction of the structure, access to the structure and floor plans should be made according to these factors. There are 6 different types (Figure 5.4). 1. Garden courtyards; the four sides are arranged around a covered garden courtyard. Since the four sides are closed, the outdoor area has a very friendly character. This type of building is ideally suited for intense urban housing development structures, since it can be connected to neighboring units on three sides. 2. Common courtyards; It consists of several buildings open to the courtyard volume due to special arrangements. 3. L-shaped courtyards; maximum daylight exposure and economic use in the field. 4. L-shaped group courtyards; shows the potential of an L-shaped house type with housing development structure. Intelligent floor plans, a very efficient housing development structures can be formed according to the routing and level. 5. Patio-type courtyards; with the added benefit of creating interesting voluminous relationships, the ground area naturally has several small courtyards outside the building's volume for lighting. It can be arranged at different levels and it enables multi-layered floor plans to be made.6. Atrium type courtyards; It is derived from classical Greek and Roman courtyard type. In contrast to the courtyards where one or more courtyards are arranged in different locations on the floor plan, this courtyard type is the spatial center of the courtyard structure. The inner courtyard also serves as a circulation zone, relaxation area and access area to adjacent rooms [69].

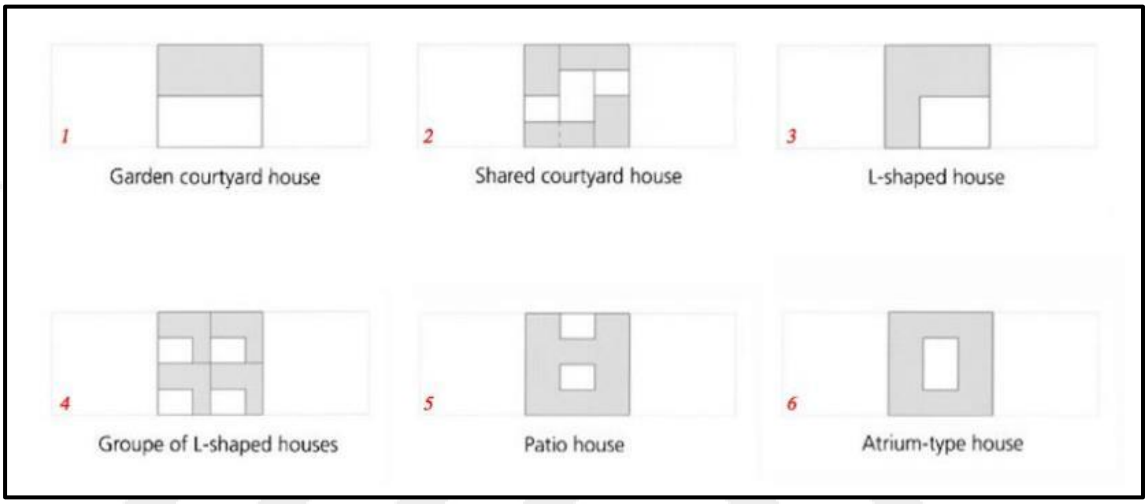


Figure 5.4. Günter Pfeiferand Per Brauneck typology [69]

5.2. COURTYARD TYPOLOGY IN TERMS OF SUSTAINABILITY

In the past, traditionally, the courtyards were important in their presence as spaces used to easily reach an airy exterior. However, it can be seen that the role of courtyards is very important when it comes to sustainable architectural design movement in the world. As described in the previous chapters, ecological quality is included in sustainable design. In this sense, the courtyards are the most important places of the structure and in the sense of sustainable construction gives many qualities. These qualities vary from courtyards. Therefore, the typology of courtyards in terms of sustainability criteria was needed.

In this study, the typology of the courtyard is highlighted considering the possibilities described in the chapter “4.3.1.2. Basic Positive Qualifications of Courtyard in terms of Sustainability” For this purpose, the main factors of sustainable courtyard typology are determined.

5.2.1. Factors That Depend on Sustainable Courtyard Typology

The main factors affecting the provision of positive qualities in Table 4.2 are listed below.

- The location of the courtyards
- The shape and size of the courtyard
- The ground quality of the courtyard
- The amount of the courtyard planting

5.2.1.1. Location of the Courtyard in the Building

The location of the courtyard is determined by some main factors. Courtyards are constructed based on these factors which are determined according to the function of the building (housing, commercial, health, education, etc.), climatic conditions (hot, cold, temperate, tropical, etc.), natural lighting and natural ventilation requirements. Therefore, depending on these needs, courtyards can be designed at different locations and positions on the ground floor, upper floors, semi-open or closed surroundings. These different locations of the courtyards in the structure also provide a difference in the sustainable qualities that the building brings. In the ground floor of natural ground, different plant varieties, water elements, walking paths create an outdoor effect in the interior while the same courtyard is made of hard ground, the effect of the space and the effect of the gathering area differs. In the courtyards on the storeys of the building, planting is done with flower pots or specially separated plant areas. The location of the courtyards can be changed within the structure, depending on the feature. It provides a different living space to the users by providing usage such as gathering, recreation and entertainment areas.

5.2.1.2. Shape and Size of the Courtyard

While designing the courtyard, when it is aimed to create a climatic environment, factors such as the perimeter of the yard, the rate of closure, shape, size of the area, angle of incidence, amount and duration of the sun should be taken into consideration.

There are four basic geometric forms made in the historical process. These are square, rectangle, circle and triangle forms. These forms are analyzed in terms of sustainable benefits provided by the structure of the courtyard; the shape of the courtyards in different geometric forms as well as the closeness in the courtyard space is also important. These rates are determined by the height of the building surrounding the courtyard and the width of the courtyard-ground area.

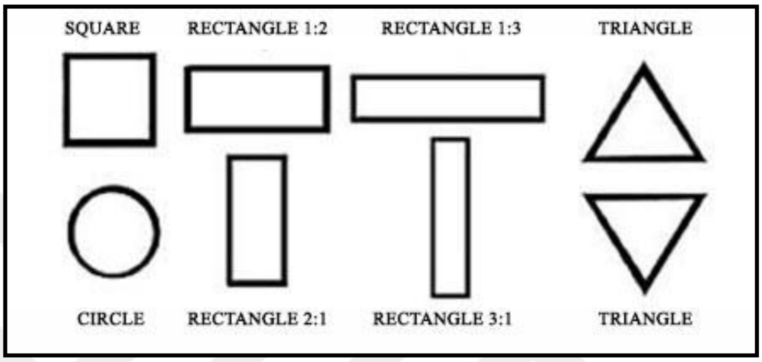


Figure 5.5. Courtyard ratios [70]

Various studies have been carried out on the optimum size of courtyards, whether circular, polygonal, rectangular or square in different climates, places and latitudes. Muhaisen and Gadi (2006) found that shallow courtyards perform better than deeper, while deep courtyards require less energy to cool down in summer. In polygonal models, they emphasized that any form of deep courtyard is recommended to obtain the most interior shaded area during the summer months. However, in winter, shallow forms are desired to obtain sunny areas. Muhaisen revealed that the optimum courtyard height to achieve reasonable performance in summer and winter is threefold in a hot, humid climate; two floors in warm, dry and temperate climates; in the cold climate, it concluded its research as a single story [70, 71].

Kocagil and Oral (2015) research in Diyarbakir, Turkey, a hot and dry climate, which represent a traditional courtyard four common types of standardized plans. The total volume (A / V) ratio of the total surface area showed that they consumed 63% less heating energy and 79% less cooling energy than the L-type plan with a ratio of 0.50 A / V. Manioğlu and Oral (2015) examined the shape of the courtyard to reduce the heating and cooling loads by proportioning the width of the courtyard (W) to the length of the courtyard (L). They found that W / L ratios requiring low energy for cooling could lead to high heat loads and therefore more heating needs. 2: 1 rectangular shaped courtyards, winning the radiation in the winter months, the most preventive form in the summer months, rectangular and square form courtyards in 3: 1 form, providing the ideal environment in terms of microclimatic and living conditions, circular form courtyard type, radiation gain in winter but most of the summer solar radiation control is observed to be in the most difficult circular form [44, 72]. The opening ratios of the courtyards are shown in Figure 5.6.

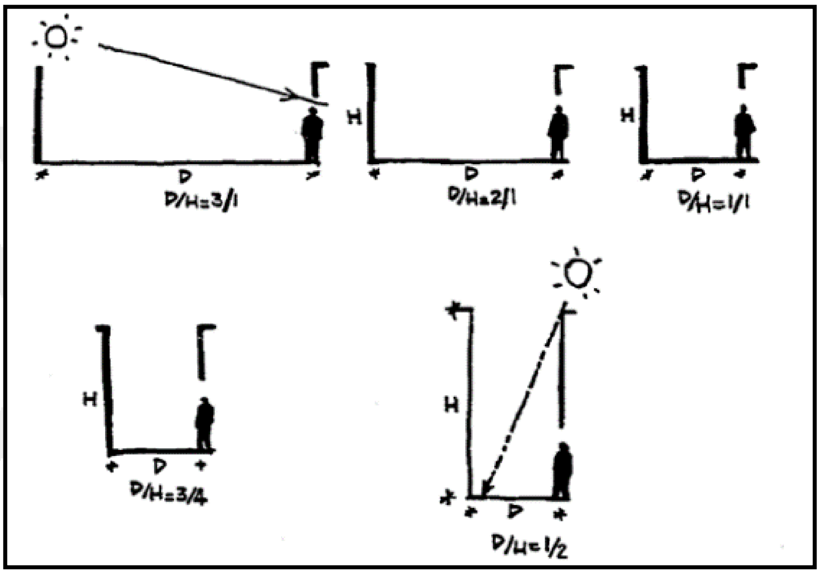


Figure 5.6. Opening ratio [73]

5.2.1.3. The Quality of the Courtyard Ground

The performance of the same courtyard can change based on the courtyard ground, soil, firm ground, grass and herbal covering. Factors such as reflection of the sun's rays on the hard ground and the absorption of the natural ground bring ecological differences. Also, in section 4.3.1.2, about the plant area on the natural ground of the designated courtyard, important contribution is subject to the provision of a minimum share of the land area in the building of the plant level. In addition, about the natural ground in the courtyard mentioned in section 4.3.1.2; also contributes to the minimum share of the building level plant area in the land. Therefore, the ground quality of the courtyard is an important factor in the typological classification of courtyards.

5.2.2. Table of the Courtyard Typology for Sustainability

While creating the typology of the courtyard, the position of the courtyard in the structure, shape and area size and the properties specified as ground quality were used. These features have also been mentioned in the literature and in the section of 5.1 to 5.2.1 this study, the factors that the courtyard typology is connected to have been revealed.

Considering the optimum position and dimensions of these factors, it is aimed to create a table of courtyard typology in terms of sustainability. The generated table of sustainability of square and rectangular form which contributed most to provide interpretation is specified and solution based on this form is given [44, 72].

The impact on the sustainability of the courtyard can be created when at least considering these three factors. As a fourth factor the amount of the planting in the courtyard can be effective regardless of herbal variation. The positive effects of this factor in each courtyard type is based on the examples examined in Chapter 6, they are brought to the basic structure of the courtyard and will be evaluated in terms of relations with the positive attributes of natural herbal environment.

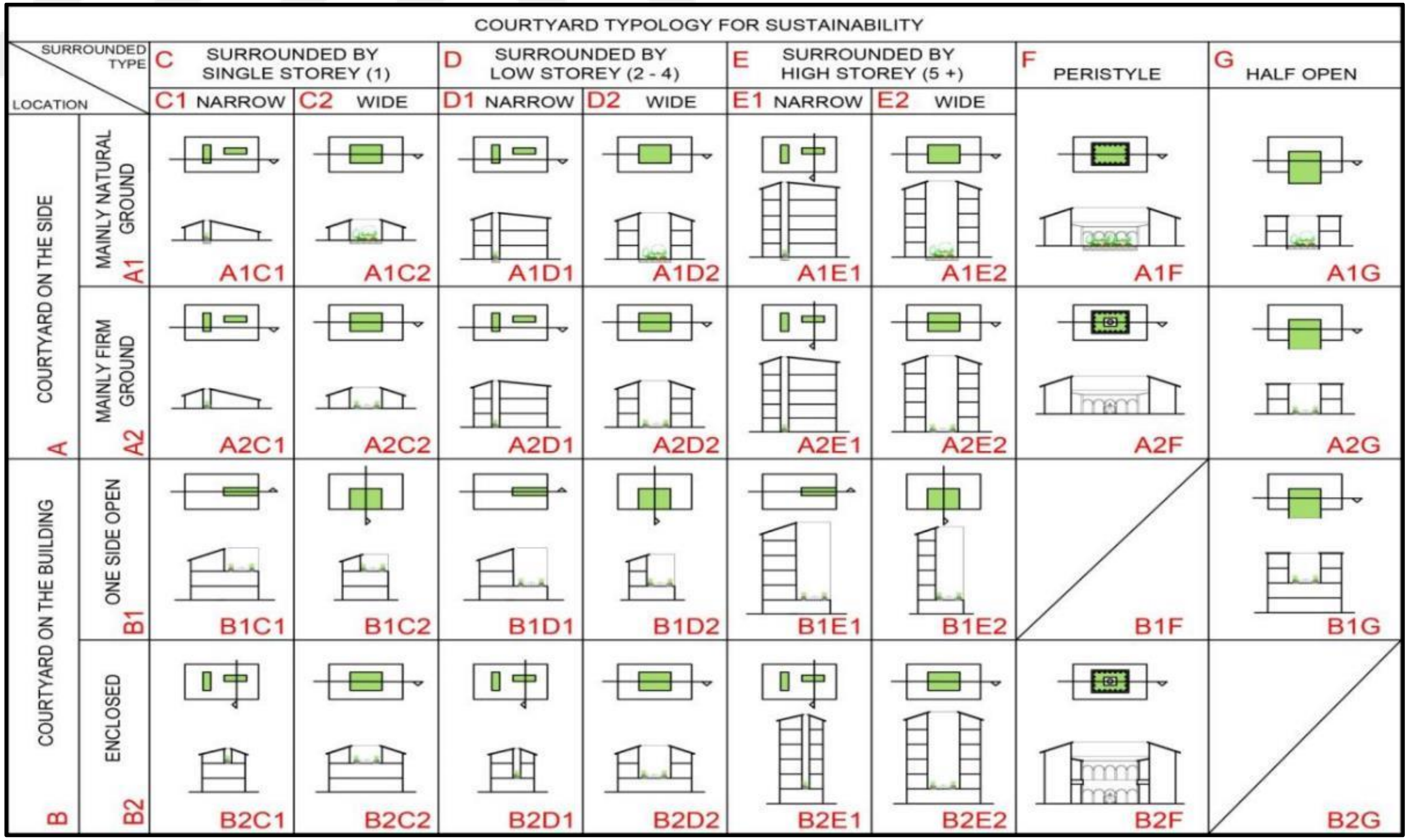
The main focal points of the courtyard typology table for sustainability are courtyard location and courtyard surrounding types. The subdivisions of the location are natural (A) and firm ground (B) main courtyards on the ground; single storey (C), low level (D), multi-storey (E) surrounded by courtyards, peristyle (F) and semi-open (G) courtyards were determined as.
Table 5.1 shows the combinations of the distinctions made by the location and the enclosure type with each other. Table 5.2 shows examples of typology depending on Table 5.1.

The types of the courtyard in the sustainability typology will be discussed in terms of location and surrounding and will be explained as follows. As a result of these explanations, the combinations they create with each other are discussed with the images of the typology samples in Table 5.2.

Table 5.1's larger version is in Appendix B.

Table 5.1. Courtyard typology table for sustainability

(Constitute by Author)



Courtyard in Terms of Location:

(A) Courtyard on the Side: When designing the structure on the land, the courtyard area is left empty and the building wall is surrounded by the courtyard and the courtyard is the natural or hard floor. There are two different courtyard floors. These floors are mainly separated from Mainly Natural Ground (A1) and Mainly Firm Ground (A2).

(A_1) Mainly Natural Ground Courtyards: The ground floor is located on the land, and the soil structure and the plants on it are preserved to a large extent, and the garden is formed by creating a sense of outdoor space in the interior with natural ventilation and solar radiation without the upper cover in the structure. A more useful and livable, sustainable environment is provided by different landscape elements. Use of natural soil elements and plant types is explained in detail in chapter 5.3.1 Natural Soft Landscape Elements.

(A_2) Mainly Firm Ground Courtyards: The ground floor is located on the plot, the soil structure of concrete, stone, ceramic, etc. This courtyard type is provided with elements such as landscaping and planting pots, stone gardens, and water elements in the courtyard. Although there are many aesthetic elements and visuals from the architectural point of view, the rate of contributing to sustainability decreases due to the damage caused to soil. However, it provides comfort in rainy, snowy and wet weather, and prevents the formation of muddy dirty surfaces. Chapter 5.3.2 Hardscape Elements are explained in detail.

Courtyard in Terms of Surrounded Type:

(B) Courtyard on the Building: The courtyard floor is located on the floors of the structure, the construction of the building due to the hard floor, surrounded by multiples of the structure of the courtyard type. In this courtyard type, planting is provided by pots or decorative areas created in the upholstery. There are two different courtyard types on the building, one side open and surrounded completely.

(B_1) One Side Open Courtyards: The courtyard floor is located on the floors of the structure; one side is open; structure shell is not surrounded by a firm-floor courtyard type. There is no complete enclosure in this courtyard type. This allows communication in a sheltered interior at the same time with the outside space and distinguishes this courtyard type from other fully enclosed types.

(B_2) Enclosed Courtyards: It is a type of firm floor courtyard where the building shell surrounds the courtyard and its floor is located on the floors of the building. According to the location of the building, it is ensured that the floor heights are shortened in the sunny south direction and that the sunbathing surfaces are increased and benefit from natural lighting.

(C) Surrounded by Single Storey Courtyards: Single-storey building surrounded by a shell is the type of courtyard. According to the design of the Natural or Hard floor weight, according to the aspect ratio of the courtyard; It is Narrow (C1) or Wide (C2). In the courtyard surrounded by a single floor, the elevation is less than the sun, so it is quite well utilized. It is a kind of courtyard, which provides protection against negative external effects (wind, noise, air pollution, privacy etc.) while providing natural ventilation with open sheltered public space.

(D) Surrounded by Low Storey Courtyards: Surrounded by a low-rise building (between 2 and 4 floors) and surrounded by construction shell. According to the design of the Natural or Firm floor weight, according to the aspect ratio of the courtyard; Narrow (D1) or Wide (D2). Because the height is average in the courtyard, which is surrounded by a little floor, natural lighting with sun bathing is beneficial depending on the location of the building. It is a kind of courtyard which is protected from negative external effects and provides positive effects while providing natural ventilation.

(E) Surrounded by High Storey Courtyards: It is a courtyard type surrounded by multi-storey (5 and over floor) building shell. According to the design of the Natural or Hard floor weight, according to the aspect ratio of the courtyard; It is Narrow (E1) or Wide (E2). In the multi-storey buildings according to the other courtyard types, the physical benefits of the courtyard such as sun lounger and natural lighting, harmony with nature and temperature control decreases as the floor height increases. It is preferably used in places where the number of users such as commercial buildings and dwellings is high.

(F) Peristyle Courtyards: It is a kind of courtyard which is surrounded by a continuous column array around the courtyard. From the Middle Ages religious places (temples, monasteries, churches courtyards, like mosque courtyards) widely used, allowing both satisfies both rallying need for privacy, allowing to perform rituals outdoors located are indoors.

(G) Half Open Courtyards: The courtyard surrounding the courtyard is a type of courtyard in which the shell is partially open. Even though full enclosure has not been provided, the sheltered space is created and the physical benefits such as sunbathing, natural lighting and natural ventilation are utilized. As in all courtyard types, semi-open courtyard type desired natural and hard ground environment by providing outdoor planting can be done.

5.2.2.1. Examples of Courtyard Typology Table for Sustainability

Table 5.1. Courtyard Typology Table for Sustainability shows the combinations of the distinctions made by the location and the enclosure type with each other. Table 5.2 Examples of Courtyard Typology Table for Sustainability shows examples of typology depending on Table 5.1. Table 5.2 includes several examples of each type of buildings from the world.

Table 5.2’s larger version and explanation are in Appendix C.

Table 5.2. Examples of courtyard typology table for sustainability

(Constitute by Author)

COURTYARD TYPOLOGY FOR SUSTAINABILITY									
SURROUNDED TYPE / LOCATION		C SURROUNDED BY SINGLE STOREY (1)		D SURROUNDED BY LOW STOREY (2 - 4)		E SURROUNDED BY HIGH STOREY (5 +)		F PERISTYLE	G HALF OPEN
		C1 NARROW	C2 WIDE	D1 NARROW	D2 WIDE	E1 NARROW	E2 WIDE		
A COURTYARD ON THE SIDE	A1 MAINLY NATURAL GROUND	Longmont United Hospital Elie Tahari Office A1C1	The Six Courtyard Houses A1C2	Kadir Has University Sisecam R&D Center A1D1	Topkapi Palace Istanbul Technical University (Taskisla) Istanbul Technical University (Gumussuyu) A1D2	Court Square Press A1E1	Istanbul University - Faculty of Science and Literature A1E2	Cuxa Cloister Boston Public Library A1F	RönesansBiz Mecidiyeköy Dogan Residence 38-30 Cheese Factory A1G
	A2 MAINLY FIRM GROUND	It's a Garden House A2C1	Ishak Pasha Palace A2C2	Ipekyol Textile Factory Alhambra Palace - Mexuar Courtyard A2D1	Baker's Boot Factory Istanbul Technical University (Macka) A2D2	Kronstad Psychiatric Hospital A2E1	Camden Courtyards A2E2	Alhambra Palace - Palaces of the Ambassadors Alhambra Palace - Palaces of the Lions Nuruosmaniye Mosque Valetta Palace A2F	St. Georg Austrian High School A2G
B COURTYARD ON THE BUILDING	B1 ONE SIDE OPEN	Courtyard House - Canada Courtyard House - Japan B1C1	Affiliated Bilingual Kindergarten - East China B1C2	Doğuş Maslak Tower B1D1	Tekfen Bomonti Houses B1D2	Yeditepe University Fine Arts Building B1E1	Union Of Turkish Public Notaries Central Building and the Cultural-Social Facility B1E2	B1F	A School in Cekmekoy, Istanbul B1G
	B2 ENCLOSED	Zorlu Center B2C1	Valenzá Healthcare Centre B2C2	Crystal Tower B2D1	Doğan Holding Head Office The EK3 Mall Central Municipal Library B2D2	"Avlu 138" Residence B2E1	Lapis Han B2E2	Alhambra Palace - Courtyard of the Palace of Charles V. Monasterio de Santo Domingo de Silos B2F	B2G

5.3. EQUIPMENT OF THE COURTYARD

The equipment of the courtyard is as important as its shape and location. One of the main items of the typology table is the ground feature; mainly firm ground and mainly natural ground change the ecological sustainability of the building. The equipment of the courtyard is explained in detail in section 5.3.1 Amount of Planting in the Courtyard and 5.3.2 Landscape Elements Using on the Courtyard.

