BIDGE Publications

Architectural Sciences and Applications-I

Editor: Doç. Dr. Murat Dal

ISBN: 978-625-6707-71-9

Page Layout: Gözde YÜCEL

1st Edition:

Publication Date: 25.12.2023

BIDGE Publications,

Certificate No: 71374

www.bidgeyayinlari.com.tr - bidgeyayinlari@gmail.com

Krc Bilişim Ticaret ve Organizasyon Ltd. Şti.
Güzeltepe Mahallesi Abidin Daver Sokak Sefer Apartmanı No: 7/9 Çankaya / Ankara

PREFACE

In our age, all the developments in the process of architectural applications have been examined on many different topics through architectural structures. The use of information technologies in architecture, modeling and practical applications have been specifically emphasized. The issue of managing the building construction process in the most effective way has gained much more importance after the earthquakes. In this study; urban design, fire-resistant architectural designs, landscape design and virtual landscape applications have been examined in full detail.

This book named "**ARCHITECTURAL SCIENCES and APPLICATIONS-I**" consists of five chapters. In the book, the topics "Virtual Landscaping: Interacting with Nature in the Digital World", "Compilation of Architecture Design Guidelines for Residental Buildings in Wildfire Zones", "An Ideal Form for Developing Landscape Understanding in Interiors: Patio (Pasyo)", "Architectural Value Analysis for Boutique Hotels", "Urban Agriculture and Sustainable Cities" are discussed in detail. We would like to thank the authors, the referees of the chapters, BIDGE Publishing House and all those who contributed to the completion of the book.

The book "**ARCHITECTURAL SCIENCES and APPLICATIONS-I**" will be useful to readers.

30.12.2023

Assoc. Prof. Dr. Murat DAL

Munzur University, Faculty of Fine Arts, Design and Architecture, Department of Architecture, muratdal1122@gmail.com

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CHAPTER I

Virtual Landscaping: Interacting With Nature In The Digital World

Elif AKPINAR KÜLEKÇİ[1]
Feran AŞUR[2]

Introductıon

With the rapid advancement of technology, people's relationship with nature is also changing. Today, the emergence of the concept of virtual landscape and the interaction with nature in the digital world is being redefined. Prensky (2007) defines the generation that grew up using computer technologies and smart devices as digital natives. Prensky stated that the brain and perception structure of this generation fundamentally changes the

[1] Doç. Dr. Elif AKPINAR KÜLEKÇİ, Atatürk University, Faculty of Architecture and Design, Department of Landscape Architecture
[2] Doç. Dr. Feran AŞUR, Van Yüzüncü Yıl University, Faculty of Architecture and Design, Department of Landscape Architecture

learning processes of individuals. At the same time, he emphasised that digital natives prefer visualised information instead of written information, and are prone to learning by making connections between information networks and being rewarded. He argues that the structure of the current education system, which is based on text-oriented knowledge, static and passive for the student, cannot meet the needs of this generation and needs to adapt to change. He also states that computer games and digital game technologies should play an active role in this change.

Despite the general perception that the act of playing computer games is only a harmful and time-wasting pastime, current scientific research reveals the benefits of using these games for purposes other than entertainment (Sansur, 2023). At this point, experimental studies in the field of neuroscience come to the fore. These studies have shown that computer games do not have a negative effect on eye health, on the contrary, they have positive effects on vision and depth perception. It has also been found that the three-dimensional intellectual and visual memory of individuals who play computer games is more developed than those who do not play computer games. In this context, it is stated that the motivational and instructive benefits of computer games have led to the concept of serious games (Green & Bavelier, 2007).

Serious games, as emphasised by Prensky, refers to the use of computer games not only for entertainment purposes but also for useful purposes. In this context, according to Lange (2001), the first examples of serious games were developed for the purpose of gaining knowledge and skills related to military training in a virtual environment. For example, the computer game called American Army was used in the training of recruits and provided solutions to the problems encountered in basic training.

Finally, according to the definition of Harvard University, the city is considered as a design environment and the discipline of landscape architecture is a field that covers the built and natural environment using social, ecological and environmental resources.

In this context, landscape architecture education aims to provide students with skills in various subjects such as field engineering, irrigation, lighting, levelling, drainage, vegetative materials as well as design (Açıkçay, 2015). It is emphasised that the motivational and educational potentials that computer games can provide can contribute positively to the specialisation processes of landscape architecture students in theoretical and applied subjects. Therefore, the evaluation of computer games in terms of landscape architecture pedagogy is an important issue.

Three-dimensional virtual environment software are applications that are based on a server-client model and contain three-dimensional graphical interfaces that allow the participation and interaction of a large number of users (Lange, 2001). By connecting to the internet or local network through client software installed on their computers or mobile devices, users can navigate in three-dimensional virtual environments through their virtual characters called avatars, communicate with other users in written, audio and visual form, create new objects, shape the topography and interact with the virtual environment (Portman et al., 2015).

The first three-dimensional virtual environment software was developed to enable information based on text and static two-dimensional visuals to move around the virtual environment in a spatial order and to communicate between users sharing the same environment. Activeworlds software was introduced in 1995 as one of the pioneers of three-dimensional virtual environment servers (Spicer and Apuzzo, 2003). This software aimed to provide users with an experience beyond web page navigation, such as the functions of buttons within the web page, solid objects created in the virtual environment, and visual dashboards assigned to surfaces. Over the last 20 years, three-dimensional virtual environment software has made significant progress in improving the quality of visual representation, providing compatibility with operating systems, and enriching audio-visual communication tools (Laurel, et al., 1995).

Virtual landscape and virtual reality is a concept that refers to natural environments created in the digital world. This concept includes virtual landscapes realised through visual, auditory and even tactile experiences designed with computer graphics, virtual reality, augmented reality and other digital technologies (Kühne and Jenal, 2020). Virtual landscapes are created to provide the user with a similar experience in the context of the real world. With this study, it is tried to reveal the interaction of these concepts emerging in the changing and transforming digital world with nature in a scientific framework. In this context, this research was conducted to investigate what a virtual landscape is, how its types emerged and how people interact with nature in the digital world.

1.MATERYAL VE YÖNTEM

This study analyses the interaction of virtual landscape with nature in the digital world in terms of landscape architecture profession discipline. Written information obtained as a result of domestic and foreign sources, articles, theses, literature and internet searches related to the subject constitute the basic data of the study. This research deals with the importance of virtual landscape in the age of technology in a conceptual framework and analyses its effects on today. In the study, in addition to virtual landscape, the concepts of virtual reality, hereness, social hereness are explained in the basic framework. In addition, the usage areas of virtual reality and virtual landscape, analogue and digital visualisation techniques, the effects of virtual landscape on environmental awareness are discussed.

For this purpose, the definition of virtual landscape from a scientific perspective, the potential effects of this technology on interaction with nature and its social importance are emphasised in the research. In addition, how the use of virtual landscape affects individuals' perception of nature, how it shapes environmental awareness and how it can contribute to future nature conservation efforts has been tried to be revealed in a scientific framework.

2.FINDINGS

In this section, the concept of virtual landscape will be discussed in detail under different headings.

2.1.Importance of Virtual Landscape

The concept of virtual landscape has emerged with the development of computer graphics and virtual reality technologies. People have turned to this field with the desire to explore (Figure 1) and experience realistic landscapes created by computers. Virtual landscapes are used for both entertainment and therapeutic purposes (Fontaine, 2020).

Figure 1. *An example of a virtual landscape created with 3d design (Url-1, 2023).*

Virtual landscapes have many advantages. People can overcome time and space constraints while exploring nature in the digital world. They can also develop environmental awareness by experiencing different ecosystems through virtual landscapes (Holland et al., 2020). This is an important opportunity especially for those who have lost their connection with nature in busy city life.

Although virtual landscapes offer a number of advantages, this technology also has some challenges. It cannot replace the real experience of nature and cannot fully provide the elements needed

for physical activity and healthy living. Furthermore, its excessive use can risk detachment from the real world and virtual reality addiction (Güzel, 2015).

It is possible to speculate on the future trends of virtual landscapes. With the advancement of technology, more realistic and interactive virtual landscape experiences are expected. In addition, virtual landscape applications focusing on nature conservation and sustainability issues are likely to increase (Güzel, 2015; Örnek, 2016).