5.3.1. The Amount of Planting in the Courtyard

The values of the total plant area at the building level according to the shade types (according to CGUB) were determined [58]. Courtyards are an important opportunity for building the total vegetation area at the building level. However, this possibility increases or decreases depending on the planting amount of the courtyards. For this reason, it provides more opportunities in terms of its contribution to the ecological sustainability of the building compared to the planting, low plantation or uncultivated courtyards. Consequently, "the amount of planting in the courtyard" factor is considered important in the typological classification of the courtyard.

5.3.2. Landscape Elements Using on the Courtyard

Landscape elements used in the courtyard; it will be covered in two sections as hard and natural soft.

5.3.2.1. Natural Soft Landscape Elements

Plants used in the courtyard according to their characteristics, flowering and hugging hangers, flowering trees, groundcovers, species growing in the shadow, fence plants and espalier plants as the following table.

* All tables in this chapter (Table 5.3, Table 5.4, Table 5.5, Table 5.6, Table 5.7 and Table 5.8) in the book Ornamental Plants and Landscape by Prof. Dr. Hüseyin Celik; www.agaclar.org, www.peyzajadresim.com, www.wikipedia.com, English and Latin plant names are compiled [74].

Flowering and Hugging Hangers; that give herbal designs a different dimension and an attractive surface. These species are usually vertical greening elements used to decorate structures such as pergolas, walls, railings, porticoes, and tunnels, and to cover the undesired surfaces and facades.

Hugging Hangers take on a complementary role in environmental regulation. They are used in balconies, pergola, sitting groups, undergrowth arrangements. They can be prepared in a very short time with their green or colored types and can be used in many different areas [75]. They can be green or leaves. Some plant species are exemplified in Table 5.3.

Table 5.3. Flowering and hugging hangers
(Constitute by Author)

TURKISH	**ENGLISH**	**LATIN**
İLKBAHARDA ÇIÇEK AÇANLAR	**SPRING BLOOMING PLANTS**	
Kivi	Kiwi	Actinidia deliciosa
Gelin Duvağı	Bridal Veil	Bougainvillea spectablis
Orman Asması	Forest Hangers	Clematis vitalba
Sarı Yasemin	Yellow Jasmine	Jasminum fruticans
Çarkıfelek	Passionflower	Passiflora
Gül	Rose	Rosa
Yıldız Yasemin	Star Jasmine	Trachelospermum jasminoides
Mor Salkım	Chinese Wisteria	Wisteria sinensis
SONBAHARDA ÇIÇEK AÇANLAR	**FALL BLOOMING PLANTS**	
Mercan Asması	Coral Creeper	Russelia equisetiformis
Orman Asması	Forest Hangers	Clematis vitalba

Çarkıfelek	Passionflower	Passiflora
Çoban Değneği	Common Knotgrass	Polygonum aviculare
Gül	Rose	Rosa
YAZIN ÇIÇEK AÇANLAR	**SUMMER BLOOMING PLANTS**	
Mercan Asması	Coral Creeper	Russelia equisetiformis
Gelin Duvağı	Bridal Veil	Bougainvillea spectablis
Acemborusu	Trumpet Creeper	Campsis radicans
Melez Orman Asması	Old Man’s Beard	Clematis vitalba
Orman Asması	Forest Hangers	Clematis vitalba
Sarmaşık Ortanca	Climbing Hydrangea	Hydrangea petiolaris
Yasemin	Jasmine Flower	Jasminum officinale L.
Hanımeli	Honeysuckle	Caprifolioideae
Çarkıfelek	Passionflower	Passiflora
Çoban Değneği	Common Knotgrass	Polygonum aviculare
Gül	Rose	Rosa
Yıldız Yasemin	Star Jasmine	Trachelospermum jasminoides
KIŞIN ÇIÇEK AÇANLAR	**WINTER BLOOMING PLANTS**	
Sarı Yasemin	Yellow Jasmine	Jasminum fruticans
Çin Yasemini	Pink Jasmine	Jasminum polyanthum

Flowering Trees; they have a very rich appearance in terms of species. Although the varieties of these trees are very high, they are rare beings of nature. They create colors of colors in their natural environment by adding color to the environment [76]. In Table 5.4, the flowering trees that open according to the seasons were tabulated.

Table 5.4. Flowering trees
(Constitute by Author)

TURKISH	ENGLISH	LATIN
İLKBAHARDA ÇIÇEK AÇANLAR	**SPRING BLOOMING PLANTS**	
Akasya	Acacia	Robinia pseudoacacia
At Kestanesi	Horse Chestnut	Aesculus hippocastanum
Taş Armudu	Shadwood	Amelanchier
Kocayemiş	Strawberry Tree	Arbutus Unedo
Mor Orkide Ağacı	Purple Orchid Tree	Phanerapurpurea
Fırça Çalısı	Callistemon	Callistemon citrinus
Turunçgiller	Citrus Fruits	Citrus
Erguvan	Judas-Tree	Cercis siliquastrum
Florida Kızılcığı	The Flowering Dogwood	Cornus Florida
Duman Ağacı	The European Smoketree	Cotinus coggygria
Geyik Dikeni	Midland Hawtowrn	Crataegus oxyacantha
Mercan Ağacı	The Cockspur Coral Tree	Erythrina crista galli
Çiçek Dişbudağı	European Ash	Fraxinus ornus
Jakaranda	Jacaranda	Jacaranda mimosifolia
Manolya	Magnolia	Magnolia grandiflora L.
Çiçek Elması	Japanese Crabapple	Malus Floribunda
Erik	Common Plum	Prunus Domestica
Süs Armudu	The Callery Pear	Pyrus calleryana
Kuş Üvezi	European Mountain Ash	Sorbus aucuparia
SONBAHARDA ÇIÇEK AÇANLAR	**FALL BLOOMING PLANTS**	
Fırça Çalısı	Callistemon	Callistemon citrinus
Floş Ağacı	Floss Silk Tree	Chorisia speciosa
Mercan Ağacı	The Cockspur Coral Tree	Erythrina crista galli
Franklin Ağacı	Franklin Tree	Franklinia alatamaha
Manolya	Magnolia	Magnolia grandiflora
Zakkum	Oleander	Nerium oleander
YAZIN ÇIÇEK AÇANLAR	**SUMMER BLOOMING PLANTS**	

Gülibrişim	The Silk Tree	Albizia julibrissin
Katalpa	Southern Catalpa	Catalpa bignonioides
Horozibiği Püskül	Celosia	Celosia argentea
Kızılcık	Cornelian Cherry	Cornus mas
Mercan Ağacı	The Cockspur Coral Tree	Erythrina crista galli
Okaliptüs	Eucalyptus	Eucalyptus globulus
Franklin Ağacı	Franklin Tree	Franklinia alatamaha
Fener Çiçeği	Redhot Poker	Kniphofia uvaria
Jakaranda	Jacaranda	Jacaranda mimosifolia
Oya Ağacı	Crape Myrtle	Lagerstroemia indica
Ligustrum	Common Privet	Ligustrum vulgare L.
Manolya	Magnolia	Magnolia grandiflora
Zakkum	Oleander	Nerium oleander
Japon Pagoda Ağacı	Japanese Pagoda Tree	Sophora japonica
Tespih Çalısı	Chinaberry Tree	Melia azedarach
KIŞIN ÇIÇEK AÇANLAR	**WINTER BLOOMING PLANTS**	
Yalancı Mimoza	Silver Wattle	Acacia dealbata
Akasya	Acacia	Robinia pseudoacacia
Kocayemiş	Strawberry Tree	Arbutus Unedo
Floş Ağacı	Floss Silk Tree	Chorisia speciosa
Mercan Ağacı	The Cockspur Coral Tree	Erythrina crista galli

Groundcovers; plants between 0-30 cm in length, forming dense vegetation on the soil surface, ivies, creeping plants are stunted and spanning. Woody, herbaceous, green in summer-winter or green alone, these plants appear as grass cover on the soil surface. Groundcover plants prevent soil erosion and water loss, but also give the surface color, pattern and texture properties. The main purpose of ground cover plants is to create a kind of plant laying task in landscaping areas [77]. Table 5.5 some of the groundcover plants categorized according to the seasons.

Table 5.5. Groundcovers
(Constitute by Author)

TURKISH	ENGLISH	LATIN
İLKBAHARDA ÇIÇEK AÇANLAR	**SPRING BLOOMING PLANTS**	
Buz Çiçekleri	Baby Sunrose	Aptenia cordifolia
Mayasıl Otu	Pilewort	Ranunculus ficaria
Müge	Lily Of The Valley	Convallaria majalis
Hazine Çiçekleri	Treasure Flower	Gazania ringens
Dam Koruğu	Spanish Stonecrop	Sedum hispanicum
Cezayir Menekşesi	Bigleaf Periwinkle	Vinca major
YAZIN ÇIÇEK AÇANLAR	**SUMMER BLOOMING PLANTS**	
Buz Çiçekleri	Baby Sunrose	Aptenia cordifolia
Mayasıl Otu	Pilewort	Ranunculus ficaria
İrlanda Yosunu	Heath Pearlwort	Sagina subulata
Romen Sarıpapatyası	Roman Chamomile	Chamaemelum nobile
Müge	Lily of The Valley	Convallaria majalis
Hazine Çiçekleri	Treasure Flower	Gazania ringens
Cezayir Menekşesi	Bigleaf Periwinkle	Vinca major
Hosta	Fragrant Plantain Lily	Hosta plantaginea
Boncuk Çimi	Mondo Grass	Ophiopogon spp.
Kekik	Thyme	Thymus

Species Growing in the Shadow; mostly colorful flowers are not found in these plants. Equipped with shade-resistant plants, the space gives a view of green water gushing from a dark corner. In the city, breathtaking areas of buildings such as courtyards and small gardens can be overshadowed. Some of the courtyards are constantly in the shade, and some may be a small area where the sun passes a little at certain times of the day [74]. Plants used in such places should be able to grow easily in the place, in the sunless environment. In Table 5.6 plant species that can live in shadow areas are given.

Table 5.6. Species growing in the shadow

(Constitute by Author)

TURKISH	**ENGLISH**	**LATIN**
YER ÖRTÜCÜ	**GROUNDCOVERS**	
Mayasıl otu	Pilewort	Ranunculus ficaria
İrlanda yosunu	Heath Pearlwort	Sagina subulata
Romen sarıpapatya	Roman Chamomile	Chamaemelum nobile
Yaban çilekleri	Wild Strawberry	Fragaria vesca
Hosta	Fragrant Plantain Lily	Hosta plantaginea
Boncuk çimi	Mondo Grass	Ophiopogon spp.
Japon sütleğeni	Japanese Pachysandra	Pachysandra terminalis
Cezayir menekşesi	Bigleaf Periwinkle	Vinca major
ÇALILAR	**SHRUBS**	
Şimşir	Buxus Sempervirens	Buxus
Kamelya	Camellia	Camellia japonica
Doğuş eriği	Natal Plum	Carissa grandiflora
Yalancı servi	Lawson's Cypress	Chamaecyparis
Karayemiş	Cherry Laurel	Prunus laurocerasus
Gardenya	Cape Jasmine	Gardenia jasminoides
Ortanca	French Hydrangea	Hydrangea macrophylla
Ligustrum	Common Privet	Ligustrum vulgare L.
Mahonya	Holly-Leaved Barberry	Mahonia aquifolium
Gerçek mersin	True Myrtle	Myrtus communis
Orman gülü	Alpenrose	Rhododendron ferrugineum
Porsuk	Yew	Taxus
AĞAÇLAR (YAPRAĞINI DÖKEN)	**TREES (DECIDUOUS)**	
Japon akçaağaç	Japanese Maple	Acer palmatum
Taş armudu	Shadwood	Amelanchier
Doğu erguvanı	Judas-Tree	Cercis siliquastrum
Püsküllü ağaç	White Fringetree	Chionanthus virginicus

Kızılcık	Cornelian Cherry	Cornus mas
Tespih çalısı	Chinaberry Tree	Melia azedarach
AĞAÇLAR (HERDEMYEŞIL)	**TREES (EVER GREEN)**	
Kocayemiş	Strawberry Tree	Arbutus unedo
İncir	Fig	Ficus carica
Çoban püskülü	English Holly	Ilex aquifolium
Palmiyeler	Palm Trees	Arecaceae
Akdeniz defnesi	Bay Tree	Laurus nobilis
Taş porsuğu	Buddhist Pine	Podocarpus macrophyllus
Adi porsuk	English Yew	Taxus baccata
Kivi	Kiwi	Actinidia deliciosa
Yaban yasemini	Bittersweet Nightshade	Solanum dulcamara
Orman asması	Forest Hangers	Clematis vitalba
Papaz Külahı	Spindle Tree	Euonymus fortunei
Fatshedera	Tree İvy	Fatshedera lizei
Orman sarmaşıkları	The Common İvy	Hedera
Yasemin	Jasmine Flower	Jasminum officinale L.
Hanımeli	Honeysuckle	Caprifolioideae
Amerikan sarmaşığı	Virginia Creeper	Parthenocissus quinquefolia
Çoban değneği	Common Knotgrass	Polygonum aviculare
Yıldız yasemin	Star Jasmine	Trachelospermum jasminoides

Fence Plants; with different leaves, flowers, branches and body features add a different color to the nature. These plants have the chance to use it for different purposes because of their different characteristics in the landscape area [78]. Table 5.7 shows some fence plants that are separated according to their length.

Table 5.7. Fence plants
(Constitute by Author)

TURKISH	**ENGLISH**	**LATIN**
ÇALILAR (1 M)	**SCRUB (1 M)**	
Diken üzümü	Barberries	Berberis spp.
Şimşir	Buxus Sempervirens	Buxus
Doğuş eriği	Natal Plum	Carissa grandiflora
Yalancı servi	Lawson's Cypress	Chamaecyparis
Dağ muşmulası	Rockspray Cotoneaster	Cotoneaster
Çoban püskülü	English Holly	Ilex aquifolium
Ardıç	The Cypress Family	Cupressaceae
Yıldız Çalısı	Japanese Pittosporum	Pittosporum tobira
Ateş dikeni	Firethorn	Pyracantha
Biberiye	Rosemary	Rosmarinus officinalis
Lavantin	Santolina	Santolina chamaecyparissus
Keçi sakalı	Meadowsweet	Filipendula ulmaria
Porsuk	Yew	Taxus
Batı mazısı	Eastern Arborvitae	Thuja occidentalis
ÇALILAR (1-2 M)	**SCRUB (1-2 M)**	
Kadın tuzluğu	Barberries	Berberis spp.
Kamelya	Camellia	Camellia japonica
Süs ayvası	Flowering Quince	Chaenomeles japonica
Turunçgiller	Citrus Fruits	Citrus
Dağ muşmulası	Rockspray Cotoneaster	Cotoneaster
Gümüşi iğde	Silverberry	Elaeagnus
Papaz külahı	Cherry Laurel	Prunus laurocerasus
Çoban püskülü	English Holly	Ilex aquifolium
Ardıç	The Cypress Family	Cupressaceae
Ligustrum	Common Privet	Ligustrum vulgare L.
Hanımeli	Honeysuckle	Caprifolioideae

Alev ağacı	Taiwanese Photinia	Photinia serratifolia
Mugo çamı	Creeping Pine	Pinus mugo
Porsuk	Yew	Taxus
Ateş dikeni	Firethorn	Pyracantha
Gül	Rose	Rosa
Kartopu	European Cranberrybush	Viburnum
Doğu (batı) mazısı	Eastern Arborvitae	Thuja occidentalis
AĞAÇLAR (2-4 M <)	**TALL (2-4 M <)**	
Büyük Çiçekli Güzellik Çalısı	Glossy Abelia	Abelia x grandiflora
Mavi göknar	Silver fir	Abies concolor
Ova akçaağacı	Field maple	Acer campestre
Akçaağaç	Maple	Acer
Kadın tuzluğu	Barberries	Berberis spp.
Fırça çalısı	Callistemon	Callistemon citrinus
Bezelye çalısı	The Siberian Peashrub	Caragana arborescens
Keçi boynuzu	Carob tree	Ceratonia siliqua
Kafur ağacı	Camphor Tree	Cinnamomum camphora
Yalancı servi	Lawson's Cypress	Chamaecyparis
Turunçgiller	Citrus Fruits	Citrus
Dağ muşmulası	Rockspray cotoneaster	Cotoneaster
Papaz külahı	Cherry Laurel	Prunus laurocerasus
Porsuk	Yew	Taxus
Ardıç	The Cypress Family	Cupressaceae
Kartopu	European Cranberrybush	Viburnum
Sedir	Cedar	Cedrus
Gümüşi iğde	Silverberry	Elaeagnus
Okaliptüs	Eucalyptus	Eucalyptus globulus
Ardıç	The Cypress Family	Cupressaceae
Defne	Daphne	Laurus
Zakkum	Oleander	Nerium oleander
Çam	Pine	Pinus

Espalier Plants; the word espalier means "flat". In this system, plants are shaped flat on a vertical plane. Plants are often tightly bonded to geometrical structures (walls or wires) and take the form of these structures. This method aims to create aesthetic views in small spaces and to include more plants in the field [79]. Table 5.8 in the application of espalier suitable plants that can be grown are tabulated.

Table 5.8. Espalier plants
(Constitute by Author)

TURKISH	**ENGLISH**	**LATIN**
ÇALILAR	**SHRUBS**	
Fırça çalısı	Callistemon	Callistemon citrinus
Kamelya	Camellia	Camellia japonica
Gümüşüiğde	Silverberry	Elaeagnus
Papaz külahı	Cherry Laurel	Prunus laurocerasus
Gardenya	Cape Jasmine	Gardenia jasminoides
Çin gülü	China rose	Hibiscus rosa-sinensis
Çoban püskülü	English Holly	Ilex aquifolium
Ardıç	The Cypress Family	Cupressaceae
Alev ağacı	Taiwanese Photinia	Photinia serratifolia
Ateş dikeni	Firethorn	Pyracantha
Porsuk	Yew	Taxus
Kartopu	European Cranberrybush	Viburnum
AĞAÇLAR	**TREES**	
Fırça çalısı	Callistemon	Callistemon citrinus
Turunçgiller	Citrus Fruits	Citrus
Kaymak çalısı	Pineapple Guava	Acca sellowiana
Manolya	Magnolia	Magnolia grandiflora L.
Çiçek elması	Japanese Crabapple	Malus Floribunda
Taş porsuğu	Buddhist Pine	Podocarpus macrophyllus
Prunus türleri	Prunus	Prunus
ASMALAR	**VINES**	

Kivi	Kiwi	Actinidia deliciosa
Fatshedera	Tree İvy	Fatshedera lizei
Orman sarmaşığı	The Common İvy	Hedera helix
Gül	Rose	Rosa
Üzüm asması	Grape Vine	Vitis

5.3.2.2. Hardscape Elements

Hardscape elements in courtyards vary according to their design, usage and form in the building. These elements; flooring, transportation and circulation, sitting and resting, covering, curtain, water, decorative, lighting and activity elements are examined as separate titles [80].

The Floor Elements are divided into soft and hard flooring according to space functions. Soft flooring is used in places arranged for visual purposes with little or no circulation. When using groundcover plants visually, floor elements such as compressed soil and tartan are preferred.

Roads, stairs and ramps in the courtyard provided circulation; hard floor is chosen according to the size of the place, intensity of use, activities performed and visual comfort. Mosaic, brick, natural stone, travertine, paving stone is preferred.

Transport and Circulation Elements are composed of roads, ramps and stairs that are arranged by using laying elements to connect different spaces together. Depending on the function, the pedestrian and vehicle roads are divided into two and the flooring is made accordingly.

Living and Recreation Elements are very important to serve the people's cultural, social and psychological needs. Benches, tables, steps meet the needs of the people within the space while reading, listening to nature, environment and also allows you to make meetings.

The Top Cover Elements are used to provide climatic comfort, such as protection from excessive sunlight in the courtyards and asylum under rain. Simple protection can be provided with umbrellas, pergolas, patio or gazebos.

The Shielding Elements, are restrict or reserve places, as commonly used items such as walls and fences to increase the degree of privacy. In the courtyards surrounded by four facades, inter-space screening requirements are provided by elements such as fences or boards.

Water Elements are divided into two stationary and moving. Water elements in landscape design, climate comfort, noise control, circulation control in space as well as for visual purposes.

Depending on the scale and function of the space, still water elements can be designed for different uses such as swimming pool, ornamental pool (pools with water lilies and reeds), fish pool or children's play pool.

The moving water elements are divided into two elements, such as cascades in pools, water gardens, waterfalls, flowing in the opposite direction of gravity, such as fountains. The cascades are formed by the flowing of water from the various levels into the main pool. The fountains create coolness in the pool by raising the water in the pool with the power of the engine and add aesthetic function to the place as a show vehicle.

The water elements in the courtyards are mostly located in the center in terms of water accumulation. At the same time, it is mostly located in the center. By using the reflection feature of the water, water mirrors are created and lighting and expansion are provided. Wells are used as functions other than visual function.

Decorative Elements are the most important decorative elements used after plants. It serves as a fountain when used in a pool. When a suitable theme is made, the sculptures provide space to live. It is also used in landscaping design.

Lighting Elements are used in the dark to increase the visual impact and facilitate the functional use. It differs according to the lighting potential of the lighting elements.

- On the wall and ground level to illuminate small areas,

- Medium size in park, garden and roads,
- High in the general lighting of the gardens and parks and in the vehicle roads,
- Airport, bright needed in large areas such as highway as needed very high dimensional lighting elements are divided into four [80].

Activity Elements are the ones in which activities such as gathering, cooking, eating-drinking, dishwashing, preparing food besides the living and resting needs meet daily household needs.

6. EXAMINATION ON COURTYARD SAMPLINGS IN MARMARA REGION

The Marmara Region has a transition climate with several climates in some of the sources between the Mediterranean and Black Sea climates. It has different characteristic according to other climate types. The Mediterranean climate in the South and West Marmara, the continental climate in the Thrace region and the Black Sea climate in the Northern Marmara Black Sea coasts are seen. The average annual temperature is 14-16°C. In summer there is an average temperature of 9.4^{o} C and 3.9^{o} C in winter higher than 26^{o}C. Summers are usually hot and partly dry, winters are cold and rainy sometimes profitable. The wind direction is in the North-Northeast direction [81].

Table 6.1. Marmara region average temperatures [81]

Marmara Region	**Winter (Dec-Jan-Feb)**	**Spring (Mar-Apr-May)**	**Summer (June-July-Aug)**	**Autumn (Sep-Oct-Nov)**
Avg. Temp. (^{o} C)	4.4	12.3	21.1	15.6
The max. Avg. temp. (^{o} C)	9.4	15.4	26.0	19.2
The min. Avg. temp. (^{o} C)	3.9	8.0	18.7	12.9
Avg. number of rainy days (^{o} C)	16.7	10.8	5.1	12.6

There are many studies about the formation of climatic comfort in the hot-dry climate of the courtyards, in cold climatic zones; it is preferable to minimize the loss of heat with compact structures, so the courtyard buildings are not preferred. But in temperate regions there are diversity in courtyard structures. The courtyard is used not only to provide climatic comfort but also to create comfortable living spaces. In this thesis, there are 13 different courtyard buildings to be examined in Marmara Region with temperate - transition climate. These courtyard buildings are limited as commercial and educational buildings. Examples to be examined are shown in Table 6.2. The architectural plans and sections of the sample structures will be analyzed and the results will be calculated and evaluated according to Table 4.2 Basic Positive Qualifications Table in terms of the main positive qualities brought to the structure by the courtyard in the fourth section; the results will be explained comparatively.

Table 6.2. Courtyard examples

NO	BUILDING NAME	COURTYARD TYPE	BUILDING TYPE
1	Avlu 138 Residence / İstanbul	B2E1	Residence + Commercial
2	Tekfen Bomonti Residence / İstanbul **(LEED GOLD)**	B1D2	Residence + Commercial
3	Doğan Holding Management Building / İstanbul	B2D2	Commercial
4	Rönesans Biz Mecidiyeköy Offices / İstanbul **(LEED GOLD)**	A1G	Commercial
5	Lapis Han / İstanbul	B2E2	Commercial
6	İstanbul Technical University, Taşkışla Campus / İstanbul	A1D2	Education
7	İstanbul Technical University, Maçka Campus / İstanbul	A2D2	Education
8	Crystal Tower / İstanbul **(LEED SILVER)**	B2D1	Commercial
9	İpekyol Textile Factory / Kırklareli	A2D1	Commercial
10	A School in Çekmeköy / İstanbul	B1G	Education
11	Şişecam R&D Center / Kocaeli **(LEED GOLD)**	A1D1	Commercial
12	İstanbul University, Faculty of Science and Literature Building / İstanbul	A1E2	Education
13	St. Georg Austrian High School / İstanbul	A2G	Education

The examples examined above were selected from the Marmara Region. The reason is to reveal the benefits of the courtyards in the transition-temperate climate. The samples were selected from commercial and educational buildings which were used intensively throughout the day.

6.1. ANALYSIS OF BUILDING SAMPLES WITH COURTYARDS

6.1.1. Avlu 138 Residence

- Courtyard on the Building, Surrounded by High Storey, Narrow Type in Enclosed (B2E1)
- 6 Floor, Floor Height: 3,00 m
- Total Floor Area: 7000 m^2

Figure 6.1. Avlu 138 Residence plan [82]

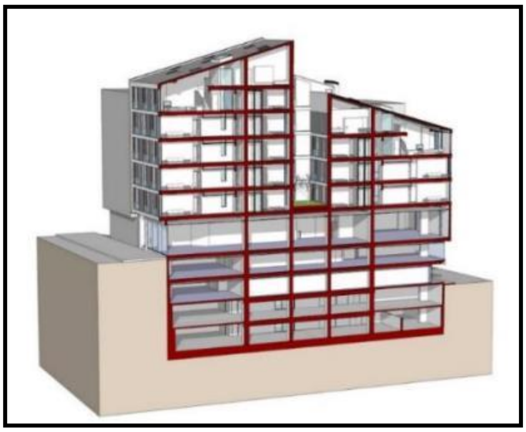


Figure 6.2. Avlu 138 Residence section [82]

Table 6.3. Analysis of Avlu 138 Residence

MAXIMUM UTILIZATION IN PASSIVE SOLAR ENERGY for AVLU 138 RESIDENCE
The Perpendicular Depth of the Courtyard to the South (d) / The Height of the North Wall of the Courtyard (h) $\geq$ 2 ($d/h \geq 2$)
5 / 18= 0,27
MAXIMUM UTILIZATION IN WIND ENERGY for AVLU 138 RESIDENCE
Ratio (R) = The Height of the Wall (h) / The Courtyard Short Edge Depth (d) (R=h/d) ($0.3< R < 1$)
18 / 5 = 3,6
COMPLIANCE WITH NATURE for AVLU 138 RESIDENCE
Total Planted Area on Building (TPAB) $\geq$ Coefficient of Green Usage in Buildings (CGUB) x Total Floor Area (TPAB $\geq$ CGUB x TFA)
CGUB: 0,30 Total Floor Area (TFA): 7000 m^2 **TPAB that should be in the Building =** 0,30 x 7000 **= 2.100 m^2** **TPAB = 50 m^2** **Lack of Green Spaces in Building =** 2100 – 50 = **2050 m^2**
IMPROVED OUTDOOR COMFORT for AVLU 138 RESIDENCE
The Long Edge of the Courtyard / The Short Edge of the Courtyard = Form (F) ($1<F< 2$)
The Short Edge of the Courtyard: 5 m, The Long Edge of the Courtyard:15 m **15 / 5 = 3**

6.1.2. Tekfen Bomonti Residence

- Courtyard on the Building, Surrounded by Low Storey, Wide Type in One Side Open (B1D2)
- 9 Floor (5 floor ground, 4 floor underground), Floor Height: 3,00 m
- Total Floor Area: 17.552 m^2

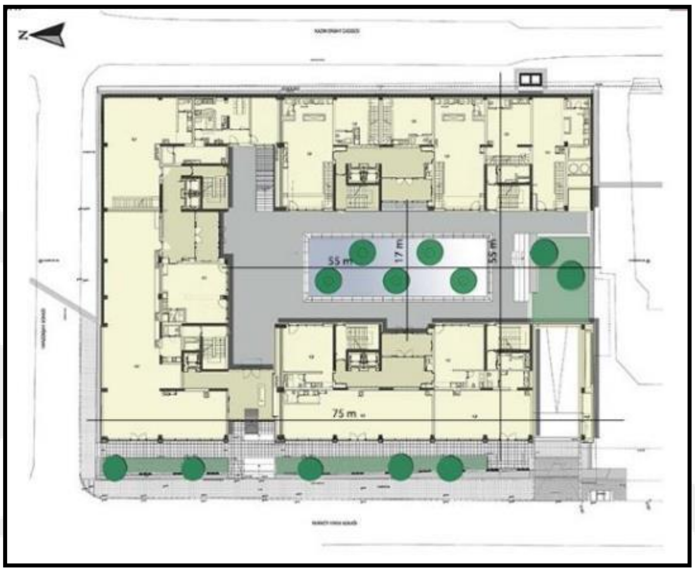


Figure 6.3. Tekfen Bomonti Residence plan [83]

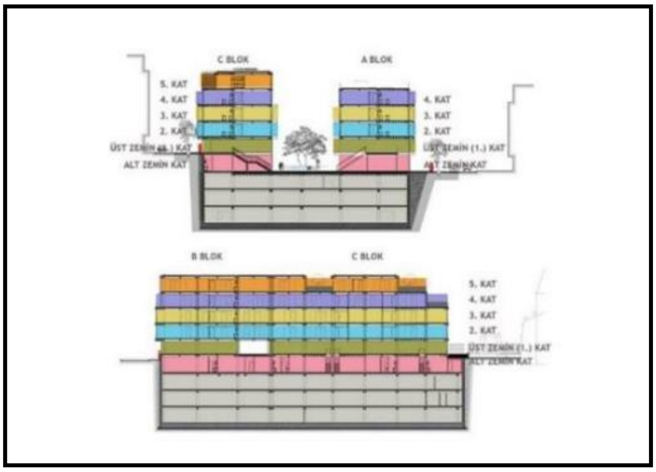


Figure 6.4. Tekfen Bomonti Residence sections [83]

Table 6.4. Analysis of Tekfen Bomonti Residence

MAXIMUM UTILIZATION IN PASSIVE SOLAR ENERGY for TEKFEN BOMONTI RESIDENCE
The Perpendicular Depth of the Courtyard to the South (d) / The Height of the North Wall of the Courtyard (h) $\geq$ 2 (d/h $\geq$ 2)
55 / 15 = 3,6
MAXIMUM UTILIZATION IN WIND ENERGY for TEKFEN BOMONTI RESIDENCE
Ratio (R) = The Height of the Wall (h) / The Courtyard Short Edge Depth (d) (R=h/d) (0.3< R < 1)
15 / 55 = 0.27
COMPLIANCE WITH NATURE for TEKFEN BOMONTI RESIDENCE
Total Planted Area on Building (TPAB) $\geq$ Coefficient of Green Usage in Buildings (CGUB) x Total Floor Area (TPAB $\geq$ CGUB x TFA)
CGUB: 0,30 Total Floor Area (TFA): 17.552 m^2 **TPAB that should be in the Building =** 0.30 x 17.552 = **5.265 m^2** **TPAB = 80 m^2** **Lack of Green Spaces in Building =** 5.265 - 80 = **5185 m^2**
IMPROVED OUTDOOR COMFORT for TEKFEN BOMONTI RESIDENCE
The Long Edge of the Courtyard / The Short Edge of the Courtyard = Form (F) (1<F< 2)
The Short Edge of the Courtyard: 17 m, The Long Edge of the Courtyard:55 m **55 / 17 =3,23**

6.1.3. Doğan Holding Management Building

- Courtyard on the Building, Surrounded by Low Storey, Wide Type in Enclosed (B2D2)
- 5 Floor (3 floor ground, 2 floor underground), Floor Height: 3,00 m
- Total Floor Area: 12.200 m^2

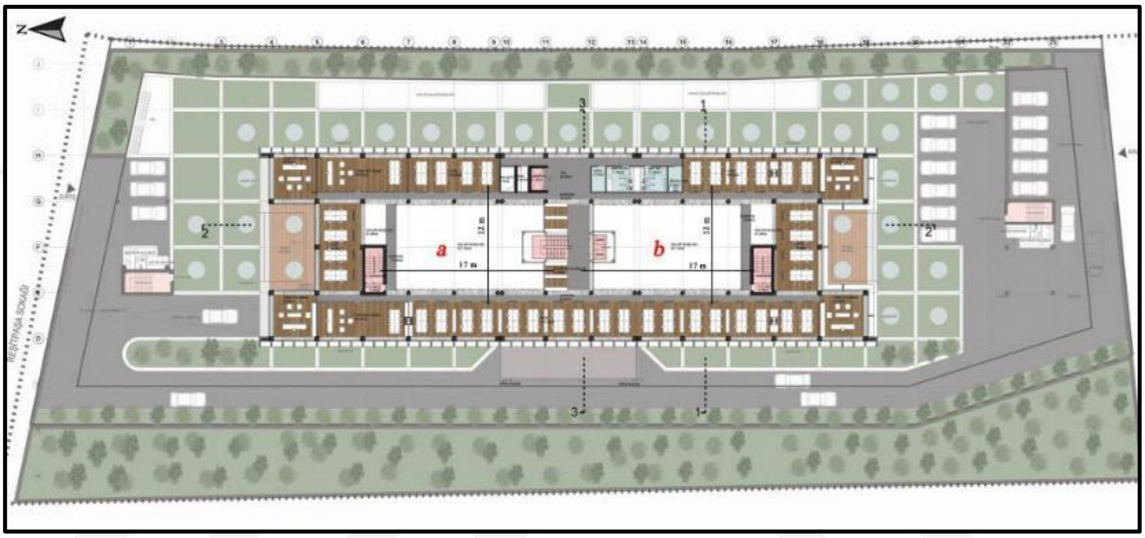


Figure 6.5. Doğan Holding Management Building plan [84]

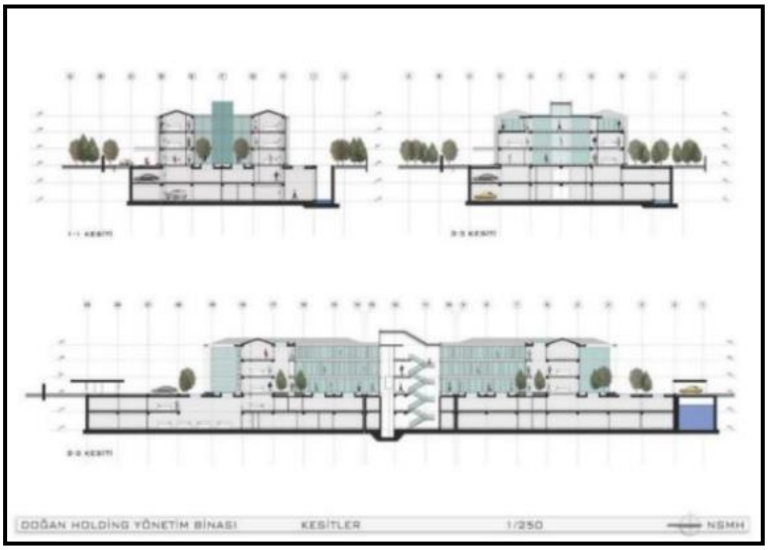


Figure 6.6. Doğan Holding Management Building sections [84]

Table 6.5. Analysis for Doğan Holding Management Building

MAXIMUM UTILIZATION IN PASSIVE SOLAR ENERGY for DOĞAN HOLDİNG MANAGEMENT BUILDING
The Perpendicular Depth of the Courtyard to the South (d) / The Height of the North Wall of the Courtyard (h) ≥ 2 (d/h ≥ 2)
a) 17 / 9 = 1,8 b) 17 / 9 = 1,8
MAXIMUM UTILIZATION IN WIND ENERGY for DOĞAN HOLDİNG MANAGEMENT BUILDING
Ratio (R) = The Height of the Wall (h) / The Courtyard Short Edge Depth (d) (R=h/d) (0.3< R < 1)
a) 9/17 = 0.52 b) 9/17 = 0.52
COMPLIANCE WITH NATURE for DOĞAN HOLDİNG MANAGEMENT BUILDING
Total Planted Area on Building (TPAB) ≥ Coefficient of Green Usage in Buildings (CGUB) x Total Floor Area (TPAB ≥ CGUB x TFA)
CGUB: 0,30 Total Floor Area (TFA): 12.200 m^2 **TPAB that should be in the Building** = 0,30 x 12.200 **= 3.660 m^2** **TPAB = 2500 m^2** **Lack of Green Spaces in Building =** 3.660 - 2.500 = **1.160 m^2**
IMPROVED OUTDOOR COMFORT for DOĞAN HOLDİNG MANAGEMENT BUILDING
The Long Edge of the Courtyard / The Short Edge of the Courtyard = Form (F) (1<F< 2)
The Short Edge of the Courtyard: 12 m, The Long Edge of the Courtyard: 17 m **a) 17 / 12 = 1,41 b) 17 / 12 = 1,41**

6.1.4. Rönesans Biz Mecidiyeköy Offices

- Courtyard on the Side, Half Open in Mainly Natural Ground (A1G)
- 11 Floor (3 floor underground, 3 facades are 4 floor, eastern facade is 8 floor), Floor Height: 3,85 m
- Total Floor Area: 16.625 m²
- Winter Electricity Consumption: 175.000 KWh [85]
- Summer Electricity Consumption: 195.000 KWh [85]

Figure 6.7. Rönesans Biz Mecidiyeköy Offices section, İstanbul [86]

Figure 6.8. Rönesans Biz Mecidiyeköy Offices section, İstanbul [86]

Table 6.6. Analysis of Rönesans Biz Mecidiyeköy Offices

MAXIMUM UTILIZATION IN PASSIVE SOLAR ENERGY for RÖNESANS BİZ MECİDİYEKÖY OFFICES
The Perpendicular Depth of the Courtyard to the South (d) / The Height of the North Wall of the Courtyard (h) $\geq$ 2 (d/h $\geq$ 2)
10 / 32 = 0,31
MAXIMUM UTILIZATION IN WIND ENERGY for RÖNESANS BİZ MECİDİYEKÖY OFFICES
Ratio (R) = The Height of the Wall (h) / The Courtyard Short Edge Depth (d) (R=h/d) (0.3< R < 1)
32 / 10 = 3.2
COMPLIANCE WITH NATURE for RÖNESANS BİZ MECİDİYEKÖY OFFICES
Total Planted Area on Building (TPAB) $\geq$ Coefficient of Green Usage in Buildings (CGUB) x Total Floor Area (TPAB $\geq$ CGUB x TFA)
CGUB: 0,30 Total Floor Area (TFA): 16.625 m² **TPAB that should be in the Building =** 0,30 x 16.625 = **4.987 m²** **TPAB = 850 m²** **Lack of Green Spaces in Building =** 4.987 – 850 = **4.137 m^2**
IMPROVED OUTDOOR COMFORT for RÖNESANS BİZ MECİDİYEKÖY OFFICES
The Long Edge of the Courtyard / The Short Edge of the Courtyard = Form (F) (1<F< 2)
The Short Edge of the Courtyard: 10 m, The Long Edge of the Courtyard: 40 m **40 / 10 = 4**

6.1.5. Lapis Han

- Courtyard on the Building, Surrounded by High Storey, Wide Type in Enclosed (B2E2)
- 11 Floor (8 floor ground, 3 floor underground), Floor Height: 3,10 m
- Total Floor Area: 31.600 m^2
- Winter Electricity Consumption: 53.395 KWh [87]
- Summer Electricity Consumption: 84.567 KWh [87]

Figure 6.9. Lapis Han storey plan [88]

Figure 6.10. Lapis Han section [89]

Table 6.7. Analysis of Lapis Han

MAXIMUM UTILIZATION IN PASSIVE SOLAR ENERGY for LAPIS HAN
The Perpendicular Depth of the Courtyard to the South (d) / The Height of the North Wall of the Courtyard (h) ≥ 2 (d/h ≥ 2)
50 / 28 = 1,78
MAXIMUM UTILIZATION IN WIND ENERGY for LAPIS HAN
Ratio (R) = The Height of the Wall (h) / The Courtyard Short Edge Depth (d) (R=h/d) (0.3< R < 1)
28 / 50 = 0.56
COMPLIANCE WITH NATURE for LAPIS HAN
Total Planted Area on Building (TPAB) ≥ Coefficient of Green Usage in Buildings (CGUB) x Total Floor Area (TPAB ≥ CGUB x TFA)
CGUB: 0,30 Total Floor Area (TFA): 31.600 m^2 **TPAB that should be in the Building =** 0,30 x 31.600 = **9.480 m^2** **TPAB = 1290 m^2** **Lack of Green Spaces in Building** = 9.480 – 1290 **= 8.190 m^2**
IMPROVED OUTDOOR COMFORT for LAPIS HAN
The Long Edge of the Courtyard / The Short Edge of the Courtyard = Form (F) (1<F< 2)
The Short Edge of the Courtyard: 31 m, The Long Edge of the Courtyard: 50 m **50 / 31 = 1,61**

6.1.6. İstanbul Technical University, Taşkışla Campus

- Courtyard on the Side, Surrounded by Low Storey, Wide Type in Mainly Natural Ground (A1D2)
- 2 Floor, Floor Height: 8,25 m
- Total Floor Area: 52.000 m^2
- Winter Electricity Consumption: 91.300 KWh [90]
- Summer Electricity Consumption: 56.520 KWh [90]

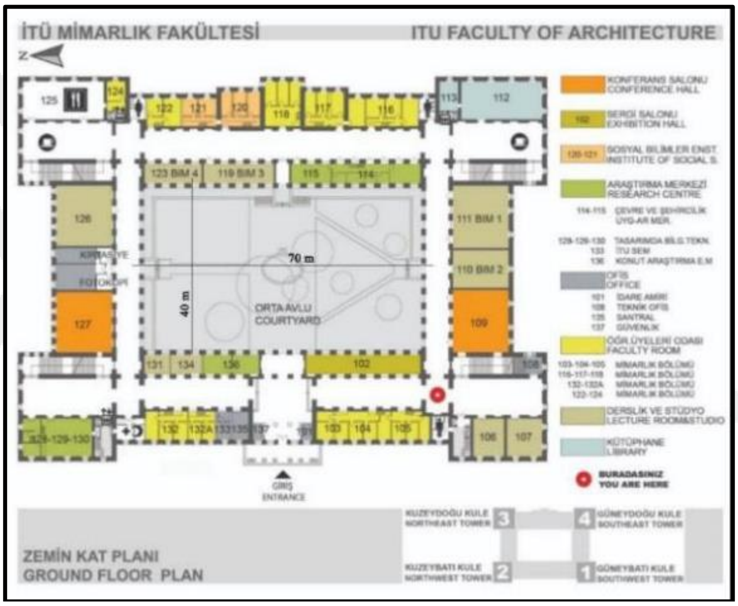


Figure 6.11. İstanbul Technical University, Taşkışla Campus floor plan [91]

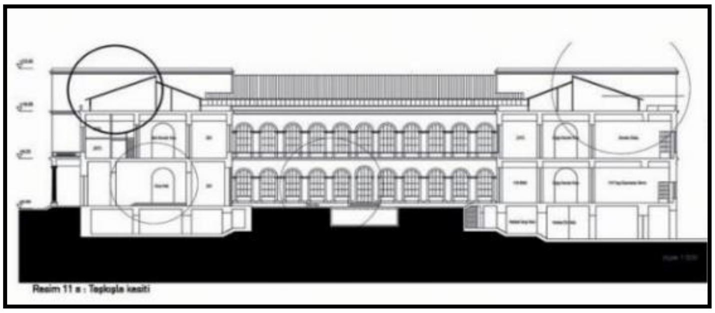


Figure 6.12. İstanbul Technical University, Taşkışla Campus section [92]

Table 6.8. Analysis of İstanbul Technical University, Taşkışla Campus

MAXIMUM UTILIZATION IN PASSIVE SOLAR ENERGY for İSTANBUL TECHNICAL UNIVERSITY, TAŞKIŞLA CAMPUS
The Perpendicular Depth of the Courtyard to the South (d) / The Height of the North Wall of the Courtyard (h) $\geq$ 2 (d/h $\geq$ 2)
70 / 20 = 3,5
MAXIMUM UTILIZATION IN WIND ENERGY for İSTANBUL TECHNICAL UNIVERSITY, TAŞKIŞLA CAMPUS
Ratio (R) = The Height of the Wall (h) / The Courtyard Short Edge Depth (d) (R=h/d) (0.3< R < 1)
33 / 70 = 0.47
COMPLIANCE WITH NATURE for İSTANBUL TECHNICAL UNIVERSITY, TAŞKIŞLA CAMPUS
Total Planted Area on Building (TPAB) $\geq$ Coefficient of Green Usage in Buildings (CGUB) x Total Floor Area (TPAB $\geq$ CGUB x TFA)
CGUB: 0,30 Total Floor Area (TFA): 52.000 m^2 **TPAB that should be in the Building =** 0,30 x 52.000 **= 15.600 m^2** **TPAB = 35.000 m^2** **Lack of Green Spaces in Building = 35.000 m^2 > 15.600** **(There is no deficiency in Building Herbal Area)**
IMPROVED OUTDOOR COMFORT for İSTANBUL TECHNICAL UNIVERSITY, TAŞKIŞLA CAMPUS
The Long Edge of the Courtyard / The Short Edge of the Courtyard = Form (F) (1<F< 2)
The Short Edge of the Courtyard: 40, The Long Edge of the Courtyard: 70 **70/40 = 1,75**