Virtual landscapes play an important role in the interaction of modern society with nature and the sustainability of this interaction. People tend to move away from nature due to increasing urbanisation and technological developments. In this context, virtual landscapes can offer users the opportunity to explore and experience nature, strengthen their ties with nature and increase environmental awareness. Virtual landscapes are nature-like landscapes created in digital environments. Created through virtual reality, augmented reality and other digital technologies, these landscapes offer people the opportunity to experience real nature. This provides an important alternative for people who have no or limited opportunity to interact with physical nature.

Virtual landscape is a term that refers to natural environments created in the digital world (Kühne and Jenal, 2020). This concept includes virtual landscapes realised through visual, auditory and even tactile experiences designed with computer graphics, virtual reality, augmented reality and other digital technologies. Virtual landscapes are created to provide the user with a similar experience in a real-world context.

2.2.Virtual Reality (VR)

Virtual reality is the combination of reality and imagination with fictions created using technology. Virtual learning environments are platforms designed to enrich students' learning experiences with the inclusion of developing technology in

educational environments. Virtual learning environments also change and develop with technology. Finally, it is seen that virtual reality technologies are ready to be included in educational environments and have high potential in terms of educational gains.

Virtual reality technology is a tool where individuals can interact directly with computers to solve much more complex problems, and the most important feature of virtual reality is that it imitates real environments. Developers are now able to create astonishingly realistic worlds filled with artificial intelligences that behave in believable ways. Although the term virtual reality has historically been used to cover expressions such as virtual environment, three-dimensional simulation, computer and console games, visualisation, digital prototype, today it is used for systems in which virtual environments that can be interacted with in a virtual sphere that provides 360-degree vision through headsets can be experienced (Akman, 2019).

Three-dimensional virtual learning environments offer a real-life simulation environment and provide students with the opportunity to interact with the virtual environment and other students, thereby increasing the sense of presence (Kayabaşı, 2002).

The term sense of presence refers to the sense of presence that users perceive in their environment. An academic study conducted by Witmer and Singer (1998) revealed that there is a positive and stable relationship between the level of sense of presence and learning and study performance. In experimental studies, it was found that participants exhibited higher performance and achievement at higher levels of presentness. With the development of digital technologies, the term telepresence describes the presence of individuals in audio-visual virtual environments offered by platforms such as television and computers (Lombart, 2007). These concepts are important for individuals to experience and interact with the sense of presence in virtual environments with the development of digital technologies.

Virtual reality defines an experience in which users interact in a simulated environment created with the help of computer technology (Bayraktar & Kaleli, 2007). These environments, which include visual and auditory elements, provide the user with a sense of presence like in the real world. VR is often applied in many fields such as learning, entertainment, medicine and industrial training.

Presence, refers to the user's feeling of being in a virtual environment. As the user interacts with this environment through VR or other interactive technologies, the experience of presence is enhanced (Orland et al., 2001). This concept is an important element that makes the user feel as if they are in the virtual world and makes interactive experiences richer and more effective.

Tele-presence, is a concept that emerged with the developing digital technologies. It refers to the state of being in visual and auditory virtual environments offered by platforms such as television and computer. Tele-presence allows users to feel present in a place where they are physically far away (Steidle et al., 2023). This concept plays an important role in areas such as distance communication, virtual meetings and distance education.

The relationships between the concepts of virtual reality, presence and telepresence show how technology can be integrated to increase user presence and interaction. These concepts can be directed to many application areas, such as providing more effective learning experiences in education, simulation in medicine, and enhanced interactivity in distance communication.

Social presence is the degree to which people are perceived as real people in online communication environments (Seferoğlu et al., 2011; Gunawardena, 1995), the degree to which individuals show themselves in the environment (Garrison, 1997), the degree to which an individual is perceived as a real person (Gunawardena & Zittle (1997), the feeling of being in a social environment with other

people. It is the ability of learners to reflect themselves as real individuals in social and emotional terms (Garrison et al., 2000), It is the degree of awareness between individuals interacting in online environments. It is the degree of feeling other participants in an interaction environment (Leh, 2001), It is the emotion that individuals feel while participating in the communication process. It is the degree of feeling, perception and reaction to the computer-based communication network towards other individuals in an online environment. It is the student's perception of being part of an online course (Picciano, 2002). As can be seen from these definitions, all researchers working on social presence have defined this concept with slight differences (Figure 2). Naturally, this makes it difficult for researchers and practitioners to make definitive judgements about the nature of social presence.

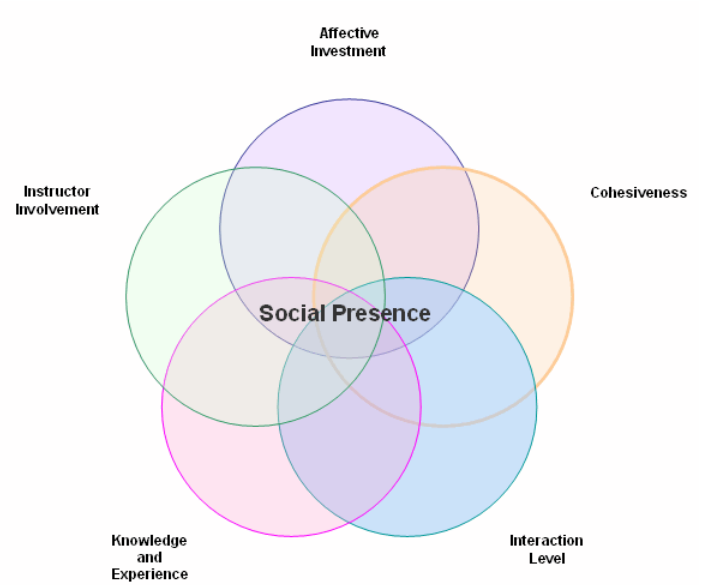

Figure 2. *Model of social embeddedness (Url-2, 2023).*

The perception of social presence has a complex structure. In the first emergence of the concept, the effect of a communication tool on how individuals experience the communication activity was

tried to be explained. Over time, research on social embeddedness and online communication tools has shown that individual perceptions of social embeddedness and the adaptation efforts that people experience in communication processes are more important than the communication tool itself (Lowenthal, 2009). Later research has provided clues that learners' perceptions of social embeddedness are related to their degree of satisfaction with a course they take, the instructor of the course, and sometimes with what they have learnt.

2.3.Augmented Reality (AR)

Augmented reality is a type of technology that combines the real world with computer-generated virtual information. This technology allows the user to experience the real world in a richer and more interactive way (Huang et al., 2018).

Augmented reality involves the addition of computer-generated graphics, audio, video and other sensory inputs through a device that displays the real world. Its basic principles include the integration of real-world and virtual content, user interaction, and live image processing. There are various devices for augmented reality applications. These include mobile devices such as smartphones, tablet computers, glasses and headsets. Specialised AR devices often include features such as sensors, cameras and eye-tracking technologies to provide a more interactive experience for the user (Billinghurst, 2002).

There are various software and development tools for developing augmented reality applications. Game engines such as Unity and Unreal Engine are frequently used platforms for AR applications. AR applications generally use software-based solutions that include features such as object recognition, localisation and motion detection. Augmented reality is used in many industries. For example, there are many applications such as providing interactive experiences to students in education, surgical planning and simulation in the field of medicine, and improving design processes in engineering. The use of augmented reality is also increasing in

sectors such as sales and marketing, military training, tourism and retail. For augmented reality technology to gain wider acceptance, challenges such as energy efficiency, lighter and more portable devices, more accurate positioning and greater naturalness in interacting with content need to be overcome. In the future, augmented reality is expected to be used in more personal and business applications, more sophisticated imaging technologies and more data integration (Yuen et al., 2011).

Augmented Reality (AR) technology has the potential to integrate virtual landscapes with the real world and this can offer creative and immersive experiences in a variety of application areas. Here are some important issues about the virtual landscape relationship in augmented reality (Seferoğlu et al., 2011; Yuen et al., 2011; Billinghurst, 2002; Farshid et al., 2018);

- *Enhancing the Natural Environment:* AR provides an interface that displays real-world physical environments. This allows users to see natural environments and enrich these environments with virtual objects. For example, while walking in a park, users can interact with virtual flowers, animals or virtual artworks.
- *Entertainment and Art*: In the world of arts and entertainment, AR offers the possibility to integrate artworks or digital art installations into real-world spaces. In museums or outdoor events, it is possible to create interactive art experiences with virtual landscapes.
- *Education and Tourism:* In education, on excursions to historical sites or natural beauties, AR gives users the opportunity to virtually show historical events or important information. In touristic areas, guides can offer a rich experience to tourists by virtually describing historical events or architectural artefacts.
- *Architecture and Urban Planning:* In the fields of urban planning and architecture, AR can be used to show in

advance what buildings and other infrastructure might look like using virtual landscapes. This allows urban planners and clients to evaluate architectural designs in real time.