6.1.7. İstanbul Technical University, Maçka Campus

- Courtyard on the Side, Surrounded by Low Storey, Wide Type in Mainly Firm Ground (A2D2)
- 2 Floor, Floor Height: 6 m
- Total Floor Area: 63.000 m^2

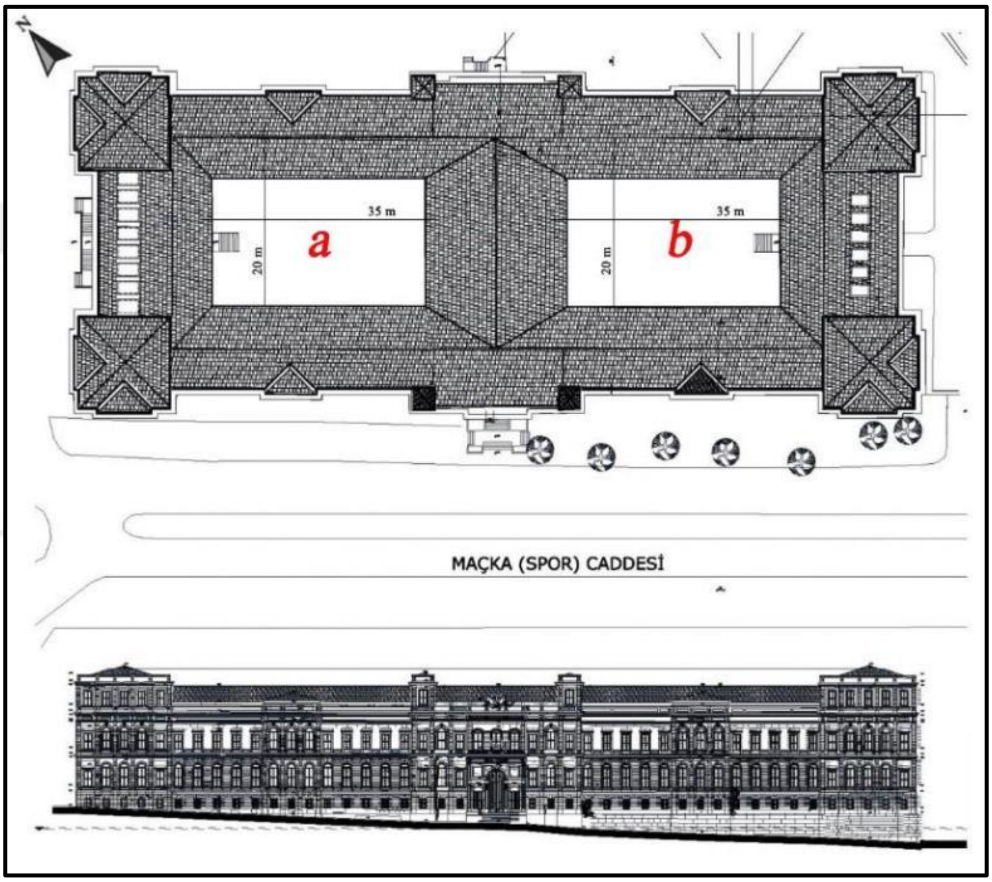


Figure 6.13. İstanbul Technical University, Maçka Campus [93]

Table 6.9. Analysis of İstanbul Technical University, Maçka Campus

MAXIMUM UTILIZATION IN PASSIVE SOLAR ENERGY for İSTANBUL TECHNICAL UNIVERSITY, MAÇKA CAMPUS
The Perpendicular Depth of the Courtyard to the South (d) / The Height of the North Wall of the Courtyard (h) ≥ 2 (d/h ≥ 2)
a) 35 / 15 = 2,3 b) 35 / 15 = 2,3
MAXIMUM UTILIZATION IN WIND ENERGY for İSTANBUL TECHNICAL UNIVERSITY, MAÇKA CAMPUS
Ratio (R) = The Height of the Wall (h) / The Courtyard Short Edge Depth (d) (R=h/d) (0.3< R < 1)
a) 15 / 35 = 0.42 b) 15 / 35 = 0.42
COMPLIANCE WITH NATURE for İSTANBUL TECHNICAL UNIVERSITY, MAÇKA CAMPUS
Total Planted Area on Building (TPAB) ≥ Coefficient of Green Usage in Buildings (CGUB) x Total Floor Area (TPAB ≥ CGUB x TFA)
CGUB: 0,30 Total Floor Area (TFA): 63.000 m^2 **TPAB that should be in the Building =** 0,30 x 63.000 = **18.900 m^2** **TPAB = 100 m^2** **Lack of Green Spaces in Building =**18.900 - 100 = **18.800 m^2**
IMPROVED OUTDOOR COMFORT for İSTANBUL TECHNICAL UNIVERSITY, MAÇKA CAMPUS
The Long Edge of the Courtyard / The Short Edge of the Courtyard = Form (F) (1<F< 2)
a) The Short Edge of the Courtyard: 20 m, The Long Edge of the Courtyard: 35 m **35 / 20 = 1,75** b) The Short Edge of the Courtyard: 20 m, The Long Edge of the Courtyard: 35 m **35/20 = 1,75**

6.1.8. Crystal Tower

- Courtyard on the Building, Surrounded by Low Storey, Narrow Type in Enclosed (B2D1)
- Total 41 floor – Courtyards Surrounded 2 Floors, Floor Height: 4 m
- Total Floor Area: 96.622 m^2

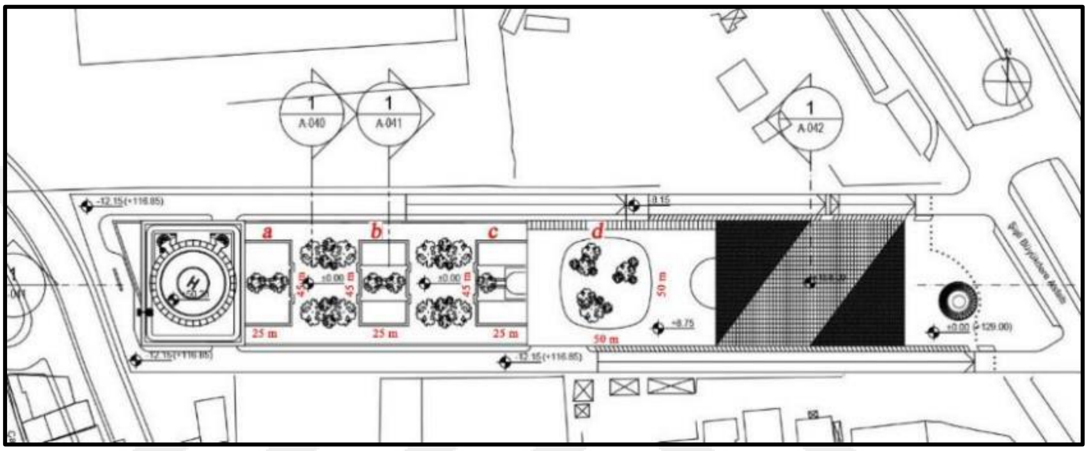


Figure 6.14. Crystal Tower plan [94]

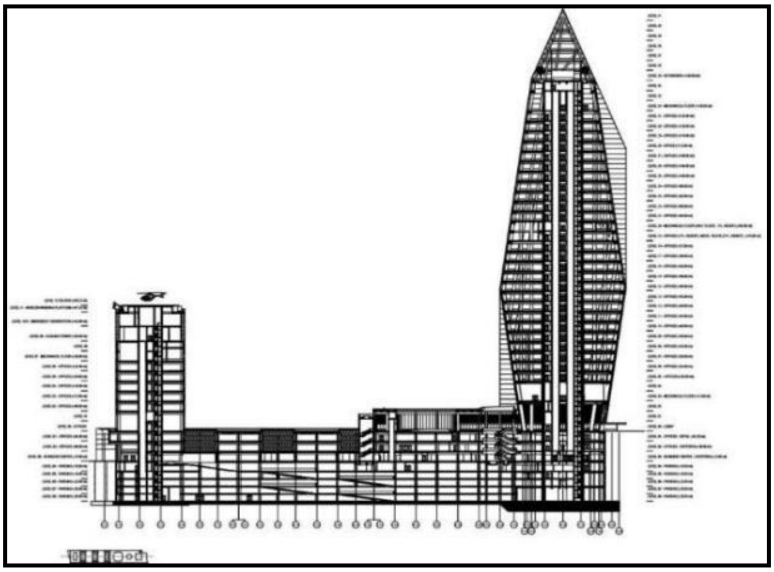


Figure 6.15. Crystal Tower section [94]

Table 6.10. Analysis of Crystal Tower

MAXIMUM UTILIZATION IN PASSIVE SOLAR ENERGY for CRYSTAL TOWER
The Perpendicular Depth of the Courtyard to the South (d) / The Height of the North Wall of the Courtyard (h) $\geq$ 2 (d/h $\geq$ 2)
a) 45 / 8 = 5,6 b) 45 / 8 = 5,6 c) 45 / 8 = 5,6 d) 50 / 8 = 6,2
MAXIMUM UTILIZATION IN WIND ENERGY for CRYSTAL TOWER
Ratio (R) = The Height of the Wall (h) / The Courtyard Short Edge Depth (d) (R=h/d) (0.3< R < 1)
a) 8 / 45 = 0.17 b) 8 / 45 = 0.17 c) 8 / 45 = 0.17 d) 8 / 50 = 0.16
COMPLIANCE WITH NATURE for CRYSTAL TOWER
Total Planted Area on Building (TPAB) $\geq$ Coefficient of Green Usage in Buildings (CGUB) x Total Floor Area (TPAB $\geq$ CGUB x TFA)
CGUB: 0,30 Total Floor Area (TFA): 96.622 m^2 **TPAB that should be in the Building =** 0,30 x 96.622 = **28.986 m^2** **TPAB = 500 m^2** **Lack of Green Spaces in Building =** 28.986- 500 = **28.486 m^2**
IMPROVED OUTDOOR COMFORT for CRYSTAL TOWER
The Long Edge of the Courtyard / The Short Edge of the Courtyard = Form (F) (1<F< 2)
a)The Short Edge: 25 m, The Long Edge: 45 m **45/25 = 1,8** b)The Short Edge: 25 m, The Long Edge: 45 m **45/25 = 1,8** c)The Short Edge: 25 m, The Long Edge: 45 m **45/25 = 1,8** d) The Short Edge: 50 m, The Long Edge: 50 m **50/50 = 1**

6.1.9. İpekyol Textile Factory

- Courtyard on the Side, Surrounded by Low Storey, Narrow Type in Mainly Firm Ground (A2D1)
- 2 floor, Floor Height: 8 m
- Total Floor Area: 20.000 m^2

Figure 6.16. İpekyol Textile Factory plan [95]

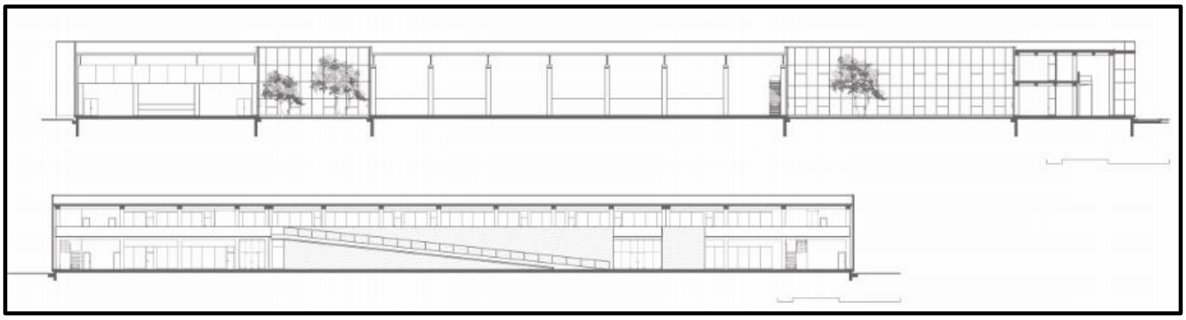


Figure 6.17. İpekyol Textile Factory sections [95]

Table 6.11. Analysis of İpekyol Textile Factory

MAXIMUM UTILIZATION IN PASSIVE SOLAR ENERGY for İPEKYOL TEXTILE FACTORY
The Perpendicular Depth of the Courtyard to the South (d) / The Height of the North Wall of the Courtyard (h) $\geq$ 2 ($d/h \geq 2$)
a) 5 / 8 = 0,62 b) 45 / 8 = 5,62 c) 5 / 8 = 0,62 d) 15 / 8 = 1,8 e) 45 / 8 = 5,62
MAXIMUM UTILIZATION IN WIND ENERGY for İPEKYOL TEXTILE FACTORY
Ratio (R) = The Height of the Wall (h) / The Courtyard Short Edge Depth (d) ($R=h/d$) ($0.3 < R < 1$)
a) 8 / 5 = 1.6 b) 8 / 45 = 0.17 c) 8 / 5 = 1.6 d) 8 / 15 = 0.53 e) 8 / 45 = 0.17
COMPLIANCE WITH NATURE for İPEKYOL TEXTILE FACTORY
Total Planted Area on Building (TPAB) $\geq$ Coefficient of Green Usage in Buildings (CGUB) x Total Floor Area (TPAB $\geq$ CGUB x TFA)
CGUB: 0,30 Total Floor Area (TFA): 20.000 m^2 **TPAB that should be in the Building** = 0,30 x 20.00 = **6.000 m^2** **TPAB = 1.500 m^2** **Lack of Green Spaces in Building =** 6.000 - 1.500 = **4.500 m^2**
IMPROVED OUTDOOR COMFORT for İPEKYOL TEXTILE FACTORY
The Long Edge of the Courtyard / The Short Edge of the Courtyard = Form (F) ($1 < F < 2$)
a)The Short Edge: 5 m, The Long Edge: 28 m **28/5 = 5,6** b)The Short Edge: 5 m, The Long Edge: 45 m **45/5 = 9** c)The Short Edge: 5 m, The Long Edge: 15 m **15/5 = 3** d)The Short Edge: 5 m, The Long Edge: 28 m **45/5 = 9** e)The Short Edge: 10 m, The Long Edge: 15 m **15/10 = 1,5**

6.1.10. A School in Çekmeköy

- Courtyard on the Building, Half Open in One Side Open (B1G)
- 6 floor (4 floor ground, 2 floor underground) Floor Height: 3 m
- Total Floor Area: 15.000 m^2

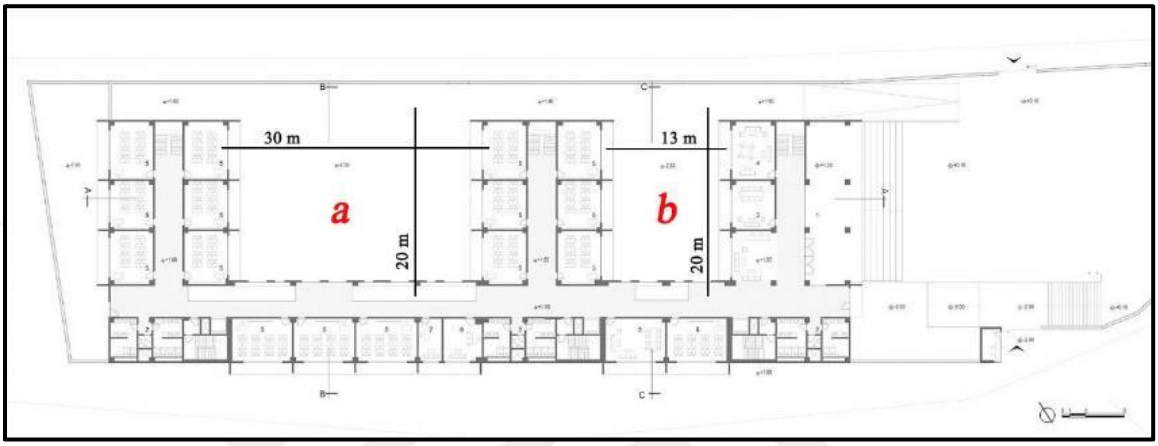


Figure 6.18. A School in Çekmeköy plan [96]

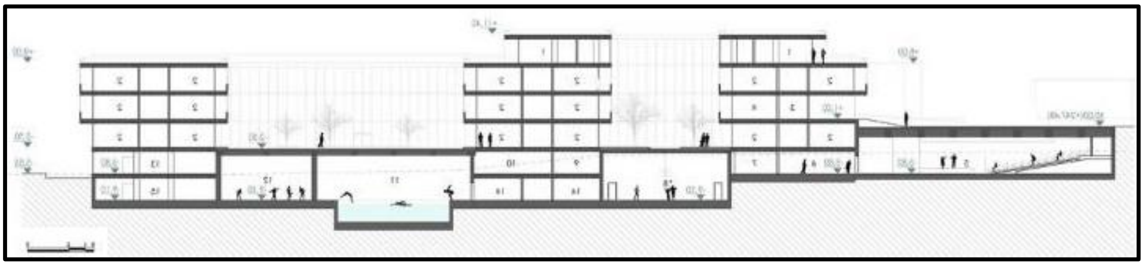


Figure 6.19. A School in Çekmeköy section [96]

Table 6.12. Analysis of a School in Çekmeköy

MAXIMUM UTILIZATION IN PASSIVE SOLAR ENERGY for A SCHOOL IN ÇEKMEKÖY
The Perpendicular Depth of the Courtyard to the South (d) / The Height of the North Wall of the Courtyard (h) ≥ 2 (d/h ≥ 2)
20 / 13,90 = 1,43 ≤ 2
MAXIMUM UTILIZATION IN WIND ENERGY for A SCHOOL IN ÇEKMEKÖY
Ratio (R) = The Height of the Wall (h) / The Courtyard Short Edge Depth (d) (R=h/d) (0.3< R < 1)
a) 13,90 / 20 = 0.69 b) 13,90 / 20 = 0.69
COMPLIANCE WITH NATURE for A SCHOOL IN ÇEKMEKÖY
Total Planted Area on Building (TPAB) ≥ Coefficient of Green Usage in Buildings (CGUB) x Total Floor Area (TPAB ≥ CGUB x TFA)
CGUB: 0,30 Total Floor Area (TFA): 15.000 m^2 **TPAB that should be in the Building** = 0,30 x 15.000 = **4.500 m^2** **TPAB = 1.500 m^2** **Lack of Green Spaces in Building** = 4.500 - 1.500 = **3000 m^2**
IMPROVED OUTDOOR COMFORT for A SCHOOL IN ÇEKMEKÖY
The Long Edge of the Courtyard / The Short Edge of the Courtyard = Form (F) (1<F< 2)
a) The Short Edge: 20 m, The Long Edge: 30 m **30 / 20 = 1,5** b) The Short Edge: 20 m, The Long Edge: 13 m **20 / 13 = 1,5**

6.1.11. Şişecam R&D Center

- Courtyard on the Side, Surrounded by Low Storey, Narrow Type in Mainly Natural Ground (A1D1)
- 4 floor, Floor Height: 4 m
- Total Floor Area: 8.000 m^2

Figure 6.20. Şişecam R&D Center plan [97]

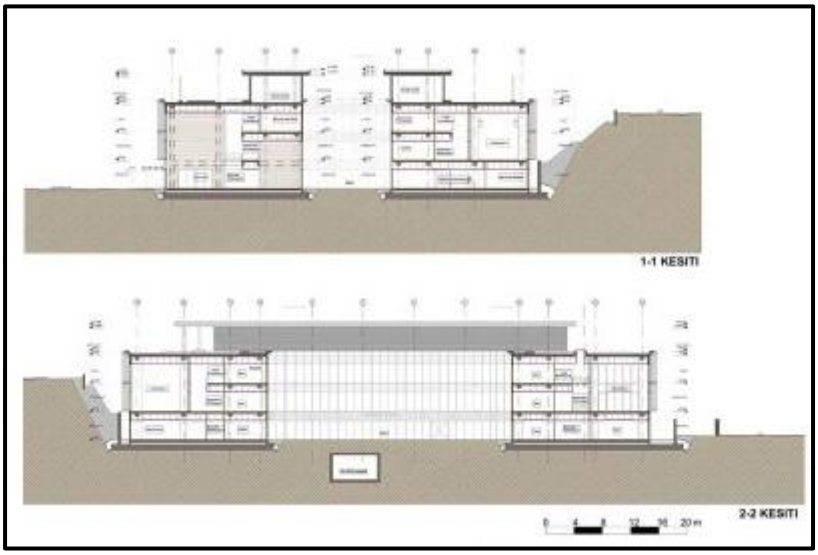


Figure 6.21. Şişecam R&D Center sections [97]

Table 6.13. Analysis of Şişecam R&D Center

MAXIMUM UTILIZATION IN PASSIVE SOLAR ENERGY for ŞİŞECAM R&D CENTER
The Perpendicular Depth of the Courtyard to the South (d) / The Height of the North Wall of the Courtyard (h) $\geq$ 2 (d/h $\geq$ 2)
35 / 12 = **2,91**
MAXIMUM UTILIZATION IN WIND ENERGY for ŞİŞECAM R&D CENTER
Ratio (R) = The Height of the Wall (h) / The Courtyard Short Edge Depth (d) (R=h/d) (0.3< R < 1)
12 / 35 **= 0.34**
COMPLIANCE WITH NATURE for ŞİŞECAM R&D CENTER
Total Planted Area on Building (TPAB) $\geq$ Coefficient of Green Usage in Buildings (CGUB) x Total Floor Area (TPAB $\geq$ CGUB x TFA)
CGUB: 0,30 Total Floor Area (TFA): 8.000 m^2 **TPAB that should be in the Building =** 0,30 x 8.000 **= 2.400 m^2** **TPAB = 1.500 m^2** **Lack of Green Spaces in Building = 2.400 > 1.500** **(There is no deficiency in Building Herbal Area)**
IMPROVED OUTDOOR COMFORT for ŞİŞECAM R&D CENTER
The Long Edge of the Courtyard / The Short Edge of the Courtyard = Form (F) (1<F< 2)
The Short Edge:10 m, The Long Edge: 32 m **32/10 = 3,2**