- *Aerospace Research:* In the aerospace industries, it is possible to create virtual landscapes for space research or flight simulations using AR. This can be used in the training of astronauts or to improve the flight skills of pilots.
- *Social Interaction and Games*: AR can enable users to interact with each other through virtual landscapes. Multiplayer AR games or virtual interactive experiences allow users to come together and interact together in the real world.

The role of virtual landscapes in augmented reality has the potential to offer creative experiences in many different application areas by making users' environments richer and more interactive.

2.4.Usage Areas of Virtual Reality and Virtual Landscape

The concept of virtual landscape has emerged with the development of computer technology and advances in the field of virtual reality. Initially, the term virtual landscape was used for applications in computer-aided design and visualisation (Portman et al., 2015).

As people started to use computer-based tools to design, visualise and analyse projects in various sectors, landscape architects and designers also adopted these technologies. Computer-aided design (CAD) and three-dimensional modelling software have made landscape design processes more efficient and enabled the creation of various landscape scenarios in the virtual world.

Virtual reality (VR) is an advanced human-computer interface that simulates a realistic environment (Zheng et al., 1998). The development of virtual reality (VR) technology has allowed users to experience computerised virtual landscapes in a more interactive way. VR glasses and other haptic (sensory feedback)

technologies have enabled users to perceive and interact with virtual landscapes in a more realistic way.

Especially in fields such as architecture, urban planning, landscape architecture and environmental design, the use of virtual landscapes has enabled projects to be planned more effectively, presented to stakeholders and environmental impacts to be assessed in advance. This technology has provided a tool for designers and planners to visualise and optimise their projects in a virtual environment.

The origin of the virtual landscape is closely linked to the evolution of computer technology and the widespread use of virtual reality applications. The development of these technologies has opened up new perspectives and application methods in landscape design (Figure 3).

Figure 3. *An example of a virtual landscape made with 3D Landscape design software (Url-3, 2023).*

Until recently, spatial disciplines such as urban planning and landscape planning have often been faced with the necessity of working in two dimensions without the possibility of effectively representing the third dimension. This has led in principle to a

predominant use of two dimensions in planning. This includes the reduction of a building to a black rectangle, a tree to a green circle, and the terrain to a series of contour lines.

However, in addition to analogue techniques for visual representation of the environment, digital visual simulation techniques are also available. These visualisations are often only partially integrated into the planning process and seen as an additional cost to sell the final planning product. This is due to the lack of connection between the planning action, the data used and the represented outcome of the planning process.

The techniques used for visual simulation of the environment can generally be classified as static or dynamic simulations and analogue or digital. Static simulations show an area as seen by a static observer. Dynamic simulations are shown as seen from the perspective of a moving observer, which may be part of an animated sequence. The main advantage of this method is that the observer is not limited to a specific viewpoint and can move freely in real time depending on the size of the digital model (Li and Hou, 2021).

Different techniques are used in the use of virtual reality and virtual landscapes. These techniques are listed below (Chandler et al., 2021; Portman et al., 2015; Ghadirian, and Bishop, 2008):

Analogue Visualisation Techniques : Classical analogue visualisation tools used in planning and design processes include plans, sections, sketches, perspective drawings, photomontages and physical models. Although perspective was discovered in Greece in 465 BC, it took several years to become popular in architecture during the Renaissance. In landscape architecture, Repton's Red Books can be considered an early pioneer, with its focus on representing proposed changes in perspective view. Photomontage is a widely used technique for representing the proposal. With advancing technology, digital photomontage has replaced analogue photomontage and can achieve higher levels of geometric accuracy.

Digital Visualisation Techniques: In recent years, technological innovations have emerged that allow three-dimensional work. In landscape planning, where mainly terrain, structures and vegetation need to be represented, image data are used in various resolutions, such as terrain data. Sensors providing satellite imagery are constantly evolving. New technological developments, such as the Inonos sensor, are capable of providing high resolution images.

Integrating built objects into a virtual environment is a challenging process. However, a new approach that allows planar structures to be fitted to a measured set of point clouds makes it possible to create 3D models of structures semi-automatically. Vegetation is often modelled as a combination of polygonal surfaces. Techniques such as L-systems enable the creation of photorealistic vegetation. The most effective method for visualising vegetation structures is to use species-specific texture mapping. This method can increase the visual complexity of complex 3D geometries and microstructures by applying simple texture maps to object surfaces (Li and Zhang, 2020).

Virtual Reality (VR) usage areas from different sources are listed as follows (Zhang et al., 2020; Li and Zhang, 2020; Li and Hou, 2021; Berg and Varce, 2017; Kaplan et al., 2021):

- *Education and Simulation:* VR is used to simulate real-world experiences in medicine, military training, aviation, and other professions. Students can experience and practice complex situations without risk.
- *Health and Rehabilitation:* In the medical field, VR is used as an effective tool in the treatment of diseases, surgical planning, psychotherapy and rehabilitation processes. It can provide treatment by simulating real-world activities, especially in physical rehabilitation processes.

- *Industrial Training:* Virtual reality can be used in industrial training programmes to train employees in the use, maintenance and repair of dangerous or expensive machines.
- Engineering and Design: In engineering and design, VR is used to create product prototypes, visualise architectural projects and optimise design processes.
- *Entertainment and Gaming:* The gaming industry uses VR technology to offer players a deeper and immersive experience. VR games offer interactive and exciting experiences by transporting users into virtual worlds.

Virtual landscape is a subfield of virtual reality (VR) technology and has various uses as follows (Li and Zhang, 2020; Li and Hou, 2021; Berg and Varce, 2017; Portman et al., 2015; Ghadirian, and Bishop, 2008):

- *Tourism and Travel:* Virtual landscapes offer potential tourists in the tourism industry the opportunity to explore destinations virtually. This gives tourists a pre-travel preview.

Figure 4. *An example of a virtual landscape prepared for tourism purposes (Url-4, 2023).*

- *Education and Research:* Landscape architects find the opportunity to showcase and evaluate their projects in a virtual environment for students and colleagues. Additionally, virtual landscapes can be utilized in research to understand the ecological interactions of natural landscapes.
- *Urban Planning and Architectural Design:* Urban planners and architects can visualize and analyze urban projects using virtual landscapes. This can be presented more effectively to project stakeholders.
- *Therapy and Relaxation: Virtual landscapes can be employed for therapeutic purposes to reduce stress, improve mental health, and enhance overall well-being. Experiencing natural landscapes virtually can provide users with relaxation.*

In essence, virtual reality and virtual landscapes are complementary fields. Virtual reality has a broad potential for simulating and providing interactive experiences in various industries. Virtual landscapes, especially in education, tourism, and design, offer the opportunity to explore and analyze real-world landscapes more closely.

Virtual landscape is a significant concept that enables interaction with nature in the digital realm. This technology provides an alternative experience for those facing challenges in accessing nature, while also holding the potential to increase environmental awareness. However, it is crucial to use it in a balanced manner and maintain a harmony with the real world. With the further development of virtual landscape technologies in the future, new possibilities for our interaction with nature may unfold.

2.5.Virtual Landscape and Its Effects on Environmental Awareness

Potential effects of virtual landscape on environmental awareness and its use for nature conservation.

Virtual landscape can be considered as a tool that has potential effects on environmental awareness, and its use for nature protection purposes can bring various advantages. The potential effects of virtual landscapes in terms of environmental awareness and nature protection are listed below (Li and Hou, 2021; Berg and Varce, 2017; Portman et al., 2015; Zheng et al., 1998; Kurbanoğlu, 1996):

- Creating Environmental Awareness: Virtual landscape gives users the chance to experience various environmental scenarios. This can contribute to users' closer understanding of natural resources, ecosystems and sustainability-related issues and to developing environmental awareness (Figure 2).