6.1.12. İstanbul University, Faculty of Science and Literature Building

- Courtyard on the Side, Surrounded by High Storey, Wide Type in Mainly Natural Ground (A1E2)
- 5 floor, Floor Height: 4 m
- Total Floor Area: 83.500 m^2

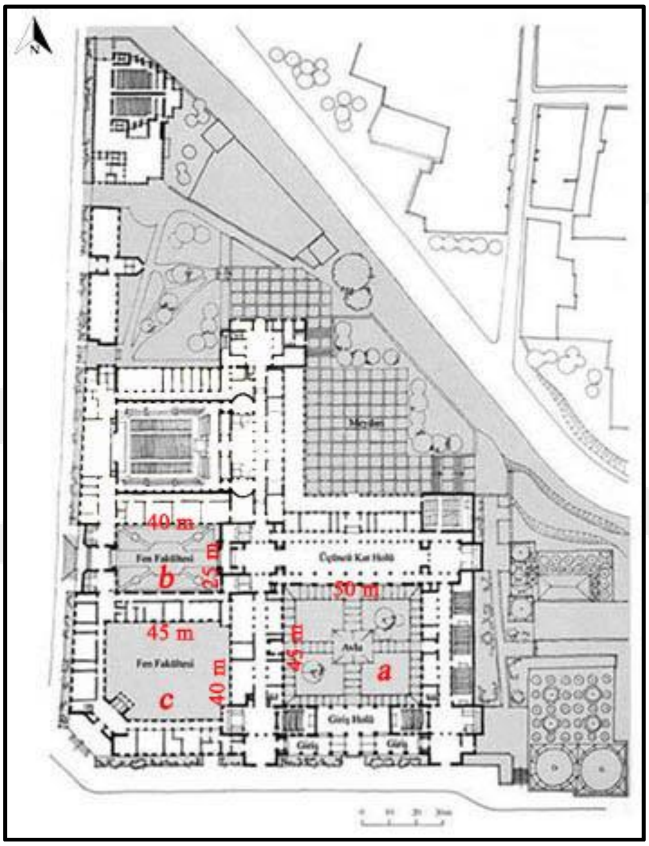


Figure 6.22. İstanbul University, Faculty of Science and Literature Building plan [98]

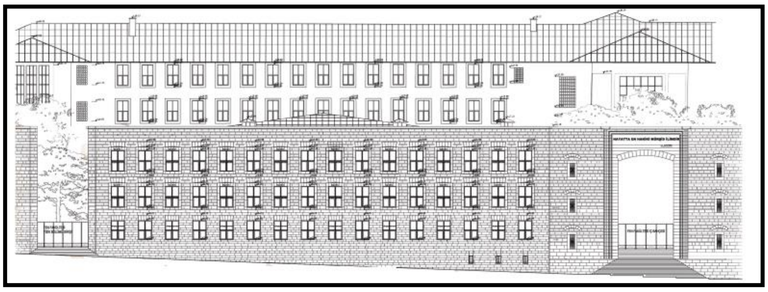


Figure 6.23. İstanbul University, Faculty of Science and Literature Building view [98]

Table 6.14. Analysis of İstanbul University, Faculty of Science and Literature Building

MAXIMUM UTILIZATION IN PASSIVE SOLAR ENERGY for İSTANBUL UNIVERSITY, FACULTY OF SCIENCE AND LITERATURE BUILDING
The Perpendicular Depth of the Courtyard to the South (d) / The Height of the North Wall of the Courtyard (h) $\geq$ 2 (d/h $\geq$ 2)
a) 45 / 29 = 1,55 **b) 40 / 29 = 1,37** **c) 25 / 29 = 0,86**
MAXIMUM UTILIZATION IN WIND ENERGY for İSTANBUL UNIVERSITY, FACULTY OF SCIENCE AND LITERATURE BUILDING
Ratio (R) = The Height of the Wall (h) / The Courtyard Short Edge Depth (d) (R=h/d) (0.3< R < 1)
a) 29 / 45 = 0.64 **b) 29 / 40 = 0.72** **c) 29 / 25 = 1.16**
COMPLIANCE WITH NATURE for İSTANBUL UNIVERSITY, FACULTY OF SCIENCE AND LITERATURE BUILDING
Total Planted Area on Building (TPAB) $\geq$ Coefficient of Green Usage in Buildings (CGUB) x Total Floor Area (TPAB $\geq$ CGUB x TFA)
CGUB: 0,30 Total Floor Area (TFA): 83.500 m^2 **TPAB that should be in the Building =** 0,30 x 83.500 **= 25.050 m^2** **TPAB = 4000 m^2** **Lack of Green Spaces in Building =** 25.050 - 4000 **= 21.050 m^2**
IMPROVED OUTDOOR COMFORT for İSTANBUL UNIVERSITY, FACULTY OF SCIENCE AND LITERATURE BUILDING
The Long Edge of the Courtyard / The Short Edge of the Courtyard = Form (F) (1<F< 2)
a) The Short Edge: 45 m, The Long Edge: 50 m **50/45 = 1,1** b) The Short Edge: 25 m, The Long Edge: 40 m **40/25 = 1,6** c) The Short Edge: 40 m, The Long Edge: 45m **45/40 = 1,1**

6.1.13. St. Georg Austrian High School

- Courtyard on the Side, Half Open in Mainly Natural Ground (A2G)
- 4 floor, Floor Height: 4 m
- Total Floor Area: 5.500 m^2

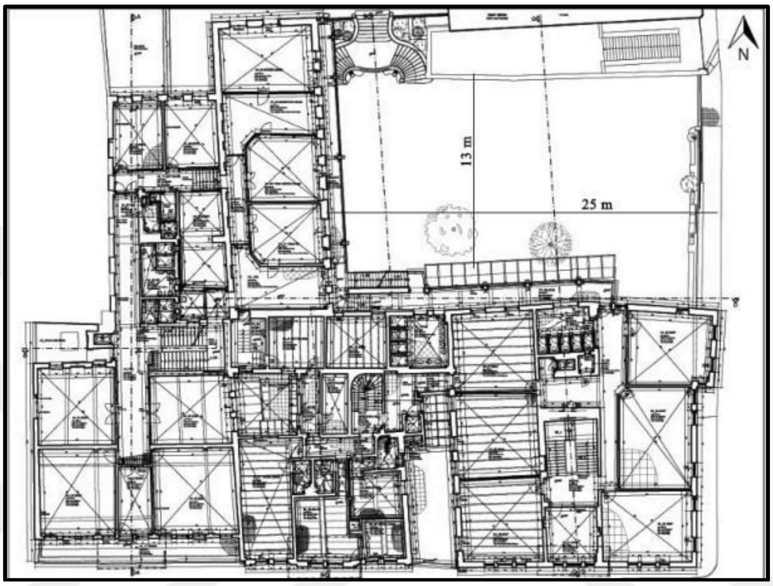


Figure 6.24. St. Georg Austrian High School plan [99]

Figure 6.25. St. Georg Austrian High School section [99]

Table 6.15. Analysis of St. Georg Austrian High School

MAXIMUM UTILIZATION IN PASSIVE SOLAR ENERGY for ST. GEORG AUSTRIAN HIGH SCHOOL
The Perpendicular Depth of the Courtyard to the South (d) / The Height of the North Wall of the Courtyard (h) $\geq$ 2 (d/h $\geq$ 2)
13 / 12 = 1,08 $\geq$ 2
MAXIMUM UTILIZATION IN WIND ENERGY for ST. GEORG AUSTRIAN HIGH SCHOOL
Ratio (R) = The Height of the Wall (h) / The Courtyard Short Edge Depth (d) (R=h/d) (0.3< R < 1)
12 / 13 = 0.92
COMPLIANCE WITH NATURE for ST. GEORG AUSTRIAN HIGH SCHOOL
Total Planted Area on Building (TPAB) $\geq$ Coefficient of Green Usage in Buildings (CGUB) x Total Floor Area (TPAB $\geq$ CGUB x TFA)
CGUB: 0,30 Total Floor Area (TFA): 5.500 m^2 **TPAB that should be in the Building =** 0,30 x 5.500 **= 1.650 m^2** **TPAB = 2000 m^2** **Lack of Green Spaces in Building = 2000 > 1.650** **(There is no deficiency in Building Herbal Area)**
IMPROVED OUTDOOR COMFORT for ST. GEORG AUSTRIAN HIGH SCHOOL
The Long Edge of the Courtyard / The Short Edge of the Courtyard = Form (F) (1<F< 2)
The Short Edge: 13 m, The Long Edge: 25 m **25/13 = 1,9**

6.2. EVALUATION OF THE EXAMPLES

13 different buildings which are evaluated and finalized in chapter 6.1 Analysis of Building Samples with Courtyard, according to Table 4.2 Basic Positive Qualifications Table. Every building samples will be explained one by one in this chapter. The Table 6.1's larger version and explanation are in the Appendix D.

6.2.1. Avlu 138 Residence

According to criteria of ***the maximum utilization in passive solar energy (d / h> 2),*** the resulting value of ***0,27*** is not equal to or greater than 2, the examined building ***is not suitable*** for this control variable. Therefore, the natural lighting and heating of the building is insufficient.

According to criteria of ***the maximum utilization in wind energy (R = h / w),*** the resulting value of ***3.6*** is not between 0.3 and 1, the examined building ***is not suitable*** for this control variable. Therefore, the natural ventilation is insufficient in the building.
According to criteria of ***compliance with nature (TPAB ≥ CGUB x TFA),*** the amount of green area should be ***2100 m^2***, the current building is ***50 m^2*** of green area. Therefore, a green area of ***2050 m^2 required***. The building is situated at the border of the plot and the plant cannot be used. Since the building courtyard is mainly firm ground, plant use is very low and ***is not suitable*** for this control variable. It does not sufficiently utilize the facilities provided by the plants.

According to criteria of ***improved outdoor comfort (Long Edge/Short Edge = Form),*** the resulting value of ***3*** is not between 1 and 2, the building examined in terms of improving the quality of life ***is not suitable*** for this control variable.

As a result, it is very difficult to create an external environment control space in the narrow courtyard building types. According to the criteria examined, this narrow courtyard structure does not provide four control variables.

6.2.2. Tekfen Bomonti Residence

According to criteria of ***the maximum utilization in passive solar energy (d / h> 2),*** the resulting value of ***3,6*** is greater than 2, the examined building ***is suitable*** for this control variable. Therefore, the natural lighting and heating of the building is sufficient.

According to criteria of ***the maximum utilization in wind energy (R = h / w),*** the resulting value of ***0,3 is*** between 0.3 and 1, the examined building ***is suitable*** for this control variable. Therefore, the natural ventilation is sufficient in the building.

According to criteria of ***compliance with nature (TPAB ≥ CGUB x TFA),*** the amount of green area should be ***5265*** m^2, the current building is ***80*** m^2 of green area. Therefore a green area of ***2050*** m^2required. The building courtyard is mainly firm ground; plant use is very low and is not suitable for this control variable. It does not sufficiently utilize the facilities provided by the plants.

According to criteria of ***improved outdoor comfort (Long Edge/Short Edge = Form),*** the resulting value of ***3,23*** is not between 1 and 2, the building examined in terms of improving the quality of life ***is not suitable*** for this control variable.
As a result, this building which has a single-sided open courtyard with a firm floor is suitable for natural climate. However, the use of firm floors is very high. This makes the natural habitat of the plant a natural building away from the microclimatic environment and the visual comfort to be provided.

6.2.3. Doğan Holding Management Building

According to criteria of ***the maximum utilization in passive solar energy (d / h> 2),*** the resulting value of ***2*** is equal to 2, the examined building is ***suitable*** for this control variable. Therefore, the natural lighting and heating of the building is sufficient.

According to criteria of ***the maximum utilization in wind energy (R = h / w),*** the resulting value of ***0,52 is*** between 0.3 and 1, the examined building ***is suitable*** for this control

variable. Therefore, the natural ventilation is sufficient in the building. It allows to common activities.

According to criteria of ***compliance with nature (TPAB ≥ CGUB x TFA),*** the amount of green area should be ***3600 m²***, the current building is ***2500 m²*** of green area. Therefore, a green area of ***1160 m²*** required. However, there is a green area around the building.

According to criteria of ***improved outdoor comfort (Long Edge/Short Edge = Form),*** the resulting value of ***1,41*** is between 1 and 2, the building examined in terms of improving the quality of life ***is suitable*** for this control variable.

As a result, a sheltered environment has been provided in this building with a large courtyard surrounded by 2 low floors in the same dimensions and the courtyards made benefit to the building in terms of air conditioning.

6.2.4. Rönesans Biz Mecidiyeköy Offices

According to criteria of ***the maximum utilization in passive solar energy (d / h> 2),*** the resulting value of ***0,31*** is not equal to or greater than 2, the examined building ***is not suitable*** for this control variable. Therefore, the natural lighting and heating of the building is insufficient.

According to criteria of ***the maximum utilization in wind energy (R = h / w),*** the resulting value of ***3,2*** is not between 0.3 and 1, the examined building ***is not suitable*** for this control variable. Therefore, the natural ventilation is insufficient in the building.

According to criteria of ***compliance with nature (TPAB ≥ CGUB x TFA),*** the amount of green area should be ***4987 m²,*** the current building is ***850 m²*** of green area. Therefore, a green area of ***4137 m²*** required. The building courtyard is semi-open and firm ground, plant use is very low and is not suitable for this control variable. It does not sufficiently utilize the facilities provided by the plants.

According to criteria of ***improved outdoor comfort (Long Edge/Short Edge = Form),*** the resulting value of ***4*** is not between 1 and 2, the building examined in terms of improving the quality of life ***is not suitable*** for this control variable.

As a result, it is very difficult to create a controlled environment in the narrow courtyard building types. According to the criteria examined, this semi-open, narrow courtyard structure does not provide four control variables.

The electrical data of this structure; average 175.000 KWh in winter and 195.000 KWh in summer. In the summer months, it is seen that 11% usage increase compared to winter months. The reason for this increase is the use of extra air conditioning in the winter for extra heating, summer cooling and ventilation. The use of solar and wind energy is very low in this narrow courtyard. The natural soft floor in the existing area is very low compared to the total m^2. The benefits to be obtained from planting cannot be achieved.

6.2.5. Lapis Han

According to criteria of ***the maximum utilization in passive solar energy (d / h> 2),*** the resulting value of ***2*** is equal to 2, the examined building ***is suitable*** for this control variable. Therefore, the natural lighting and heating of the building is sufficient.

According to criteria of ***the maximum utilization in wind energy (R = h / w),*** the resulting value of ***0,56*** is between 0.3 and 1, the examined building ***is suitable*** for this control variable. Therefore, the natural ventilation is sufficient in the building. It allows to common activities.

According to criteria of ***compliance with nature (TPAB ≥ CGUB x TFA),*** the amount of green area should be ***9480 m^2***, the current building is ***1290 m^2*** of green area. Therefore, a green area of ***8190 m^2*** required. The building is almost completely situated on the land and the plant cannot be used on the land. Since the building courtyard is mainly hard ground, plant use is very low and is ***not suitable*** for this control variable. It does not sufficiently utilize the facilities provided by the plants.

According to criteria of ***improved outdoor comfort (Long Edge/Short Edge = Form),*** the resulting value of ***1,61*** is between 1 and 2, the building examined in terms of improving the quality of life ***is suitable*** for this control variable.

As a result, this building with a surrounded by high storey, wide type in enclosed on the building is suitable for solar and wind variables. The building, which has a wide courtyard, provides a sheltered outdoor environment where users can collaborate on a common basis. But it is not sufficient in terms of green space. Therefore, the natural life with the possibility of reduction will be achieved through energy instead of natural green spaces are born artificial energy requirements.

The electrical data of this structure; in winter, the average is 53,395 KWh and in summer the average is 84,567 KWh. In summer, it is seen that the use of 58% increase compared to winter months. The reason for this increase is the use of extra air conditioning for cooling. If this plant with hard ground had been planted, it would be protected from the effective heat of the summer sun with the formation of shadow areas, and the shaded areas would create cool areas that would reduce the heat in the environment and the air conditioning need would be reduced.

6.2.6. İstanbul Technical University, Taşkışla Campus

According to criteria of ***the maximum utilization in passive solar energy (d / h> 2),*** the resulting value of ***3,5*** is greater than 2, the examined building ***is suitable*** for this control variable. Therefore, the natural lighting and heating of the building is sufficient.

According to criteria of ***the maximum utilization in wind energy (R = h / w),*** the resulting value of ***0,47*** is between 0.3 and 1, the examined building ***is suitable*** for this control variable. Therefore, the natural ventilation is sufficient in the building. It allows to common activities.

According to criteria of ***compliance with nature (TPAB ≥ CGUB x TFA),*** the amount of green area should be ***15600 m^2***, the current building is ***35000 m^2*** of green area. The green area in the existing land is more than the amount of green space that should be, the natural herbal environment is met as maximum. Therefore, there is no green field in the structure and this is very suitable for the control variable. The facilities provided by the plants are adequately utilized.

According to criteria of ***improved outdoor comfort (Long Edge/Short Edge = Form),*** the resulting value of ***1,75*** is between 1 and 2, the building examined in terms of improving the quality of life ***is suitable*** for this control variable.

As a result, all of the control variables examined in this building with surrounded by low storey, wide type in mainly natural ground on the side are all positive and the effect of the building on the sustainability is high and the best result was determined as ITU Taşkışla Campus, which is an educational building. The positive contribution of this type of courtyard to the energy expenditure throughout the year is highest compared to the others. The electricity consumption of the building also confirms this fact. Namely; the electrical data of this building; in winter, the average is 91,300 KWh and in summer the average is 56,520 KWh. It is seen that it decreased by 55% in summer months compared to winter months. The reason for this difference; due to the courtyard, which is suitable for the sustainable control variables, the increase in the facades of the buildings, windows, doors, such as the increase of openings and natural lighting and ventilation from these areas is provided. Therefore, in the winter, the central courtyard in suitable locations and sizes has the effect of natural air conditioning rather than the use of air conditioners to be used for cooling in the summer as much as the heating. In addition, this building, which is mainly based on natural soft ground, creates shade areas by planting and creates cool areas in places by protecting from the sultry weather heat of the summer. In winter, the courtyard provides soft air in the courtyard as it reduces the strong winds in the outdoor environment. In this structure, heating is provided by natural gas.

6.2.7. İstanbul Technical University, Maçka Campus

According to criteria of ***the maximum utilization in passive solar energy (d / h> 2),*** the resulting value of ***2,3*** is greater than 2, the examined building ***is suitable*** for this control variable. Therefore, the natural lighting and heating of the building is sufficient.

According to criteria of ***the maximum utilization in wind energy (R = h / w),*** the resulting value of ***0,42*** is between 0.3 and 1, the examined building ***is suitable*** for this control

variable. Therefore, the natural ventilation is sufficient in the building. It allows to common activities.

According to criteria of ***compliance with nature (TPAB ≥ CGUB x TFA),*** the amount of green area should be ***18900 m²***, the current building is ***100 m²*** of green area. Therefore, there is a lack of green space of ***18800 m²*** in the building. The building is well situated and the plant is not used in the grounds and courtyards. The building courtyard is mainly firm ground; plant use is very low and ***is not suitable*** for this control variable. It does not sufficiently utilize the facilities provided by the plants.

According to criteria of ***improved outdoor comfort (Long Edge/Short Edge = Form),*** the resulting value of ***1,75*** is between 1 and 2, the building examined in terms of improving the quality of life ***is suitable*** for this control variable.

As a result, this building with surrounded by low storey, wide type in mainly firm ground on the side has 2 courtyards in the same dimensions. This building which is suitable in terms of sun and wind variables provides a sheltered external environment in which large courtyards and common users can come together. But it is not sufficient in terms of green space. Therefore, with the reduction of natural life opportunities, the need for artificial energy arises instead of the natural energy obtained by the green areas. However, it is always possible to reduce the hard ground of the courtyards in the center of the building and to increase the cultivation. In this way, the structure becomes suitable for all control variables and the effect on the sustainability of the structure can become much higher.

6.2.8. Crystal Tower

According to criteria of ***the maximum utilization in passive solar energy (d / h> 2),*** the resulting value of ***courtyard a 5,6, courtyard b 5,6, courtyard c 5,6, courtyard d 6,2*** are greater than 2, the examined building ***is suitable*** for this control variable. Therefore, the natural lighting and heating of the building is sufficient.

According to criteria of ***the maximum utilization in wind energy (R = h / w),*** the resulting value of ***courtyard a 0,17, courtyard b 0,17, courtyard c 0,17, courtyard d 0,16*** are not between 0.3 and 1, the examined building ***is not suitable*** for this control variable. Therefore, the natural ventilation is not sufficient in the building.

According to criteria of ***compliance with nature (TPAB ≥ CGUB x TFA),*** the amount of green area should be ***28986 m^2***, the current building is ***500 m^2*** of green area. Therefore, there is a lack of green space of ***28486 m^2*** in the building. The building is well situated and the plant is not used in the grounds and courtyards. The building courtyard is mainly firm ground; plant use is very low and ***is not suitable*** for this control variable. It does not sufficiently utilize the facilities provided by the plants.

According to criteria of ***improved outdoor comfort (Long Edge/Short Edge = Form),*** the resulting value of ***courtyard a 1,8, courtyard b 1,8, courtyard c 1,8, courtyard d 1,*** are between 1 and 2, the building examined in terms of improving the quality of life ***is suitable*** for this control variable.

As a result, solar energy is utilized on a surrounded by low storey, narrow type in enclosed courtyard on the building. These courtyards between the floors do not sufficiently benefit from wind energy. Plant use is very low in hard-decked courtyards and not sufficient in terms of green area. Therefore, with the reduction of natural life opportunities, the need for artificial energy arises instead of the natural energy obtained by the green areas.

6.2.9. İpekyol Textile Factory

According to criteria of ***the maximum utilization in passive solar energy (d / h> 2),*** the resulting value of ***courtyard b 5,6, courtyard d 2, courtyard e 5,6*** are greater than 2, the examined building ***is suitable*** for this control variable and value of ***courtyard a0,6, courtyard c0,6*** are not equal to or greater than 2the examined building ***is not suitable*** for this control variable. Therefore, the natural lighting and heating of the building is insufficient.

According to criteria of ***the maximum utilization in wind energy (R = h / w),*** the resulting value of ***courtyard a 1,6, courtyard b 0,17, courtyard c 1,6, courtyard e 0,17*** are not between 0.3 and 1, the examined building ***is not suitable*** for this control variable.

Therefore, the natural ventilation is not sufficient in the building. Therefore, it cannot meet the requirement of natural ventilation in courtyards adequately. In this building, only ***courtyard d 0,53 is suitable*** for this control variable.