Figure 5. *Virtual landscape design example for creating environmental awareness made with 3D Landscape design software (Url-2, 2023).*

- *Analysis Tools for Nature Conservation Projects:* Virtual landscape can be used for planning and evaluation of various nature conservation projects. For example, the environmental impacts of a nature

conservation project to be carried out in a region can be simulated and evaluated through a virtual landscape. This allows projects to be planned more effectively in terms of environmental sustainability.

- *Education and Awareness Raising:* Virtual landscape can be used as educational material on environmental awareness and nature conservation. It offers students and general users the opportunity to teach topics such as the importance of ecosystems, biodiversity and nature conservation strategies in an interactive way.
- *Urban Planning and Green Space Design:* Virtual landscape can be used to integrate nature conservation principles and strategies in urban planning processes. It is possible to examine designs compatible with goals such as planning green areas, protecting biodiversity, and ensuring ecological balance in a virtual environment.
- *Ecotourism and Promotion:* Virtual landscape can be used to promote nature protected areas and promote ecotourism. While exploring protected areas in the virtual environment, users can learn about the importance of these areas and conservation efforts.
- *Advanced Analytical Capabilities:* Virtual landscape has the capacity to evaluate environmental impacts in a particular area by analyzing various environmental factors. These analytical capabilities can be an important tool in the process of identifying and implementing nature conservation strategies.

In short, the potential effects of virtual landscapes on environmental awareness and nature protection indicate a significant potential to expand usage areas and increase environmental awareness. This technology can be considered as an interactive tool

in the planning of nature conservation projects, use as educational material and sustainable design processes.

3.DISCUSSION AND CONCLUSION

Throughout history, education has consistently been a fundamental element for the pursuit of justice and the creation of a free and satisfying society through the dissemination of knowledge. Thus, in addition to life events that educate individuals, traditional higher education methods have long played a significant role. However, the age of technology has led to a transformation in the education system, adapting to constantly changing conditions along with the lifestyles of individuals. Over the past two decades, Information and Communication Technologies have paved the way for non-traditional education methods, leading to e-learning, which introduces an innovative dimension to virtual learning. With the advantageous features provided by the Internet and various technologies, this method transfers the control of time and space in the learning process from teachers to students (Afshar, 2022).

The concepts of virtual landscape and presence can be discussed in the context of the role of digital technologies in creating interactive virtual environments and the significance of the felt presence in these environments. Virtual landscape refers to the term used to describe virtual spaces designed in digital environments, often incorporating visual and auditory elements. These virtual landscapes offer users different experiences through computer-based simulations, virtual reality (VR) applications, or other digital environments. Virtual landscapes can either mimic natural or artificial environments in the real world or include entirely fantastical and imaginary settings.

Presence defines the feeling of being present in a virtual environment. As users interact with interactive elements within the virtual landscape and perceive this environment, the sense of presence increases. Presence is a crucial element that makes an individual feel as if they are in the virtual world, enhancing the

immersive and participatory capabilities of virtual landscapes. The interaction between the design of virtual landscapes and the user's sense of presence has significant applications in various fields. In education, virtual landscapes can provide students with interactive learning experiences, making specific subjects more engaging and effectively learned. Similarly, virtual landscapes have diverse applications in the entertainment industry, tourism, and simulation fields.

Game technologies can be considered an innovative solution accepted to familiarize learners with real-world skills and trigger their motivation. These technologies are among the most effective methods integrated into educational systems. Known as "serious games," these games combine educational content with entertainment to enhance interaction. Serious games immerse and educate players in specific skills or subjects. While serious games are widely used today, they are not universally embraced due to the immersive expectations of players (Kulakaç and Çilingir, 2023). Therefore, it is crucial to be aware of whether serious games are effective in an educational context when recommending them in place of traditional teaching methods. Investigating the learning rate of players is thus a significant topic in this regard.

In general, digital games constitute one of the world's largest and fastest-growing industries. Digital games are heavily dependent on virtual landscapes, a crucial part of the development process (Lange, 2001). The design of virtual landscapes directly influences all aspects of the game. Recently, virtual reality technology has added more immersion and interaction to games. However, the absence of a standard methodology for designing virtual landscapes results in inconsistent and low-quality outcomes. Therefore, research focusing on the role of virtual landscapes in serious games and their impact on data understanding is crucial. The development of more standardized methodologies for designing virtual landscapes in serious games could contribute to achieving high-quality results.

In this context, the success in designing virtual landscapes can reinforce users' sense of presence, contributing to a more effective and satisfying experience in the virtual environment. Virtual landscape, influenced by computer technology and virtual reality applications, has gained significance in fields such as landscape architecture and environmental design. The importance of virtual landscapes can be listed as follows:

- Virtual landscapes serve as a unique visualization tool in design processes. Visualizing architectural and landscape projects in virtual environments allows designers and stakeholders to present the final appearance of the project more clearly, making design processes more effective and understandable.
- Virtual landscapes are a powerful tool for urban planning and environmental analysis. Simulating factors such as environmental impacts, sun movements, and shading analyses in virtual environments can lead to more effective decision-making in terms of environmental sustainability and planning.
- In landscape architecture and environmental design education, virtual landscapes offer students the opportunity to translate theoretical knowledge into practice. Creating design projects in a virtual environment allows students to better understand and experience concepts, making it an effective tool in education.
- In the tourism industry, virtual landscapes are used to introduce destinations and provide tourists with a preview before travel. This helps tourists to get to know destinations more closely and plan their trips more effectively.
- Virtual landscapes provide users with the ability to simulate real-world experiences, offering a more interactive design and analysis process. Users can closely examine projects,

interact, and actively participate in the design process through virtual landscapes.

In conclusion, virtual landscape has become a significant tool in landscape design, environmental planning, and related fields. The use of this technology provides designers, students, and planners with the opportunity to work on more effective, interactive, and sustainable projects.

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CHAPTER II

Compilation of Architecture Design Guidelines for Residental Buildings in Wildfire Zones

Elif BASTEM[1]
Asena SOYLUK[2]

1.Introduction

The profession of architecture is one of the oldest professions in history. It has been defined in different ways by different architects over the years. Le Corbusier defines architecture as 'The masterly, correct, and magnificent plat of masses brought together in light.' (Corbusier & Merzi, 1999). According to Ludwig Mies van der Rohe, architecture is 'The will of the age conceived in spatial terms.' (Conrads, 1970). Although the definitions for arhitecure has

[1] Master of Architecture Student, Gazi University, Department of Architecture, Faculty of Architecture, elif.bastem@gazi.edu.tr , ORCİD: 0000-0003-3961-2795
[2] Doç. Dr., Gazi University, Department of Architecture, Faculty of Architecture, asenad@gazi.edu.tr , ORCID: 0000-0002-6905-4774

changed over the years, it has remained the task of the architect to work in coordination with other disciplines (mechanical, static, landscape architecture, interior architecture, map, electricity, etc.) for space design and application. Apart from having tasks and rights, an architect has obligations to society, employers, colleagues and the profession.

In today's world, cities shaped by the building that architecture profession design are undergoing rapid transformations. As a result of the different building that make up cities in various parts of the world, each of them undergoes different transformations. However, despite the differences between them, cities sometimes face similar problems (Yazar, 2006). Cities are dealing with health problems, environmental pollution, economic problems and socio-cultural problems. Natural disasters are one of the common problems that cities face on a global scale. Natural disasters lead to loss of life, environmental problems, and economic and social losses. Wildfires are one of the disasters that affect human life and nature since the beginning of the world. Especially with the increase of drought and global warming, the occurance risk of wildfires and the damage they cause has increased.

In the face of global-scale problems, there is a need for new planning, and solutions should stem from decisions taken at the neighborhood level (Gebel et al., 2021). To address the risks associated with wildfires, measures at the neighborhood level should be expanded, and solutions should be generated at the building scale. Because, apart from vegetable fuel, topography and climate, one of the concepts that affect the spread of fire in wildfires is the buildings construction in fire-prone areas. One of the professions most associated with the concept is architecture. In order to design buildings resistant to wildfires, there are some important details that architects need to make or avoid. Coping with the devastating effects of natural disasters is an issue that affects the whole world and need to be taken into account, especially when drought and global warming are on the rise. Taking precautions against this disaster, which affects human life directly or indirectly through the

destruction of vegetation and microclimate changes, and designing durable structures is not only an ethical duty for an architect, but also a responsibility. The occurance of fire in the buildings in wildfire zones cannot be completely prevented, but he progress of the fire can be stoppped by making the necessary design decisions.

In order to make informed design decisions, a risk analysis should be conducted first.The risk analysis of natural disasters is beneficial not only in preventing and mitigating disasters but also in reducing economic and social losses. Today, there are various methods for assessing the risk of natural disasters. The advantages and disadvantages of these methods have been the subject of many studies, providing a source for selecting and optimizing the appropriate method. These methods include Quantitative Risk Assessment (QRA), Event Tree Analysis, Risk Matrix Approach, Indicator-based Approach, Fine-Kinney, and ANFIS. The use of these methods can vary depending on the risk, and in some cases, they can be used together in a hybrid manner (Gökler et al., 2022). The analysis of risk is conducted through the employed methods, and based on the resulting values, precautionary measures are taken against the identified risks. Thus, the damage and loss of life to be experienced can be minimized.

For this reason, as in the architectural ethical codes, the architect should keep society and human rights above everything. Many things can be added to these rights, but the most basic responsibility of an architect should be to avoid design decisions that destructively affect the ‘right to life’, the most basic right of humanity (Dallı & Soyluk, 2022). The aim of this study is to decrease the loss of life, property and damage to the environment caused by the structures using architectural design decisions in the wildfires. In some countries, there are restrictions and guidelines for the architectural profession to reduce this destructive effect from wildfires. However,existing regulations and design guidelines are remain local, and the measures cannot be taken to the global level. The main objective of this study is to compile existing regulations and design guidelines for use by architects of the countries struggle

with wildfires and to guide their designs. By synthesizing wildfires and the requirements of architectural ethical codes, the interaction between the architectural ethics that shape the building environment and the effects of wildfires is examined by the compiled design guidelines.

2. Factors Affecting Wildfire Risk

2.1. Definition of Wildfires

Scientifically, fire is a chemical event that occurs as a result of the combination of matter with heat and oxygen. In order for combustion to occur, flammable substance, ignition (ignition source) and caustic substance (oxygen) must be together (YILDIZ & ÖZGÜLER). Wildfire is an uncontrolled fire that spreads through vegetative fuels. 'Vegetative fuels include those that are characteristic of wildlands, such as trees, grasses, understory growth, and ground litter; and those that are purchased at nurseries for home or community landscaping purposes, including trees, mulch, grasses, and ornamental plants.' (FEMA, 2008b). Apart from the presence of vegetative fuel, the occurrence and severity of wildfires are affected by weather conditions such as high winds, high temperature, low humidity and drought; and topography.

2.2. Types of Wildfires

Different types of wildfires occur with various combinations of these factors. Surface fire *(örtü yangını)*, which is one of the wildfires, is the out of control burning of leaves, humus, dry branches, tree residues on the forest soil which are litter. It is a type of fire in which material such as grass, pasture, tiller as a living cover, is burned. They are relatively less dangerous and generally do not harm trees. Crown fires *(taç yangını)*, on the other hand, is a type of wildfire that affects almost every part of trees together with the cover and can create distinctive combustion conditions. These wildfires emit high energy. Strugle and containment efforts can be extremely dangerous. Generally allow intervention from sides and

back. Intervention from where the fire is spreading is very risky. Lastly ground fires *(toprak yangını)*, are the wildfires that occur in areas such as reeds and swamps, peatlands on the forest soil and in the root part under it, which are not common in Turkey (TOD, 2020).

2.3. Wildfire Causes

The causes of wildfires can be divided into human and natural causes, but it should not be forgotten that there are wildfires of unknown caused. Wildfires that natual caused are mostly lightning strikes, volcanic eruptions, rubbing of dry branches (spontaneously), underground mine fires and fires that occur as result of rockfalls. Human caused wildfires are occur by cigarette butts, campfires, arson and global warming. As a result of all kinds of wildfires caused by human or nature, biodiversity is greatly damaged, the habitats of the living in the forests are destroyed, the number and speed of natural disasters such as erosion, floof and air pollution increase with the destruction of living and non-living cover, deterioration in the climate system (AFAD).

2.4. Most Recent Wildfires in the World

As the world's population has grown exponentially in the last 100 years, the damage to forests has reached greater proportions than ever before. This damage occurs in the form of deforestation, cutting and wildfires. The world has a total forest area of 4.06 billion hectares (ha), which is 31 percent of the total land area (FAO, 2020). One of the main reasons for the occurance of the wildfires, which cause the loss of forest asset, is climate variability and climate change directly or indirectly affect wildfire risk, such as temperature, soil moisture and the existence of trees, shrubs and other potential fuels. Wildfires which occur for various reasons, lead to the destruction of forest assets, damage to structures and loss of life. In this study, wildfires in which the most hectares burned in the world in the past 20 years and the 28 July 2021 Manavgat Wildfires, which was recorded as Turkey's largest wildfire, were examined in Table 1.

Table 1. The devastating consequences of wildfires according to the burned area (hectar) ranking

Name	Country	Burned Area (Hectar)	Damaged Building	Deaths
2014 Northwest Territories Wildfire	Canada	3.390.000 ha	Unknown	Unknown
2020 California Wildfires	USA	1.788.832 ha	10,488	33
2011 Texas Wildfires	USA	1.623.481 ha	2,947	10
2018 British Columbia Wildfires	Canada	1.354.284 ha	140	Unknown
2021 Manavgat Wildfires	Turkey	60.000 ha	57	3

2.5. Factors that will Affect the Damage Caused by Wildfire

The factors affecting the damages caused by wildfires are arranged in Table 2 by analyzing different sources by the author.

Table 2. Factors that will affect the damage caused by wildfire

Risk Types (TOD, 2020)	**Surface Fire** **Crown Fire** **Ground Fire**
Causes of Risk (AFAD)	Natural Causes Human Causes Unknown Causes
Areas by Risk Spread Behavior (Slope-Fire Rate) (OGM)	Area I – Slopes that up to %5, the spreading speed does not increase. Area II – Slopes that %5-55, the spreading speed is doubled. Area III – Sloped that above %55, the spreading speed doubles again.

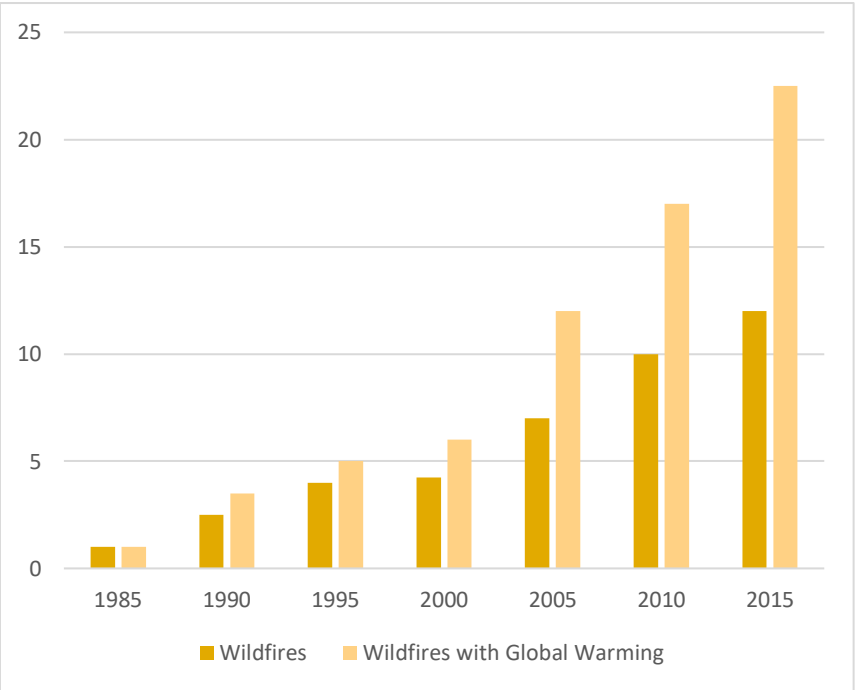
Table 2. Continued

Building Groups that May Be Highly Affected	**Residental** **Hospital** **Hotel** **Public Building** **Office** **Industrial Buildings** **Military Construction**
Building Systems (FEMA, 2008a)	Topography and Climate i. Selecting the Construction Site ii. Vegetation Defensible Space Building Envelope i. Roof ii. Eaves, Overhangs and Soffits iii. Exterior Walls / Siding iv. Ventilation v. Gutters and Downspouts vi. Windows and Skylights vii. Exterior Doors and Garage Doors viii. Foundations and Base of Walls ix. Decks and Other Attached Structures x. Sprinkler Systems xi. Landscape Fances, Walls and Gates Infrastructures i. Roads ii. Emergency Water Supply

3. Climate Change and Wildfires

The risk of wildfire depends on temperature, soil moisture, drought, atmospheric instability and presence of vegetative fuels, which are directly related to climate variability and climate change. Not only weather conditions are effective on wildfires, but also wildfires can cause some changes on natural conditions. Climate change is accelerating the drying up of vegetative fuels in the forest.