According to criteria of ***compliance with nature (TPAB ≥ CGUB x TFA),*** the amount of green area should be ***6000 m²***, the current building is ***1500 m²*** of green area. Therefore, there is a lack of green space of ***4500 m²*** in the building. The building is located on the side and the plant cannot be used. The building courtyard is mainly firm ground; plant use is very low and ***is not suitable*** for this control variable. It does not sufficiently utilize the facilities provided by the plants.

According to criteria of ***improved outdoor comfort (Long Edge/Short Edge = Form),*** the resulting value of ***courtyard a 5,6, courtyard b 9, courtyard c 3, courtyard d 9*** are between 1 and 2, the building examined in terms of improving the quality of life ***is not suitable*** for this control variable. In this building, only ***courtyard e 1,5 is suitable*** for this control variable.

As a result, in this building which is located in mainly firm ground, have five different courtyards surrounded by low storey narrow type courtyard, the fact that the plant use is low, the sun and wind energy in the courtyards are not effective and the courtyards which are narrow and long in shape do not form a sheltered common space show that the courtyards in the structure do not contribute to the sustainability.

6.2.10. A School in Çekmeköy

According to criteria of ***the maximum utilization in passive solar energy (d / h> 2),*** the resulting value of ***1,43*** is not equal to or greater than 2, the examined building ***is not suitable*** for this control variable. Therefore, the natural lighting and heating of the building is insufficient.

According to criteria of ***the maximum utilization in wind energy (R = h / w),*** the resulting value of ***0,69*** is between 0.3 and 1, the examined building ***is suitable*** for this control

variable. Therefore, the natural ventilation is sufficient in the building. It allows to common activities.

According to criteria of ***compliance with nature (TPAB ≥ CGUB x TFA),*** the amount of green area should be ***4500 m²***, the current building is ***1500 m²*** of green area. Therefore, there is a lack of green space of ***3000 m²*** in the building. The building is well situated and the plant is not used in the grounds and courtyards. The building courtyard is mainly firm ground; plant use is very low and ***is not suitable*** for this control variable. It does not sufficiently utilize the facilities provided by the plants.

According to criteria of ***improved outdoor comfort (Long Edge/Short Edge = Form),*** the resulting value of ***1,5*** is between 1 and 2, the building examined in terms of improving the quality of life ***is suitable*** for this control variable.

As a result, this building has a semi-open and low-rise structure with different widths. Due to the orientation of the yard it cannot be exploited in a northerly direction from solar energy. However, this structure, which is suitable for wind energy, provides a sheltered external environment in which it can make common activities with its large courtyards. But it is not sufficient in terms of green space. Therefore, with the reduction of natural life opportunities, the need for artificial energy arises instead of the natural energy obtained by the green areas.

6.2.11. Şişecam R&D Center

According to criteria of ***the maximum utilization in passive solar energy (d / h> 2),*** the resulting value of ***2,91*** is greater than 2, the examined building ***is suitable*** for this control variable. Therefore, the natural lighting and heating of the building is sufficient.

According to criteria of ***the maximum utilization in wind energy (R = h / w),*** the resulting value of ***0,69*** is between 0.3 and 1, the examined building ***is suitable*** for this control variable. Therefore, the natural ventilation is sufficient in the building. It allows to common activities.

According to criteria of ***compliance with nature (TPAB ≥ CGUB x TFA),*** the amount of green area should be ***2400 m²***, the current building is ***5500 m²*** of green area. Therefore, there is not a lack of green space in the building ***is suitable*** for this control variable. In addition to the green areas used in the courtyard, a green roof has been planted and the contribution to sustainability is high.

According to criteria of ***improved outdoor comfort (Long Edge/Short Edge = Form),*** the resulting value of ***3*** is not between 1 and 2, the building examined in terms of improving the quality of life ***is not suitable*** for this control variable.

As a result, this building has the mainly natural ground surrounded by a small courtyard with a narrow courtyard on the side and the maximum use of solar and wind energy is utilized, and green area usage contributes to sustainability. However, in narrow courthouses, the rate of how much of the square goes out of form, the more it becomes possible for the joint activities to be reduced.

6.2.12. İstanbul University, Faculty of Science and Literature Building

According to criteria of ***the maximum utilization in passive solar energy (d / h> 2),*** the resulting value of ***courtyard a 1,55, courtyard b 1,37, courtyard c 0,86*** are not greater than 2, the examined building ***is not suitable*** for this control variable. Therefore, the natural lighting and heating of the building is insufficient.

According to criteria of ***the maximum utilization in wind energy (R = h / w),*** the resulting value of ***courtyard a 0,64, courtyard b 0,72*** are between 0.3 and 1, ***courtyard c 1,6*** are not, the examined building courtyard a and b ***are suitable***, courtyard c ***is not suitable*** for this control variable. Therefore, the natural ventilation is half sufficient in the building.

According to criteria of ***compliance with nature (TPAB ≥ CGUB x TFA),*** the amount of green area should be ***25000 m²***, the current building is ***4000 m²*** of green area. Therefore, there is a lack of green space of ***21000 m²*** in the building. The building is well situated and the plant is not used in the grounds and courtyards. The building courtyard is mainly firm ground; plant use is very low and ***is not suitable*** for this control variable. It does not sufficiently utilize the facilities provided by the plants.

According to criteria of ***improved outdoor comfort (Long Edge/Short Edge = Form),*** the resulting value of ***courtyard a and c 1,1***, ***courtyard b 1,6*** is between 1 and 2, the building examined in terms of improving the quality of life ***is suitable*** for this control variable.

As a result, there are three different courtyards in this building with a surrounded by high storey, wide type in mainly natural ground on the side. Because the perimeter of these courtyards is surrounded by multiple floors, solar energy cannot be utilized much more. Wind energy has also benefited from the b courtyard with a car cannot take advantage of the courtyard. There is a small amount of use of green space compared to the total construction area. The shelter in the three courtyards constitutes a natural common living space.

6.2.13. St. Georg Austrian High School

According to criteria of ***the maximum utilization in passive solar energy (d / h> 2),*** the resulting value of ***1,08*** is not greater than 2, the examined building ***is not suitable*** for this control variable. Therefore, the natural lighting and heating of the building is insufficient.
According to criteria of ***the maximum utilization in wind energy (R = h / w),*** the resulting value of ***0,92*** is between 0.3 and 1, the examined building ***is suitable*** for this control variable. Therefore, the natural ventilation is sufficient in the building.
According to criteria of ***compliance with nature (TPAB ≥ CGUB x TFA),*** the amount of green area should be ***1650 m^2***, the current building is ***2000 m^2*** of green area. The green area in the existing land is more than the amount of green space that should be, the natural herbal environment is met as maximum. Therefore, there is no green field in the structure and this is very suitable for the control variable. The facilities provided by the plants are adequately utilized.
According to criteria of ***improved outdoor comfort (Long Edge/Short Edge = Form),*** the resulting value of ***1,91*** is between 1 and 2, the building examined in terms of improving the quality of life ***is suitable*** for this control variable.

As a result, in this building which has a semi-open courtyard with a firm floor, the green area has been increased with the use of plants on the walls and balconies. Due to the high density of the building, the low-rise building can benefit from solar energy. However, wind energy can be used. The courtyard also provides a sheltered natural common living space.

13 different buildings samples analyzed in chapter 6.1 and evaluated in this section. The buildings which have the least and maximum contribution to sustainability among the structures examined are shown in Table 6.16 Ranking of the Courtyard Examples Contribution of the Sustainability.

Table 6.16. Ranking of the courtyard examples contribution on sustainability

(Constitute by Author)

	CONTROL VARIABLES / EXAMPLES	MAX. UTILIZATION IN PASSIVE SOLAR ENERGY		MAX. UTILIZATION IN WIND ENERGY		COMPLIANCE WITH NATURE		IMPROVED OUTDOOR COMFORT		TOTAL RESULTS
		RESULT	EXPLANATION	RESULT	EXPLANATION	RESULT	EXPLANATION	RESULT	EXPLANATION	
		The Perpendicular Depth of the Courtyard to the South (d) / The Height of the North Wall of the Courtyard (h) (d / h ≥ 2)		Ratio (R) = The Height of the Wall (h) / The Courtyard Short Edge Depth (d) (R= h / d) (0.3 < R < 1)		Total Planted Area on Building (TPAB) is depend on the size of green area on the buildings connected to the "Coefficient of Green Usage in Buildings (CGUB)" (TPAB ≥ CGUB x TFA)		The Long Edge of the Courtyard / The Short Edge of the Courtyard = Form (F) (R = 1:1< F < 2:1)		
1	Avlu 138 Residence	~ 0,27	(-)	~ 3.6	(-)	CGUB: 2100 m2 TPAB: ~ 50 m2	(-)	~ 3:1	(-)	0
2	Tekfen Bomonti Residence	~ 3,6	(+)	~ 0.3	(+)	CGUB: 5265 m2 TPAB: ~ 80 m2	(-)	~ 3,23:1	(-)	2 (+) 2 (-)
3	Doğan Holding Management Building	~ 2	(+)	~ 0.52	(+)	CGUB: 3660 m2 TPAB: ~ 2500 m2	(-)	~ 1,41:1	(+)	3 (+) 1 (-)
		~ 2	(+)	~ 0.52	(+)			~ 1,41:1	(+)	3 (+) 1 (-)
4	Rönesans Biz Mecidiyeköy Offices	~ 0,31	(-)	~ 3.2	(-)	CGUB: 4987 m2 TPAB: ~ 850 m2	(-)	~ 4:1	(-)	0
5	Lapis Han	~ 2	(+)	~ 0.56	(+)	CGUB: 9480 m2 TPAB: ~ 1290 m2	(-)	~ 1,61:1	(+)	3 (+) 1 (-)
6	İstanbul Technical University, Taşkışla Campus	~ 3,5	(+)	~ 0.47	(+)	CGUB: 15600 m2 TPAB: ~ 35000 m2	(+)	~ 1,75:1	(+)	4 (+)
7	İstanbul Technical University – Maçka Campus	~ 2,3	(+)	~ 0.42	(+)	CGUB: 18900 m2 TPAB: ~ 100 m2	(-)	~ 1,75:1	(+)	3 (+) 1 (-)
		~ 2,3	(+)	~ 0.42	(+)		(-)	~ 1,75:1	(+)	3 (+) 1 (-)
8	Crystal Tower	~ 5,6	(+)	~ 0.17	(-)	CGUB: 28986 m2 TPAB: ~ 500 m2	(-)	~ 1,8:1	(+)	2 (+) 2 (-)
		~ 5,6	(+)	~ 0.17	(-)		(-)	~ 1,8:1	(+)	2 (+) 2 (-)
		~ 5,6	(+)	~ 0.17	(-)		(-)	~ 1,8:1	(+)	2 (+) 2 (-)
		~ 6,2	(+)	~ 0.16	(-)		(-)	~ 1:1	(+)	2 (+) 2 (-)
9	İpekyol Textile Factory	~ 0,6	(-)	~ 1.6	(-)	CGUB: 6000 m2 TPAB: ~ 1500 m2	(-)	~ 5,6:1	(-)	0
		~ 5,6	(+)	~ 0.17	(-)		(-)	~ 9:1	(-)	1 (+) 3 (-)
		~ 0,6	(-)	~ 1.6	(-)		(-)	~ 3:1	(-)	0
		~ 2	(+)	~ 0.53	(+)		(-)	~ 9:1	(-)	2 (+) 2 (-)
		~ 5,6	(+)	~ 0.17	(-)		(-)	~ 1,5:1	(+)	2 (+) 2 (-)
10	A School in Çekmeköy	~ 1,43	(-)	~ 0.69	(+)	CGUB: 4500 m2 TPAB: ~ 1500 m2	(-)	~ 1,5:1	(+)	2 (+) 2 (-)
		~ 1,43	(-)	~ 0.69	(+)		(-)	~ 1,5:1	(+)	2 (+) 2 (-)
11	Şişecam R&D Center	~ 2,91	(+)	~ 0.34	(+)	CGUB: 2400 m2 TPAB: ~ 5500 m2	(+)	~ 3,2:1	(-)	3 (+) 1 (-)
12	İstanbul University, Faculty of Science and Literature	~ 1,55	(-)	~ 0.64	(+)	CGUB: 25000 m2 TPAB: ~ 4000 m2	(-)	~ 1,1:1	(+)	2 (+) 2 (-)
		~ 1,37	(-)	~ 0.72	(+)			~ 1,6:1	(+)	2 (+) 2 (-)
		~ 0,86	(-)	~ 1.16	(-)			~ 1,1:1	(+)	1 (+) 3 (-)
13	St. Georg Austrian High School	~ 1,08	(-)	~ 0.92	(+)	CGUB: 1650 m2 TPAB: ~ 2000 m2	(+)	~ 1,9:1	(+)	3 (+) 1 (-)

SUITABLE : (+) UNSUITABLE: (-)

6.3. GENERAL EVALUATION

- Among the 13 buildings examined, ITU Taşkışla building is determined the best example according to the control variables. Avlu 138, Rönesans Biz Mecidiyeköy and İpekyol Textile Factory with narrow courtyards are determined as poor examples according to the control variables because they are both poor examples based on solar, wind energy and plant areas.

- According to the results of the control variables, the electrical data of the three structures, which resulted in good, average and poor results, were compared. Since the heating is done with natural gas in these buildings, the investigations and comparisons are only examined according to the use of artificial lighting, artificial ventilation and air conditioning.

- İstanbul Technical University Taşkışla Campus courtyard is suitable for A1D2 courtyard type as the best example and has the highest contribution to energy expenditure throughout the year compared to the others. The positive contribution of this building to energy expenditure throughout the year is source of the fact that the courtyard was suitable for all of its sustainability gains.

- The example with average result was determined as Lapis Han (B2E2) commercial building. The courtyard is also suitable for three qualifications, and the fact that it is hard ground has a negative impact on sustainability.

- Rönesans Biz Mecidiyeköy (A1G), commercial building, has been determined as a poor example. Courtyard is not suitable for all achievements of sustainability.

- It is determined that the most contributing types of sustainability in the courtyard typology were mainly natural ground, plant-rich, south facade was long, north facade was short and courtyard area was not narrow.

- 4 of the 13 buildings examined have LEED certificate as specified in Table 2.1.
  Tekfen Bomonti Residence / İstanbul (LEED GOLD)
  Rönesans Biz Mecidiyeköy Offices / İstanbul (LEED GOLD)

Crystal Tower / İstanbul (LEED SILVER)
Şişecam R&D Center / Kocaeli (LEED GOLD)

- While LEED certification asseses a structure on terms of green building, the investigations made in this thesis aim to reveal the contribution of the courtyard to the structure in terms of sustainability.

- Rönesans Biz Mecidiyeköy Offices has “LEED GOLD” certification. However, when it’s examined in terms of contribution of courtyard to the sustainable building, this structure was found to be the worst sample according to the control variables. The reason is that the courtyard is semi-open and narrow. Sun, wind and natural common living space is insufficient. Although it is located on the natural ground, the plant environment is small. For these reasons, it was not appropriate according to the control variables.

7. CONCLUSIONS AND DISCUSSIONS

- In the past, the courtyards were used as a common open relaxation area within the building, and nowadays it has become an architectural venue that contributes to sustainable ecological natural life.
- The courtyards are the most suitable interior spaces in terms of the concept of “external space which is taken into the building” that are developed in this thesis for sustainability in architecture.
- The fact that courtyards are made in terms of sustainability different from the typologies made in the past facilitates the evaluation of courtyard types from this perspective.
- The courtyards were considered as elements that could cope with the warm climates alone, and they were considered as elements that provide comfortable living with different forms and positioning in different climate and topographies. The microclimate provides comfortable living in both indoor and outdoor areas and makes use of natural factors.
- When the examples in the historical process are examined, it is observed that the typology of the courtyard has a long history. Compared to the first developed examples, time material selection, plan scheme, construction methods, size and relationship with other structures have also changed. When the samples of the past courtyard were examined, it was seen that this typology is a widely preferred typology on the world map. The repetition of the same architectural form in the periods when fully passive systems are dominant is due to the provision of the most basic needs and facilities.
- The courtyard has both cultural and architectural features. As a cultural element, the courtyard is a space where users can socialize together.
- It has been observed that the radiation gains of the courtyard have changed with varying rates according to different climatic zones, orientation is important in the

courtyard buildings as in every building example and the direct effects of the architectural elements such as material, landscape and water surface on thermal comfort have been observed. Every climate has changing properties according to their own property. For example, compared to cold climates, the choice of landscaping and water surface elements in more moderate climates are directly influenced by humidity. Considering the priorities, it was determined that the first radiation gains in the cold climates, the humidity balance in the moderate climates and the air flow gain in the tropical climate have priority.

- The courtyard, which has an interior extension, has a very strong regulatory effect. It is seen that there is thermal difference between outdoor and courtyard temperatures and the structure shows thermal mass effect and thus soften the air in its immediate environment by making microclimatic atmosphere.
- As the width of the yard was decreased and the height increased, the wind effect increased in the courtyard, and the air flow into the courtyard was facilitated by the cavities opening to the direction of the wind. In cold climates, on the contrary, protective methods are preferred against winds, and compact forms are chosen.
- Courtyards are passive climate regulators, a good solar collector in the cold period and the blocker in the hot period which is defined as the common external spaces enclosed in the building. It is determined that sustainable performance is important for different climates, most notably in hot-dry climates.
- The control variables of courtyards determined in this thesis provide features like ventilation, natural lighting, shadowing while providing the relationship with the soil, living in the open air, feeling the nature, plant breeding, providing the privacy of the individual life, protecting from negative external conditions such as thieves, noise, dust, exhaust etc.
- From past to present the goal of the gain of ecological approach from the architectural design scale with the use of vegetative elements is to strengthen the building’s identity and to provide spatial diversity. In this framework, it has been revealed that the formation of the structure in the form of a courtyard has gained importance in

architectural design as an approach adopted throughout history. Emphasizing the spatial effect of the active integration of green tissue with cultural environment, the effects of natural soft and hard floored courtyard varieties on sustainability have been evaluated.

- The concept of “External environment taken into the building” can be used for internal environment which are directly related to the natural environment and are required for the sustainability of buildings. The most suitable interior environments to these concepts are the courtyards.
- Compared to “compact structures” without common internal space associated with the external environment and “structures with atrium”, “courtyard structures” are the most suitable structures in terms of sustainability criteria.
- Among the common interiors associated with nature, the importance of courtyards in terms of sustainability can be demonstrated in comparison with Table 4.1.
- The contribution of courtyards to sustainability can be evaluated according to the control variables in Table 4.3.
- The main positive qualities of courtyards:
    - Maximum utilization of passive solar energy,
    - Maximum utilization of wind energy,
    - Compliance with nature,
    - Improved outdoor comfort can be specified as.
- The possibilities that courtyards provided to buildings in terms of sustainability can be determined by the following control variables and standard criteria of these variables:

Table 7.1. Summary of basic positive qualifications table

VARIANT	STANDART CRITERIA
The Perpendicular Depth of the Courtyard to the South (d) / The Height of the North Wall of the Courtyard (h)	**d / h ≥ 2
Ratio (R) = The Height of the Wall (h) / The Courtyard Short Edge Depth (d)	R= h / d 0.3≤ R ≤ 1
Total Planted Area on Building (TPAB) ≥ The size of green area on the buildings connected to the "Coefficient of Green Usage in Buildings (CGUB)" x Total Floor Area	TPAB ≥ CGUB x TFA
The Long Edge of the Courtyard / The Short Edge of the Courtyard = Form (F)	R = 1≤ F ≤ 2

- 13 different educational and commercial structures are examined according to Table 4.2, sustainability gains are explained and evaluated in detail in chapter 6. The best courtyard form has been found to be A1D2 courtyard type (Courtyard on the Side, Surrounded by Low Storey and Wide Type in Mainly Natural Ground) according to the courtyard typology table in terms of sustainability (Figure 5.1). Due to the vegetated natural ground of these courtyards, a temperate environment is obtained by forming shaded areas in the summer, non-windy areas in the winter. These buildings have large courtyards and are surrounded by low floors. Their radiation gains are high, wind effect is beneficial and a protected area from outside conditions is formed.

- In the Marmara region, which has in transition climate, effects of hot-dry climates cannot be observed. In this climate, which is hot in summer and cold and rainy in winters, it is very difficult to create comfortable space with courtyard in winter months. For this reason, in the old courtyard buildings courtyards are covered with top cover and converted into atrium structures. This destroys the benefits of the yard. However, it should be noted that there was a positive effect in terms of natural lighting and natural ventilation at least.

- B2E1 type in the courtyard typology made in terms of sustainability, meaning Courtyard on the Building, Surrounded by High Storey, Narrow Type defines the courtyards that have minimal contribution to sustainability.

- Regardless of the type of courtyards, the more appropriate vegetative equipment of the courtyards, the greater sustainability contribution they provide to the buildings.
- Vegetative equipment is subject to be selected from hot climate plants, which harbors moisture.
- Courtyard types on the natural ground within the building are courtyards with the most suitable position in the structure in terms of sustainability.