Along with the extinction of vegetation, large wildfires will also affect the regional energy balance and microclimate. In other words, changes in the surface characteristics of the area affect the change of the microclimate in that region. 'Climate change is playing an increasing role in determining wildfire regimes along-side human activity, with future climate variability expected to enhance the risk and severity of wildfires (Graphic 1) in many biomes such as tropical rainforests.' (Jones et al., 2020).



Graphic 1. The cumulative forest area burned by wildfires has greatly increased between 1984 and 2015, with analyses estimating that the area burned by wildfire United States over that period was twice what would have burned had clime change not occured. Adapted from (Abatzoglou & Williams, 2016)

In the future, under extremely hot climatic conditions, it is observed that the wildfire seasons will bee prolonged and there will

be a serious increase in the number of wildfires. This situation necessitated the development of risk analysis, detection of wildfires and precautions to be taken against wildfires. 'Fire risk is evaluated by using different fire indices in many countries such as Mediterranean countries, USA and Canada, where the wildfires are very common. Keetch-Byram Drought Index(KBDI), Canadian Forest Fire Index(FWI) ve Nesterov Ignition Index are some of the many indices used to indicate the relationship between wildfires and arid conditions.'(YILDIZ & ÖZGÜLER).

4. Building Design Guildelines

Factors affecting the vulnerability of a building during a wildfire can be listed as topography, climate, defensible area, building envelope components and infrastructure. If any of these factors cannot provide sufficient resistance to fire at the time of wildfire, this will cause the fire to spread faster. The building is positioned and oriented with architectural design. Decisions made by the architect when designing each component of the building also affect the wildfire propagation.

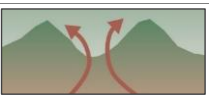
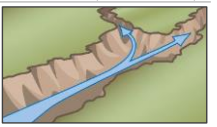
4.1.Topography and Climate

4.1.1. Selecting the Construction Site

Terrain and weather conditions often determine the direction in which wildfires will progress. While choosing the site for a building, the area where the building located and the topographical features around it should be evaluated in terms of damage to the building during a wildfire. The risk arising from topographical features should be tried to be minimized while choosing a construction site. Wildfires spread faster on sloping terrain that on flat terrain. Lands with sloping topographic features (sloped terrain, saddles, ridgetops, canyons) can affect wildfire behavior (FEMA, 2008a). In the research article published in 2011, examining the effects of land use and topography on the occurence of wildfires in 1990 and 1991 in Northern Portugal, it sought answers to the questions of which land types and topographic features cause more

fires, and whether the relationships between fire occurence and topography are related to land use. According to this article, ‘Fires spread most rapidly uphill on steep slopes, where the higher incident radiation promotes the fuel ignition also found that fires were more likely to burn on steep slopes. Selection patterns for aspect showed a weak selectivity, with only flat areas being clearly avoided by fire. In southern slopes, land covers more susceptible to fire are less frequent.’(Miguel Carmo, 2011).

Table 3. Wildfire spread behavior according to the terrain type

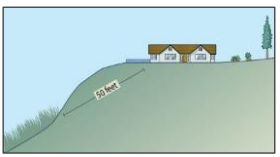
Terrain Type	Wildfire Spread Behavior
‘New homes should be built away from ridge tops, canyons, and saddles.’(Sabrina L. Drill, 2009). The effect of each 10 degree slope increase on the wildfire spred behavior rate is 2 times (BİLGİLİ, 2014).	
Sloped terrain	Wildfires spread rapidly upslope as the temperature rises. It preheats and ignites vegetative fuels and building. Wind-induced wildfires follow the wind direction and topography. In the absence of wind, the wildfire that follows the topography primarily burns the top of the sloped terrain and canyons (FEMA, 2008a).
Ridge tops	Wind speed on the ridges and hills tend to be higher than those in the surrounding lowlands, as they increase with height. Buildings in these locations can suffer 360-degree wildfires (FEMA, 2008a).
Saddles	The saddle-shaped ridge between the two hills creates a channel for wind and act as a wind funnel (Figure 1) and is one of the most dangerous places for buildings in terms of wildfire (BİLGİLİ, 2014).  *Figure 1. Fire behavior on a saddle (Slack, 2000)*
Canyons	A wildfire at the bottom of a canyon covered with vegetation can be extremely dangerous. A canyon acts as a chimney (Figure 2), collecting hot gases and diverting the superheated convection and radiant heat gradient (FEMA, 2008a).  *Figure 2. Wind behavior through a canyon (FEMA, 2008a)*

4.1.2. Vegetation and Climate

The low correlation between human-caused wildfires and human-induced changes indicates that the impact of increases in wildfire ignitions is influenced by vegetation and climate factors. The interaction between fire, vegetation and climate needs to be understood and taken into account when examining fire formation and spread behavior (Lasslop & Kloster, 2017). Since increasing drought conditions will also increase warming and exsiccation in the region, it may also increase the risk of fire in intermediate seasons,

except for long arid periods. Wildfire activity can be reduced by the availability of fine fuel and the low connectivity of vegetative fuel (Turco et al., 2017).

Table 4. Guidance for vegetation



Buildings house on or adjacent to a steep slope should be avoided. If a hillside area selected, an area that allows at least 15,5 meters of regression from the wildland vegetation on the downslope should be selected as in the Figure 3 (FEMA, 2008a).

Figure 3. Setback from wildland vegetation (FEMA, 2008a)

'The type, continuity and density of a specific plant determines how it will burn. Not all vegatation burns the same way. Some vegetation almost never burns; others burn at different times of the year; and some can burn almost anytime.' (Slack, 2000). The flammability of vegetation types and their burning behaviors (Table 5) are very important for the landscpae design around the building in the wildfire zones.

Table 5. Combustible material properties of major vegetation types in the world and types of fires occurring (ARSLANTÜRK, 2007)

Vegetation Type	**Property of Combustible Material**	**Fire Type**
Semi-arid	Sparce plants	Fires are rare or absent
Pasture	Thin, dry grasses and live herbs	Surface fires
Savannah	Thin, dry grasses and live herbs	Surface fires in which the wood layer is affected
Bush and heath	Thin-leaved shrubs; sometimes herbaceous materials can help	Fires occurring at the tip and top of the bushes
Tundra	Sparce plants	Fires are rare or absent
Coniferous forests	Consists of twigs or litter piles, and cones and bushes	Surface fires occur under normal conditions, crown fires spread quickly under dry and hot conditions; The severity of these types varies greatly.
Tropical rainforest	Layer of fallen leaves, shrubs and tall trees	Fires are rare or non-existent due to the temporary layers of debris and the high water content in the leaves.

4.2. Defensible Areas

'The vegetation surrounding a building or structure is fuel for a fire. Even the building or structure itself is considered fuel.'(BOF & CDF, 2006). The defensible area is the buffer zone created between the building and the surrounding grass, shrubs, trees, or any wildland area (CALFIRE, 2020). The purpose of the area is to minimize direct contact with fire, reducing radiative heating, lowering the possibility of ignition from embers, and reduce the risk of structural damage and loss by providing a safer area for firefighters to defend the structure against fire. The defensible area distance, which is determined by the regulations in the countries, may vary. In California, for example, a 2005 state law increased the total distance require for defensible area from 9 m (30 ft) to 30 m (100ft) (Syphard et al., 2014).

Table 6. Guidance for defensible space

Non-combustible vegetation should be planted in this area. Trees and bushes should be placed at wide intervals to prevent the fire from reaching the treetop or roof of the structure and becoming a fuel path (BOF & CDF, 2006). Therefore the horizontal and vertical aspects of the vegetation should be examined when designing the area. • To prevent the horizontal spread of wildfire, should have space between individual thin shrubs and trees so that tree crowns do not intersect. • To prevent the vertival spread of wildfire, keep the lowest tree branches pruned and trimmed to maintain vertical separation from the top of bushes and grass to lowest tree branches. (FEMA, 2008a)

Tablo 6. Continued

Three concentric zones (Figure 4) should be created around the building.

Zone 0 / Ember Resistant Zone: 1,5 m from structures, decks, etc.

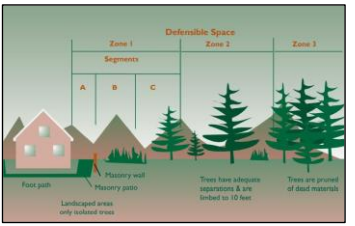


Figure 4. Defensible Space (Slack, 2000)

- Use hard ground such as gravel, paving stones, concrete and other non-flammable materials.
- Remove all the dead and dying weed, grasses, plants, shurbs, trees braches and plant debris. (leaves, needles, cones, barks etc.).
- Remove all the dead branches within 3 m of any chimney or stovepipe outlet.
- Limit the plants in this are to low-growing, non-woody, properly cared plants.
- Limit flammable substance on the deck (outdoor furniture, planters, etc.).
- Move firewood and timber to Zone 2.
- Replace flammable fences, gates and arbors attached to the house with non-flammable alternatives.

Zone 1 / Lean, Clean and Green Zone: 9 m from structures, decks, etc.

- Remove dead or dry leaves and pine needles from your garden, roof and rain gutters.
- Prune trees regularly to keep the branches at least 3 meters away from other trees.
- Remove or prune combustible plants and shrubs near the windows.

Zone 2 / Reduce Fuel Zone: Extends from 9 m to 30 m out from structures, decks, etc.

- Annualy, cut or mow the grass to a maximum height of 10 cm.
- Create horizontal and vertical deceny between grass, shrubs and trees. (CALFIRE, 2020)

Plant and Tree Spacing

- *Vertical Spacing:* Remove all the tree branches up to at least 1,8 m above the ground. Leave extra vertical space between shrubs and trees. The lack of vertical space can allow the fire to move from ground to bushes and tops of tree. To determine the appropriate vertical distance between the bushes and the lowest branches of trees:

  3x Height of Shrub = minimum vertival clearance.

- *Horizontal Spacing:* The horizontal distance depends on the slope of the terrain and the height of the bushes or trees (Figure 5).

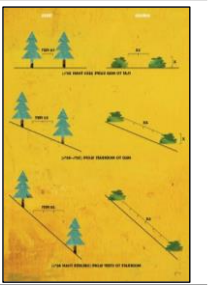


Figure 5. Minimum horizontal clearance (CALFIRE, 2020)

4.3. Building Envelope

4.3.1. Roof

The roof covering is the most severly exposed to all elements, including sun, rain, wind and embers during a wildfire due to its edges and assemblies, large horizontal surfaces, dimensions, so it is the most vulnerable component of the building (Sonoma, 2004). The roof cover can ignite due to roof components and debris on the roof, embers and burning piece of wood. The fire usually spreads inside the building after the roof ignites. The roof components have

a lot of impact on the building to get out of the wildfire without damage or with minimal damage. The material of the components and the details of their connection affects the ignition poteantial and the transfer of heat into the interior of the building. The ignition potential of the roof also affected by the fact that the roof shape is very indented, leaves and needles collected at the intersecitons of the roofs and the walls (FEMA, 2008a). Due to the weather conditions and the wildfire exposure of the roof, roof coverings and installation details require more maintenance. And it generally has a shorter life span than other construction materials used outside the building (Quarles et al., 2010).

Table 7. Guidance for steep-slope roof (roof with a slope greater than 3:12)

ROOF COVERING

- The fire rating of the material used in the roof covering should be Class A.

Class A fire rating means that the material can withstand exposure to fire for one hour without being completely burned. Covering alone or assembly (by covering and underlying materials) can be rating Class A.

Condition (age): Even if the roof covering material is Class A, it is Class A for the specified period. The age of the material and exposure to UV rays degenerate some materials, therefore reduce their resistance to fire. The roof should be maintained throughout its life and the roof should be replaced at the end of its life (Sonoma, 2004).

Tile: Clay and concrete tiles are non-combustible materials. Because of their large thermal mass, they retard the transfer of heat. The tiles should be installed over the fire-retarted-treated wood battens because the battens may ignite due to the embers that get under the tiles.

Metal shingles and panels: Metal shingles and panels are non-combustible materials. They readily transfer of heat. The shingles and panels should be installed over fire-retarted-treated wood battens.

Fiberglass-reinforced asphalt shingles: Even though fiberglass-reinforced asphalt shingles can be rated as Class A, these shingles include combustible material (e.g., asphalt). If this material is used, gypsum roof board over the wood decking should be installed for enhanced protection of the decking from fire. When the shingles are nailed that the nails shoul not overdriven.

Wood shingles and shakes: Wood shingles and shakes can be rated Class A only if the materials are fire-retardant-treated and a specific cap sheet underlayment is installed, so this materials can be used just in these conditions (FEMA, 2008a).

ROOF EDGE

- Roof edges are vulnerable to wildfire risk in two ways:

- Accumulation of debris on the edge of the roof and in the gutter, debris serving as fuel during a fire.

- Roof profiles designed in the large gaps between the roof covering and the roof sheathing, inhaling embers during a fire. These gaps can occur at the roof edge and at the roof ridge (Quarles et al., 2010).

- Birds can nest in opening on the edges of the roof, such as on a shingle roof, and it should not be forgotten that bird nests serve as a fuel for wildfires. Birdstops should be placed in the openings (Figure 6) and should be checked once a year (Sonoma, 2004).

Figure 6. Birdstops prevent debris from accumulating under tiles. Photo: Stephen L. Quarles

UNDERLAYMENT

To under some types of steep-slope roof coverings such as tile, metal shingles and panels, slate, embers can be blown. If roof covering tiles disloged or cracked, embers can easily land on the underlayment below (Figure 7). For provide protection from embers that reach the underlayment, installing an underlayment that has enhanced fire resistance is recommended (FEMA, 2008a).

Figure 7. Displaced tiles allow ember entry (FEMA, 2008a)

DECKING

A fire-retardant-treated roof decking should be used to prevent the deck from igniting. For further protection, 1.5 cm gypsum roof sheets can be added in addition to fire resistant treated deck (FEMA, 2008a).

Table 8. Guidance for low-slope roof (roof with a slope less than 3:12)

ROOF COVERING AND UNDERLAYMENT	• Polyisocyanurate roof insulation should be specified. • A 5/8-inch sheet of gypsum roofing just below the roof membrane should be specified (Figure 8). • To increase fire resistance, the roof membrane must be protected with a heavy (i.e., 7.7 kg per square meter minimum) concrete paver (FEMA, 2008a).

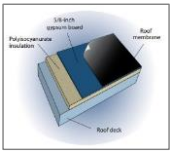


Figure 8. Components of low-slope roof (FEMA, 2008a)

A complex roof makes a Class A roof additionally vulnerable to wildfire and ember exposure (a complex roof has a series of horizontal and vertical intersections). From a fire performance perspective, these instersections provide a collection points for debris from windblown, overhanging trees and embers blowing during wildfires. If the materials at the intersections ignite, the flames from the burning vegetative debris residues also spread to the material on the exterior, roofing and window. As a result, the fewer intersections, is the less complex roof design of the building, the less space for ignition to occur (Quarles et al., 2010).

4.3.2. Eaves, Overhangs and Soffits

The eaves, overhangs and soffits of buildings (whether ventilation is used or not) may be vulnerable to fire. Embers blown by the winds can accumulate in these regions. If the vegetation around the building or siding ignites, the flames can reach the eaves, overhangs and soffits (Quarles et al., 2010). From these regions, the flames can also spread to the roof and attic decking or to the exterior walls. Soffits generally have vents for the attic ventilation system. Unprotected ventilations allow embers to enter the attic (FEMA, 2008a).

Table 9. Guidance for eaves, overhangs and soffits

EAVES, OVERHANGS AND SOFFITS

- Wider overhangs protect the exterior walls from elements such as rain and sun, on the other hand increase exposure to flame during a wildfire. Wide overhangs and soffits to be exposed to more embers and heat, so narrow overhangs are recommended for resistance to wildfires. The optimally suggested design in the eaves desig for rain and fire protection is to use an ignition-resistant or noncombustible soffit material and to provide protection against moisture with wide overhang (Quarles et al., 2010).