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APPENDIX A: BASIC POSITIVE QUALIFICATIONS TABLE

Table A.1. Basic positive qualifications table

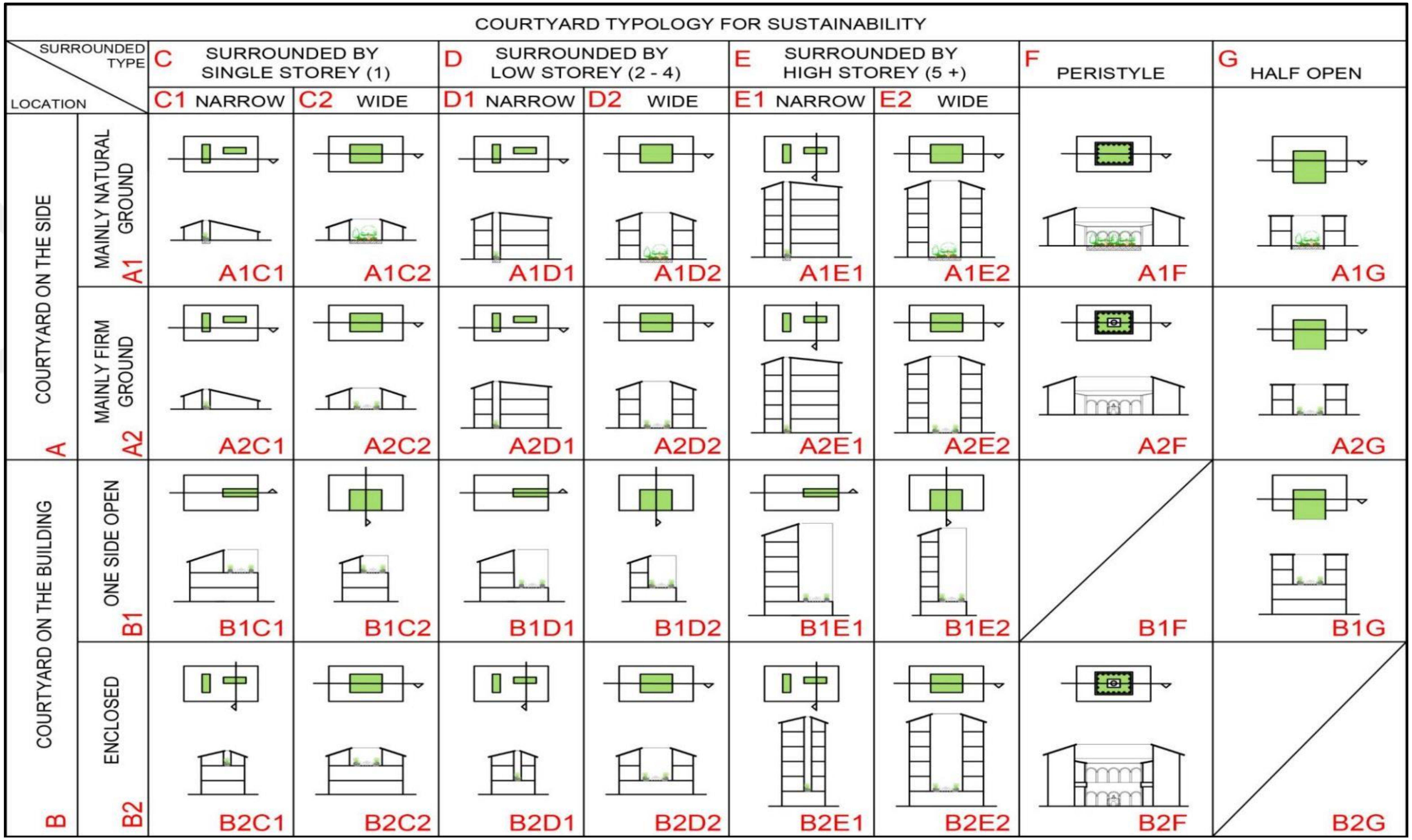
(Constitute by Author)

BASIC POSITIVE QUALIFICATIONS	CONTROL VARIABLES			OPPORTUNITIES FOR SUSTAINABILITY	SUSTAINABILITY CRITERIA IN ARCHITECTURE
	VARIANT	STANDART CRITERIA	REFERENCE		
MAXIMUM UTILIZATION IN PASSIVE SOLAR ENERGY	* The Perpendicular Depth of the Courtyard to the South (d) / The Height of the North Wall of the Courtyard (h)	**d / h ≥ 2	J.REYNOLDS (2001)	1. The natural lighting of the spaces is increasing. 2. Max. Solar space heating is increasing the possibility of benefiting from the effects of winter sun due to increased fronts. 3. Natural ventilation possibility is increasing.	1. Natural Renewable Energy Use 2. Improving the Quality of Life 3. Economic Solution Processes
MAXIMUM UTILIZATION IN WIND ENERGY	Ratio (R) = The Height of the Wall (h) / The Courtyard Short Edge Depth (d)	R= h / d 0.3 ≤ R ≤ 1	HALL et. al. (1999)	1. Natural ventilation possibility is increasing. 2. Natural air conditioning is provided. 3. Cold wind, noise etc. A protected external environment is provided that is free of adverse environmental influences. 4. The common living space where the users can come together.	1. Natural Renewable Energy Use 2. Improving the Quality of Life 3. Economic Solution Processes
COMPLIANCE WITH NATURE	Total Planted Area on Building (TPAB) is depend on the size of green area on the buildings connected to the "Coefficient of Green Usage in Buildings (CGUB)"	TPAB ≥ CGUB x TFA	S.KARAGULER (1994)	1. Natural life is growing with plants. 2. Microclimatic conditions are provided naturally. 3. Visual comfort is provided.	1. Natural Renewable Energy Use 2. Improving the Quality of Life 3. Economic Solution Processes
IMPROVED OUTDOOR COMFORT	The Long Edge of the Courtyard / The Short Edge of the Courtyard = Form (F)	R = 1≤ F ≤ 2	MUHAISEN & GADI (2005) TABESH & SERTYESILISIK (2016)	1. The common living space where the users can come together, which they have formed together. 2. It enables joint activities. 3. Cold wind, noise etc. A protected external environment is provided that is free of adverse environmental influences.	1. Improving the Quality of Life
As the control variables grow, the courtyard's efficiency in sustainability is increasing.					
* For the northern hemisphere. (In general, the "direction of the sun" direction for the South direction "North wall" is used in the "barrier wall".)					
** For 40 ° North Latitude.					

APPENDIX B: COURTYARD TYPOLOGY TABLE FOR SUSTAINABILITY

Table B. 1. Courtyard typology table for sustainability

(Constitute by Author)



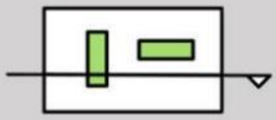
APPENDIX C: EXAMPLES OF COURTYARD TYPOLOGY TABLE FOR SUSTAINABILITY

Table C. 1. Examples of courtyard typology table for sustainability

(Constitute by Author)

COURTYARD TYPOLOGY FOR SUSTAINABILITY									
SURROUNDED TYPE / LOCATION		C SURROUNDED BY SINGLE STOREY (1)		D SURROUNDED BY LOW STOREY (2 - 4)		E SURROUNDED BY HIGH STOREY (5 +)		F PERISTYLE	G HALF OPEN
		C1 NARROW	C2 WIDE	D1 NARROW	D2 WIDE	E1 NARROW	E2 WIDE		
A COURTYARD ON THE SIDE	A1 MAINLY NATURAL GROUND	Longmont United Hospital Elie Tahari Office A1C1	The Six Courtyard Houses A1C2	Kadir Has University Sisecam R&D Center A1D1	Topkapi Palace Istanbul Technical University (Taskisla) Istanbul Technical University (Gumussuyu) A1D2	Court Square Press A1E1	Istanbul University - Faculty of Science and Literature A1E2	Cuxa Cloister Boston Public Library A1F	RönesansBiz Mecidiyeköy Dogan Residence 38-30 Cheese Factory A1G
	A2 MAINLY FIRM GROUND	It's a Garden House A2C1	Ishak Pasha Palace A2C2	Ipekyol Textile Factory Alhambra Palace - Mexuar Courtyard A2D1	Baker's Boot Factory Istanbul Technical University (Macka) A2D2	Kronstad Psychiatric Hospital A2E1	Camden Courtyards A2E2	Alhambra Palace - Palaces of the Ambassadors Alhambra Palace - Palaces of the Lions Nuruosmaniye Mosque Valetta Palace A2F	St. Georg Austrian High School A2G
B COURTYARD ON THE BUILDING	B1 ONE SIDE OPEN	Courtyard House - Canada Courtyard House - Japan B1C1	Affiliated Bilingual Kindergarten - East China B1C2	Doğuş Maslak Tower B1D1	Tekfen Bomonti Houses B1D2	Yeditepe University Fine Arts Building B1E1	Union Of Turkish Public Notaries Central Building and the Cultural-Social Facility B1E2	B1F	A School in Cekmekoy, Istanbul B1G
	B2 ENCLOSED	Zorlu Center B2C1	Valenzá Healthcare Centre B2C2	Crystal Tower B2D1	Doğan Holding Head Office The EK3 Mall Central Municipal Library B2D2	"Avlu 138" Residence B2E1	Lapis Han B2E2	Alhambra Palace - Courtyard of the Palace of Charles V. Monasterio de Santo Domingo de Silos B2F	B2G

A1C1



Courtyard on the Side, Surrounded by Single Storey, Narrow Type in Mainly Natural Ground

LONGMONT UNITED HOSPITAL

Location: Colorado, United States of America

Year: 2008

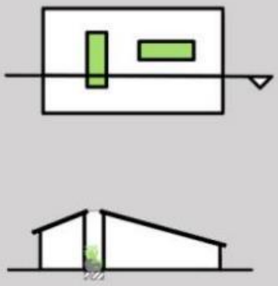
Building Type: Health

Prepared by the author

Figure C.1. Longmont United Hospital

A1C1

Courtyard on the Side, Surrounded by Single Storey, Narrow Type in Mainly Natural Ground



ELIE TAHARI DESIGN OFFICE

Location: United States of America

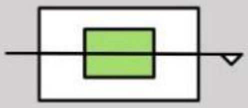
Year: 2003

Building Type: Commercial

Prepared by the author

Figure C.2. Elie Tahari Design Office

A1C2



Courtyard on the Side, Surrounded by Single Storey, Wide Type in Mainly Natural Ground

THE SIX COURTYARD HOUSES

Location: United States of America

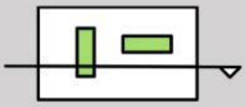
Year: 2009

Building Type: Residential

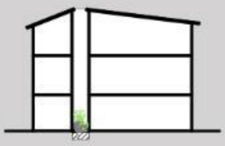
Prepared by the author

Figure C.3. The Six Courtyard Houses

A1D1



Courtyard on the Side, Surrounded by Low Storey, Narrow Type in Mainly Natural Ground

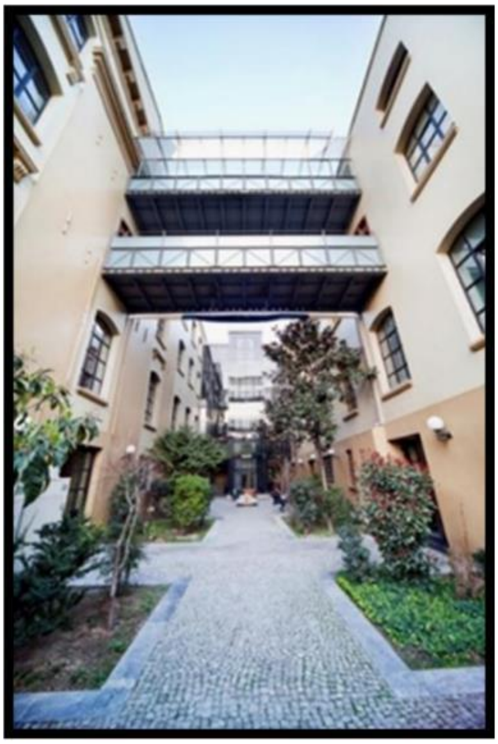


KADİR HAS UNIVERSITY

Location: İstanbul, Turkey

Year: 1923, 2008 (refunctioning)

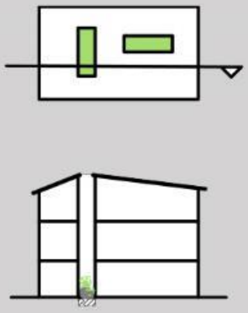
Building Type: Education



Prepared by the author

Figure C.4. Kadir Has University

A1D1



Courtyard on the Side, Surrounded by Low Storey, Narrow Type in Mainly Natural Ground

ŞİŞECAM R&D CENTER

Location: Kocaeli, Turkey

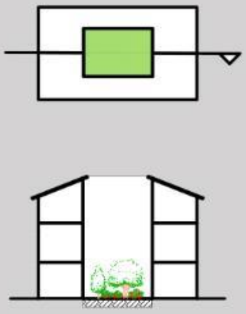
Year: 2014

Building Type: Commercial

Prepared by the author

Figure C.5. Şişemcam R&D Center

A1D2



Courtyard on the Side, Surrounded by Low Storey, Wide Type in Mainly Natural Ground

TOPKAPI PALACE

Location: İstanbul, Turkey

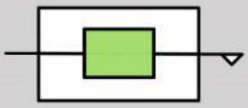
Year: 15th Century

Building Type: Culture

Prepared by the author

Figure C.6. Topkapı Palace

A1D2



Courtyard on the Side, Surrounded by Low Storey, Wide Type in Mainly Natural Ground

İSTANBUL TECHNICAL UNIVERSITY, TAŞKIŞLA CAMPUS

Location: İstanbul, Turkey

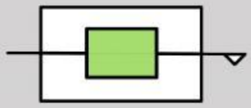
Year: 19th Century

Building Type: Education

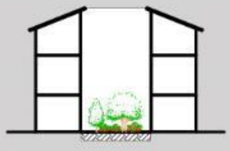
Prepared by the author

Figure C.7. İstanbul Technical University, Taşkışla Campus

A1D2



Courtyard on the Side, Surrounded by Low Storey, Wide Type in Mainly Natural Ground



İSTANBUL TECHNICAL UNIVERSITY, GÜMÜŞSUYU CAMPUS

Location: İstanbul, Turkey

Year: 19th Century

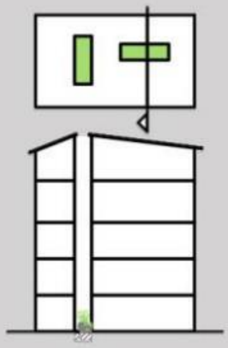
Building Type: Education

Prepared by the author

Figure C.8. İstanbul Technical University, Gümüşsuyu Campus

A1E1

Courtyard on the Side, Surrounded by High Storey, Narrow Type in Mainly Natural Ground

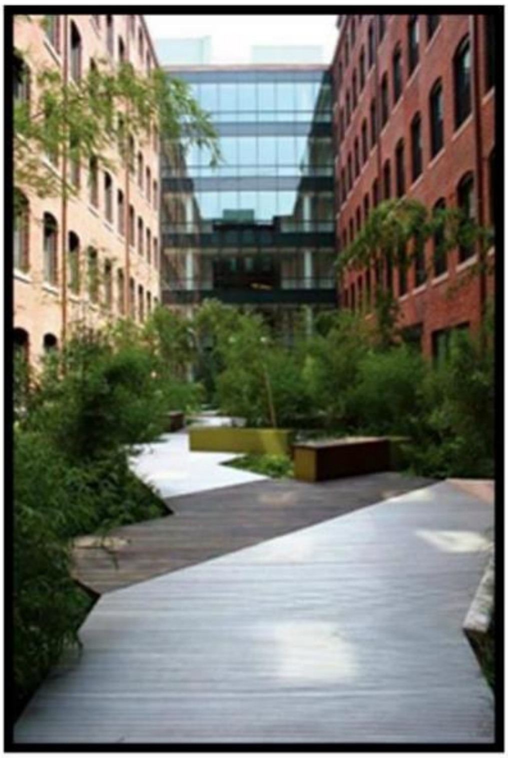


COURT SQUARE PRESS

Location: Boston, United States of America

Year: 19th Century, 2003 (refunctioning)

Building Type: Commercial

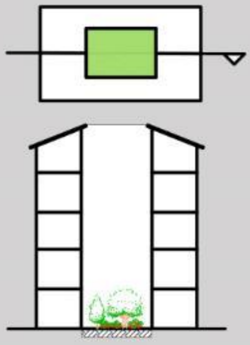


Prepared by the author

Figure C.9. Court Square Press

A1E2

Courtyard on the Side, Surrounded by High Storey, Wide Type in Mainly Natural Ground



İSTANBUL UNIVERSITY, FACULTY OF SCIENCE AND LITERATURE

Location: İstanbul, Turkey

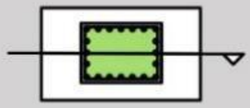
Year: 19th Century, 2003 (refunctioning)

Building Type: Commercial

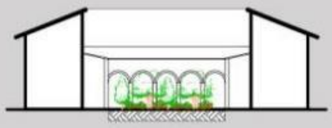
Prepared by the author

Figure C.10. İstanbul University, Faculty of Science and Literature

A1F



Courtyard on the Side, Surrounded by Peristyle in Mainly Natural Ground



CUXA CLOISTER

Location: France

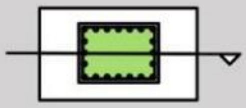
Year: 12th Century

Building Type: Religious

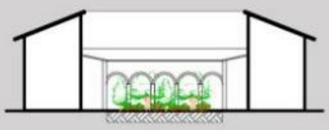
Prepared by the author

Figure C.11. Cuxa Cloister

A1F



Courtyard on the Side, Surrounded by Peristyle in Mainly Natural Ground



BOSTON PUBLIC LIBRARY

Location: United States of America

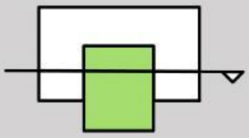
Year: 19th Century

Building Type: Education

Prepared by the author

Figure C.12. Boston Public Library

A1G



Courtyard on the Side, Half Open in Mainly Natural Ground

RÖNESANS BİZ MECİDİYEKÖY OFFICES

Location: İstanbul, Turkey

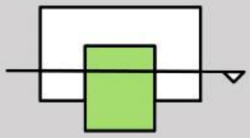
Year: 2013

Building Type: Commercial

Prepared by the author

Figure C.13. Rönesans Biz Mecidiyeköy Offices

A1G



Courtyard on the Side, Half Open
in Mainly Natural Ground

DOĞAN RESIDENCE

Location: İstanbul, Turkey

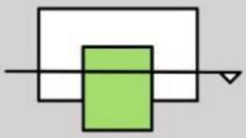
Year: 19th Century

Building Type: Residential

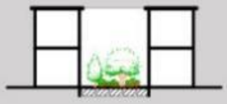
Prepared by the author

Figure C.14. Doğan Residence

A1G



Courtyard on the Side, Half Open in Mainly Natural Ground



38-30 CHEESE FACTORY

Location: Afyonkarahisar, Turkey

Year: 2016

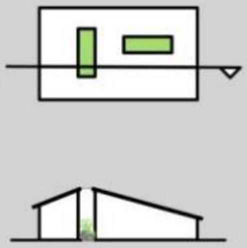
Building Type: Factory

Prepared by the author

Figure C.15. 38-30 Cheese Factory

A2C1

Courtyard on the Side, Surrounded by Single Storey, Narrow Type in Mainly Firm Ground



IT'S A GARDEN HOUSE

Location: Japan

Year: 2016

Building Type: Residential

Prepared by the author

Figure C.16. It's a Garden House

A2C2

Courtyard on the Side, Surrounded by Single Storey, Wide Type in Mainly Firm Ground

İSHAK PASHA PALACE

Location: Ağrı, Turkey

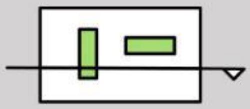
Year: 17th Century

Building Type: Culture

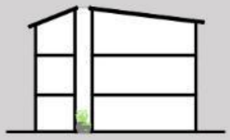
Prepared by the author

Figure C.17. Ishak Pasha Palace

A2D1



Courtyard on the Side, Surrounded by Low Storey, Narrow Type in Mainly Firm Ground



İPEKYOL TEXTILE FACTORY

Location: Edirne, Turkey

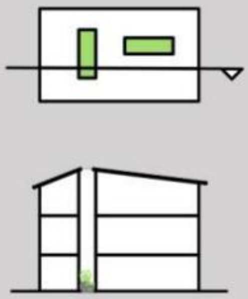
Year: 2010

Building Type: Factory

Prepared by the author

Figure C.18. İpekyol Textile Factory

A2D1



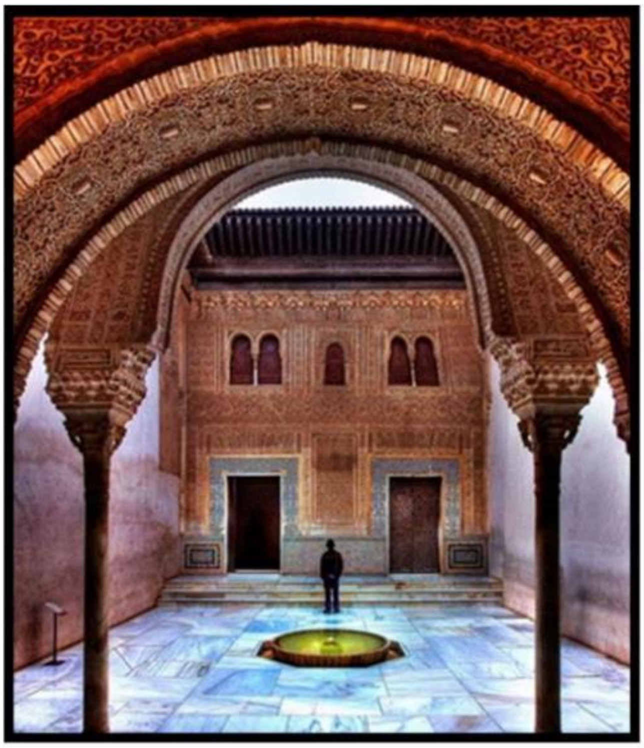
Courtyard on the Side, Surrounded by Low Storey, Narrow Type in Mainly Firm Ground

ALHAMBRA PALACE - MEXUAR COURTYARD

Location: Granada, Spain

Year: 16th Century

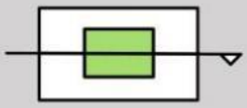
Building Type: Culture



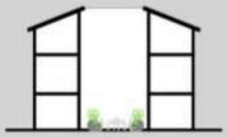
Prepared by the author

Figure C.19. Alhambra Palace - Mexuar Courtyard

A2D2



Courtyard on the Side, Surrounded by Low Storey, Wide Type in Mainly Firm Ground



BAKER'S BOOT FACTORY

Location: England, United Kingdom

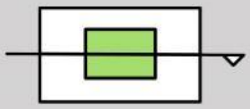
Year: 19th Century

Building Type: Factory

Prepared by the author

Figure C.20. Baker’s Boot Factory

A2D2



Courtyard on the Side, Surrounded by Low Storey, Wide Type in Mainly Firm Ground

İSTANBUL TECHNICAL UNIVERSITY – MAÇKA CAMPUS

Location: İstanbul, Turkey

Year: 19th Century

Building Type: Education

Prepared by the author

Figure C.21. İstanbul Technical University – Maçka Campus

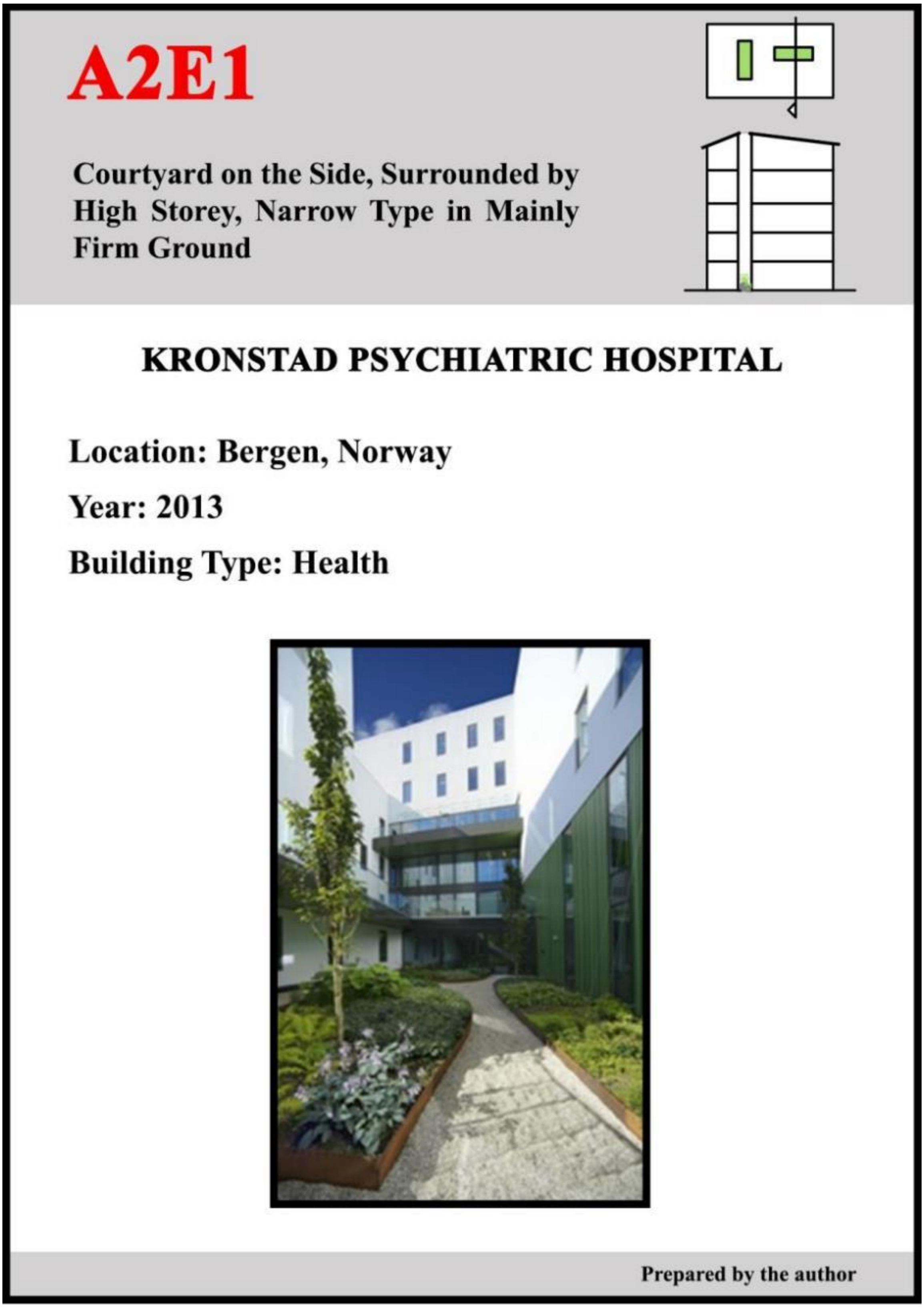
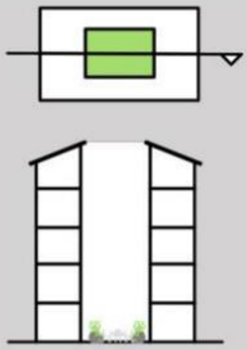


Figure C.22. Kronstad Psychiatric Hospital

A2E2

Courtyard on the Side, Surrounded by High Storey, Wide Type in Mainly Firm Ground



CAMDEN COURTYARDS

Location: London, United Kingdom

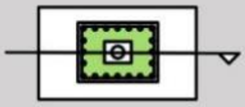
Year: 2017

Building Type: Residential, Commercial

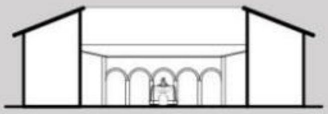
Prepared by the author

Figure C.23. Camden Courtyards

A2F



Courtyard on the Side, Surrounded by Peristyle in Mainly Firm Ground



ALHAMBRA, PALACES OF THE AMBASSADORS

Location: Granada, Spain

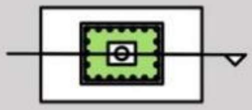
Year: 16th Century

Building Type: Culture

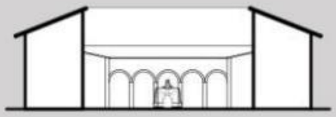
Prepared by the author

Figure C.24. Alhambra, Palaces of the Ambassadors

A2F



Courtyard on the Side, Surrounded by Peristyle in Mainly Firm Ground



ALHAMBRA, PALACES OF THE LIONS

Location: Granada, Spain

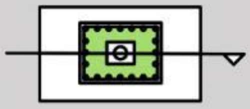
Year: 16th Century

Building Type: Culture

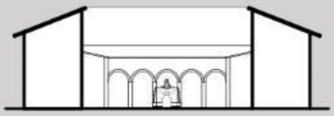
Prepared by the author

Figure C.25. Alhambra, Palace of the Lions

A2F



Courtyard on the Side, Surrounded by Peristyle in Mainly Firm Ground



NURUOSMANİYE MOSQUE

Location: İstanbul, Turkey

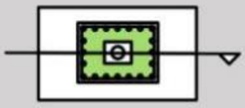
Year: 18th Century

Building Type: Religious

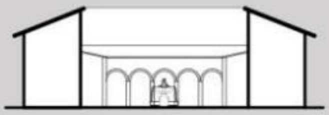
Prepared by the author

Figure C.26. Nuruosmaniye Mosque

A2F



Courtyard on the Side, Surrounded by Peristyle in Mainly Firm Ground



VALETTA PALACE

Location: Malta

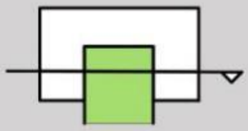
Year: 16th Century

Building Type: Culture

Prepared by the author

Figure C.27. Valetta Palace

A2G



Courtyard on the Side, Half Open in Mainly Natural Ground

ST. GEORGE'S AUSTRIAN HIGH SCHOOL

Location: İstanbul, Turkey

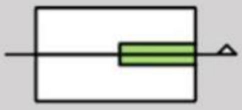
Year: 19th Century

Building Type: Education

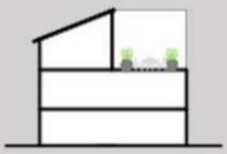
Prepared by the author

Figure C.28. St. George's Austrian High School

B1C1



Courtyard on the Building, Surrounded by Single Storey, Narrow Type in One Side Open



THE COURTYARD HOUSE, CANADA

Location: Toronto, Canada

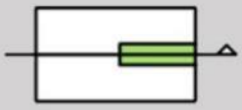
Year: 2013

Building Type: Residential

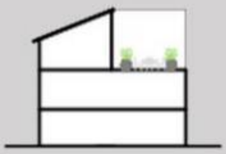
Prepared by the author

Figure C.29. The Courtyard House, Canada

B1C1



Courtyard on the Building, Surrounded by Single Storey, Narrow Type in One Side Open



THE COURTYARD HOUSE, JAPAN

Location: Shiga, Japan

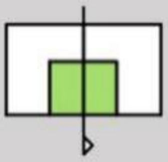
Year: 2015

Building Type: Residential

Prepared by the author

Figure C.30. The Courtyard House, Japan

B1C2



Courtyard on the Building, Surrounded by Single Storey, Wide Type in One Side Open

EAST CHINA NORMAL UNIVERSITY AFFILIATED BILINGUAL KINDERGARTEN

Location: Shangai, China

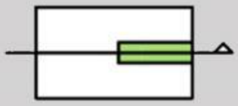
Year: 1951

Building Type: Education

Prepared by the author

Figure C.31. East China Normal University Affiliated Bilingual Kindergarten

B1D1



Courtyard on the Building, Surrounded by Low Storey, Narrow Type in One Side Open

DOĞUS MASLAK TOWER

Location: İstanbul, Turkey

Year: 2016

Building Type: Commercial

Prepared by the author

Figure C.32. Doğus Maslak Tower

B1D2

Courtyard on the Building, Surrounded by Low Storey, Wide Type in One Side Open

TEKFEN BOMONTİ RESIDENCE

Location: İstanbul, Turkey

Year: 2012

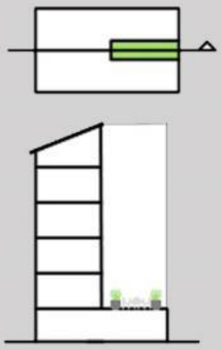
Building Type: Residential, Commercial

Prepared by the author

Figure C.33. Tekfen Bomonti Residence

B1E1

Courtyard on the Building, Surrounded by High Storey, Narrow Type in One Side Open



YEDİTEPE UNIVERSITY FINE ARTS BUILDING

Location: İstanbul, Turkey

Year: 1994

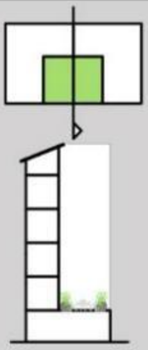
Building Type: Education

Prepared by the author

Figure C.34. Yeditepe University Fine Arts Building

B1E2

Courtyard on the Building, Surrounded by High Storey, Wide Type in One Side Open

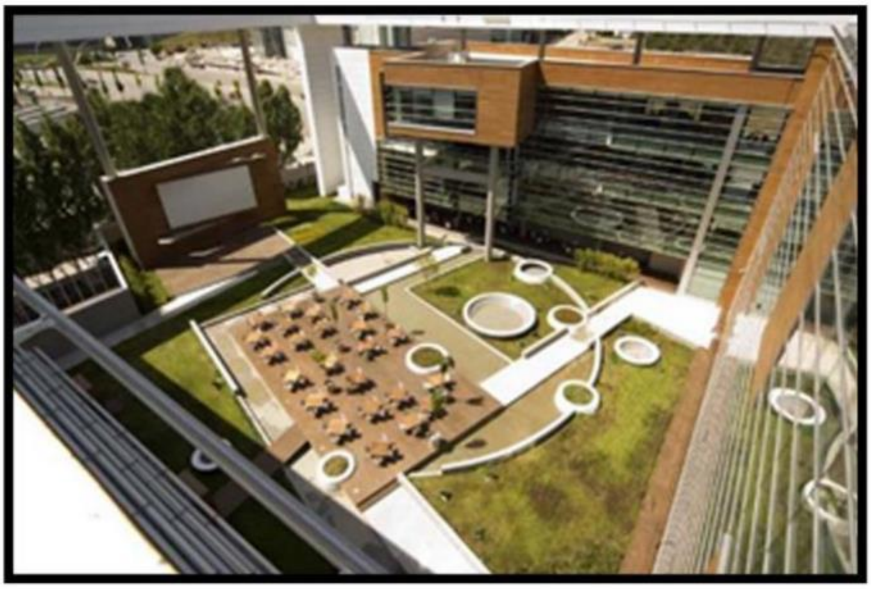


UNION OF TURKISH PUBLIC NOTARIES CENTRAL BUILDING AND THE CULTURAL-SOCIAL FACILITY

Location: Ankara, Turkey

Year: 2007

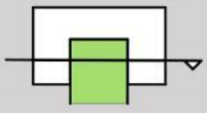
Building Type: Public



Prepared by the author

Figure C.35. Union of Turkish Public Notaries Central Building and the Cultural-Social Facility

B1G



Courtyard on the Building, Half Open in One Side Open

A SCHOOL IN ÇEKMEKÖY

Location: İstanbul, Turkey

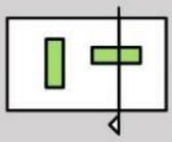
Year: 2016

Building Type: Education

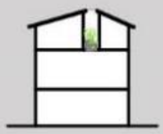
Prepared by the author

Figure C.36. A School in Çekmeköy

B2C1



Courtyard on the Building, Surrounded by Single Storey, Narrow Type in Enclosed



ZORLU CENTER SHOPPING MALL

Location: İstanbul, Turkey

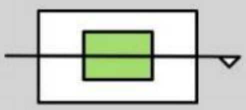
Year: 2013

Building Type: Commercial

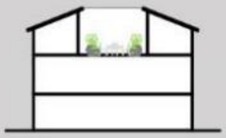
Prepared by the author

Figure C.37. Zorlu Center Shopping Mall

B2C2



Courtyard on the Building, Surrounded by Single Storey, Wide Type in Enclosed



VALENZÁ HEALTHCARE CENTRE

Location: Spain

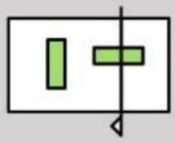
Year: 2017

Building Type: Health

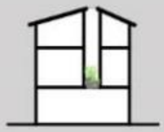
Prepared by the author

Figure C.38. Valenzá Healthcare Centre

B2D1



Courtyard on the Building, Surrounded by Low Storey, Narrow Type in Enclosed



CRYSTAL TOWER

Location: İstanbul, Turkey

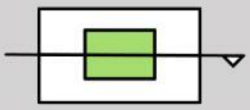
Year: 2013

Building Type: Commercial

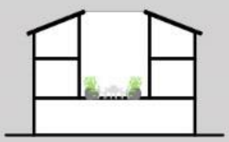
Prepared by the author

Figure C.39. Crystal Tower

B2D2



Courtyard on the Building, Surrounded by Low Storey, Wide Type in Enclosed



DOĞAN HOLDİNG MANAGEMENT BUILDING

Location: İstanbul, Turkey

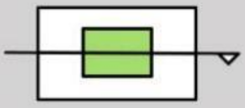
Year: 2011

Building Type: Commercial

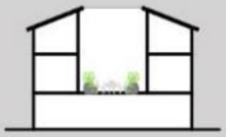
Prepared by the author

Figure C.40. Doğan Holding Management Building

B2D2



Courtyard on the Building, Surrounded by Low Storey, Wide Type in Enclosed



THE EK3 MALL

Location: Germany

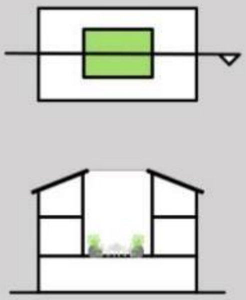
Year: 2012

Building Type: Commercial

Prepared by the author

Figure C.41. The EK3 Mall

B2D2



Courtyard on the Building, Surrounded by Low Storey, Wide Type in Enclosed

CENTRAL MUNICIPAL LIBRARY

Location: Germany

Year: 1956

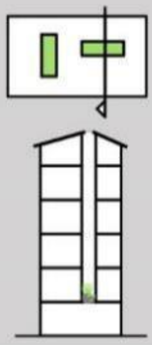
Building Type: Education

Prepared by the author

Figure C.42. Central Municipal Library

B2E1

Courtyard on the Building, Surrounded by High Storey, Narrow Type in Enclosed

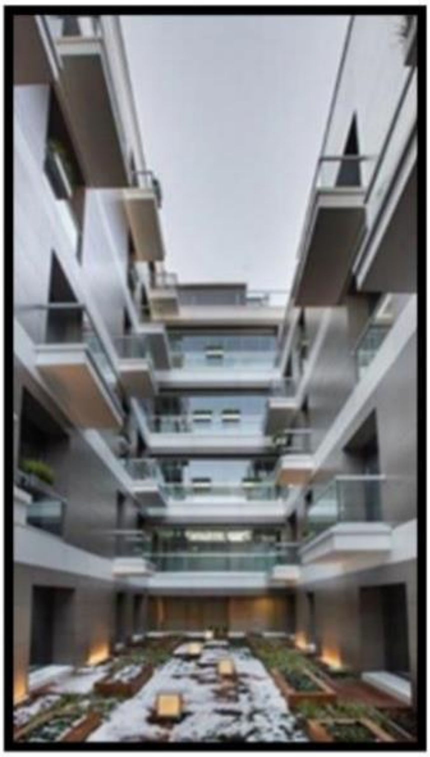


AVLU 138 RESIDENCE

Location: İstanbul, Turkey

Year: 2010

Building Type: Residential, Commercial

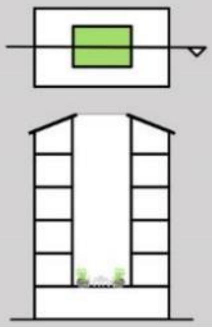


Prepared by the author

Figure C.43. Avlu 138 Residence

B2E2

Courtyard on the Building, Surrounded by High Storey, Narrow Type in Enclosed



LAPİS HAN

Location: İstanbul, Turkey

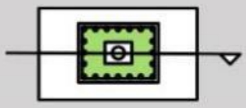
Year: 2014

Building Type: Commercial

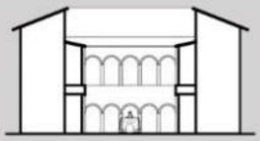
Prepared by the author

Figure C.44. Lapis Han

B2F



Courtyard on the Building, Surrounded by Peristyle in Enclosed



ALHAMBRA PALACE - COURTYARD OF THE PALACE OF CHARLES V

Location: Granada, Spain

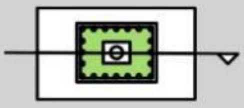
Year: 16th Century

Building Type: Culture

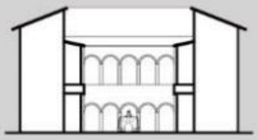
Prepared by the author

Figure C.45. Alhambra, Courtyard of the Palace of Charles V

B2F



Courtyard on the Building, Surrounded by Peristyle in Enclosed



MONASTERIO DE SANTO DOMINGO DE SILOS

Location: Spain

Year: 12th Century

Building Type: Religious

Prepared by the author

Figure C.46. Monasterio de Santo Domingo de Silos

APPENDIX D: RANKING OF THE COURTYARD EXAMPLES CONTRIBUTION ON SUSTAINABILITY

Table D.1. Ranking of the Courtyard Examples Contribution of the Sustainability

(Constitute by Author)

CONTROL VARIABLES / EXAMPLES		MAX. UTILIZATION IN PASSIVE SOLAR ENERGY		MAX. UTILIZATION IN WIND ENERGY		COMPLIANCE WITH NATURE		IMPROVED OUTDOOR COMFORT		TOTAL RESULTS
		RESULT	EXPLANATION	RESULT	EXPLANATION	RESULT	EXPLANATION	RESULT	EXPLANATION	
		The Perpendicular Depth of the Courtyard to the South (d) / The Height of the North Wall of the Courtyard (h) (d / h ≥ 2)		Ratio (R) = The Height of the Wall (h) / The Courtyard Short Edge Depth (d) (R= h / d) (0.3 < R < 1)		Total Planted Area on Building (TPAB) is depend on the size of green area on the buildings connected to the "Coefficient of Green Usage in Buildings (CGUB)" (TPAB ≥ CGUB x TFA)		The Long Edge of the Courtyard / The Short Edge of the Courtyard = Form (F) (R = 1:1< F < 2:1)		
1	Avlu 138 Residence	~ 0,27	(-)	~ 3.6	(-)	CGUB: 2100 m2 TPAB: ~ 50 m2	(-)	~ 3:1	(-)	0
2	Tekfen Bomonti Residence	~ 3,6	(+)	~ 0.3	(+)	CGUB: 5265 m2 TPAB: ~ 80 m2	(-)	~ 3,23:1	(-)	2 (+) 2 (-)
3	Doğan Holding Management Building	~ 2	(+)	~ 0.52	(+)	CGUB: 3660 m2 TPAB: ~ 2500 m2	(-)	~ 1,41:1	(+)	3 (+) 1 (-)
		~ 2	(+)	~ 0.52	(+)			~ 1,41:1	(+)	3 (+) 1 (-)
4	Rönesans Biz Mecidiyeköy Offices	~ 0,31	(-)	~ 3.2	(-)	CGUB: 4987 m2 TPAB: ~ 850 m2	(-)	~ 4:1	(-)	0
5	Lapis Han	~ 2	(+)	~ 0.56	(+)	CGUB: 9480 m2 TPAB: ~ 1290 m2	(-)	~ 1,61:1	(+)	3 (+) 1 (-)
6	İstanbul Technical University, Taşkışla Campus	~ 3,5	(+)	~ 0.47	(+)	CGUB: 15600 m2 TPAB: ~ 35000 m2	(+)	~ 1,75:1	(+)	4 (+)
7	İstanbul Technical University – Maçka Campus	~ 2,3	(+)	~ 0.42	(+)	CGUB: 18900 m2 TPAB: ~ 100 m2	(-)	~ 1,75:1	(+)	3 (+) 1 (-)
		~ 2,3	(+)	~ 0.42	(+)		(-)	~ 1,75:1	(+)	3 (+) 1 (-)
8	Crystal Tower	~ 5,6	(+)	~ 0.17	(-)	CGUB: 28986 m2 TPAB: ~ 500 m2	(-)	~ 1,8:1	(+)	2 (+) 2 (-)
		~ 5,6	(+)	~ 0.17	(-)		(-)	~ 1,8:1	(+)	2 (+) 2 (-)
		~ 5,6	(+)	~ 0.17	(-)		(-)	~ 1,8:1	(+)	2 (+) 2 (-)
		~ 6,2	(+)	~ 0.16	(-)		(-)	~ 1:1	(+)	2 (+) 2 (-)
9	İpekyol Textile Factory	~ 0,6	(-)	~ 1.6	(-)	CGUB: 6000 m2 TPAB: ~ 1500 m2	(-)	~ 5,6:1	(-)	0
		~ 5,6	(+)	~ 0.17	(-)		(-)	~ 9:1	(-)	1 (+) 3 (-)
		~ 0,6	(-)	~ 1.6	(-)		(-)	~ 3:1	(-)	0
		~ 2	(+)	~ 0.53	(+)		(-)	~ 9:1	(-)	2 (+) 2 (-)
		~ 5,6	(+)	~ 0.17	(-)		(-)	~ 1,5:1	(+)	2 (+) 2 (-)
10	A School in Çekmeköy	~ 1,43	(-)	~ 0.69	(+)	CGUB: 4500 m2 TPAB: ~ 1500 m2	(-)	~ 1,5:1	(+)	2 (+) 2 (-)
		~ 1,43	(-)	~ 0.69	(+)		(-)	~ 1,5:1	(+)	2 (+) 2 (-)
11	Şişecam R&D Center	~ 2,91	(+)	~ 0.34	(+)	CGUB: 2400 m2 TPAB: ~ 5500 m2	(+)	~ 3,2:1	(-)	3 (+) 1 (-)
12	İstanbul University, Faculty of Science and Literature	~ 1,55	(-)	~ 0.64	(+)	CGUB: 25000 m2 TPAB: ~ 4000 m2	(-)	~ 1,1:1	(+)	2 (+) 2 (-)
		~ 1,37	(-)	~ 0.72	(+)			~ 1,6:1	(+)	2 (+) 2 (-)
		~ 0,86	(-)	~ 1.16	(-)			~ 1,1:1	(+)	1 (+) 3 (-)
13	St. Georg Austrian High School	~ 1,08	(-)	~ 0.92	(+)	CGUB: 1650 m2 TPAB: ~ 2000 m2	(+)	~ 1,9:1	(+)	3 (+) 1 (-)

SUITABLE : (+) UNSUITABLE: (-)