According to the layout of the building in the topography, the direction of fire propagation changes, there is a relationship between the direction from which the flames come and the overhang width which affects each other. When the wildfire is above the eave, the eave can protect the upper part of the exterior wall from radiant heat (Cohen, 2004).

- In order to avoid fire-related problems with soffits, it should be considered to design the building without overhangs or minimize the width of the overhangs as much as possible to reduce the potantial for entrapment of ember and radiant gases (FEMA, 2008a).
- If a without or narrow overhangs are not acceptable, the following recommended measures should be applied:

- Overhangs should be sealed with soffits with a minimum fire resistance rating of 1 hour to prevent ember and hot gases from coming into the roof deck and rafters.
- Instead of attaching the soffits to the sloped joints, use flat, horizontal soffits (Figure 9). A flat soffits reduces the potential for embers and hot gases to be trapped (FEMA, 2008a).

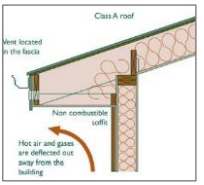


Figure 9. Fully enclosed soffit with isolated vent (Slack, 2000)

EAVES, OVERHANGS AND SOFFITS

There are 2 types of eaves:
- Open-eave design where the roof rafters extend beyond the exterior wall and are visible
- Suffited construction (boxed-in eave) design where the eave is closed.

Figure 10-11. Home on left is vulnerable to wildfire because of its aging, shrinking wood siding and single pane windows. Home on right was retrofitted with fire-resistant siding, boxed eaves, metal-clad fascia and double paned windows (Sonoma, 2004).

Vents of the boxed-in eaves can be provided by strip vents containing wire mesh (Figure 12). Vents should be located closest to the outer edge of the overhang to minimize the ingress of embers and flames. Some countries' building codes restrict the placement of vent on eaves soffits, for example The California Building Code (Quarles et al., 2010).

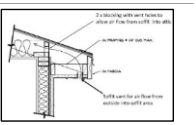


Figure 12. Diagram of construction details that allow air flow from the soffit into the attic (Quarles et al., 2010)

4.3.3. Exterior Walls / Sliding

The exterior walls, siding, of the building is the component with the largest surface area of the entire building. The fire resistance of exterior walls depends on the material of the wall, siding, and the

amount of combustible material nearby (FEMA, 2008a).The siding material of the building plays an important role in the spread of the fire from building to building or from vegetation to building to building. The Great Chicago Fire and the Manavgat Wildfires can be given examples of wildfires that cause effect with the spread of fire from building to building and cause serious damage to the whole city (Springs, 2020). Ignition resistant siding helps perevent fire from spread of fire from building to building, thereby slowing the progress of the fire and giving firefighters an oppurtunity to control the origin of the fire (Montana, 2010). Siding is vulnerable to wildfires for two reasons:

Figure 13-14. Flame penetration (burn through) at the rabbeted bevel lap joint in a solid wood siding product, as viewed from the stud cavity side of the wall (Left).Flames from the fire would have impinged on windows and eave, if they had been present (Right).(Quarles et al., 2010)

If the siding ignites, the flame can spread to the walls and eventually break windows or spread from the soffit to the attic (Figure 14).

Fire can pass through the lap joint (Figure 13) and spread to the living area through the gaps of the studs (Sabrina L. Drill, 2009).

Siding product testing at the UC Fire Research Lab showed that the siding assembly points are the most vulnerable part of the siding. Throughout the siding, the probability of exposure to flames increased at less complex overlap points (Quarles et al., 2010).

Table 10. Guidance for exterior walls / sliding

EXTERIOR WALLS / SIDING	 If there is a flammable siding, the vegetation around the building should be carefully selected (Figure 15), the distance between the building and vegetation should be decided at the design stage, and its maintenance should be done at regular intervals. The storage of flammable materials around the building should be avoided (Montana, 2010).
	Figure 15. Example of vegetation that is in close proximity to a structure siding (Springs, 2020).
	Siding materials can be examined in 3 categories. There are combustible, non-combustible and ignition resistant materials. The concept of fire-resistant material and fire-resistant building should not be confused with each other. The fire-resistant building including all components of building and their materials and vegetation around building within the defensible area (Quarles et al., 2010).
	Choose the siding material from materials that can resist fire for at least 1 hour (Class A). *Recommended siding materials:* Concrete, fiber-cement panels or siding, exterior fire-retardant-treated wood siding or panels, stucco, masonry, metal. *Not recommended siding materials:* Wood siding that is not fire-retardant-treated, vinyl siding, metal siding susceptible to warping, exterior insulation finish system (FEMA, 2008a).
	If you have a fire-prone siding, such as wood shake, but can't afford to replace it, you can reduce the chances of getting burned with a gel fire-retardant. The gel keeps the water on the wall, reducing the possibility of burning the siding from the embers. It can be applied to the building at least 4 hours before the wildfire threat (Sonoma, 2004).

4.3.4. Ventilation

Embers, flames and radiant heat entering through the exterior ventilation openings can enter to the attic spaces, crawl spaces and ducts (Figure 16), igniting the stored materials and/or combustible building components (such as wood trusses or other structural support members), causing the building to burn completely (Sabrina L. Drill, 2009).

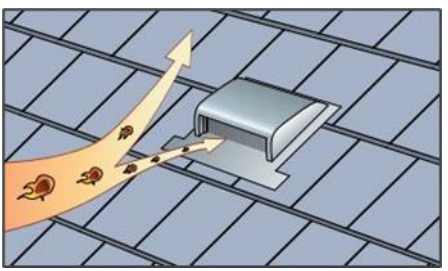


Figure 16. Embers or hot gases can be blown or pulled into vents (FEMA, 2008a).

During a wildland fire, embers even smaller than a grain of rice can penetrate through the ventilation spaces and set the building

on fire from the inside (Sonoma, 2004). The main function of the ventilation spaces is to control the water vapor in these areas (Slack, 2000). If there is too much moisture builds up, it can cause materials to mold and rot. Which causes rotten materials to ignite at a lower temperature during a wildfire. Therefore fire spreads faster because the material is less resistant to flames than its solid state can withstand (Division of Agriculture and Natural Resources).

Table 11. Guidance for ventilation

Vegetation near the building can be ignited by windblown embers, and embers enter the ventilation openings from here. Therefore, the debris accumulated near the roof vents and on the metal shutters, if any (Figure 17), should be cleaned at regular intervals (Sonoma, 2004).

Figure 17. Needles (debris) from nearby pine trees have accumulated on the lower roof section (Division of Agriculture and Natural Resources).

Combustible materials should not be stored in attics. If the embers enter through the ventilation openings, the stored combustible materials ignite and the building begins to burn internally (Springs, 2020).

Tablo 11. Continued

To reduce the total number of embers that can enter the attic, it is recommended to use 1/8 inch metal screening (Springs, 2020). Finer mesh screens are better since smaller embers have a harder time igniting building materials and debris.' (Sabrina L. Drill, 2009). In the manuel prepared by the Colorado Springs Fire Department (2020), embers passing through 1/8 -inch metal screened vents do not have the thermal energy to ignite fine fuels in the attic. On the other hand, in the laboratory studies carried out by Quarles in 2009, embers passing through the 1/8-inch screened vents can still have enough energy to ignite fine fuels. In addition, the 1/8 ich metal creened vents endanger the function of ventilation in terms of water vapor control (Quarles et al., 2010).

The user can also install a solid cover on the vents in case of wildfire, it shoul be removed after the threat has passed, for ventilation to continue (Sabrina L. Drill, 2009).

ATTIC AND CATHEDRAL CEILING VENTS

Ridge Vent

Zones running along the leading edges of the ridge vent resist the ingress of rain, wind and embers. In addition, it provides a negative pressure zone that helps draw air through the attic (Division of Agriculture and Natural Resources). Although ridge vent allows air to escape, it can allow hot gases to enter. Therefore, ridge ventilation with internal baffle media (Figure 18) should be installed. However, during a wildfire internal baffle media may melt and cannot prevent embers from entering. *Recommended:* Metal vents with internal baffle media (FEMA, 2008a).

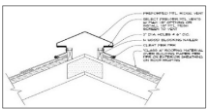


Figure 18. Example of a ridge vent drawing with proper screening (Springs, 2020).

Soffit Vent

In order to prevent embers and hot gases from entering the soffit vents, metal shutters should be installed above the soffit vents (Sonoma, 2005).

Figure 19. A 'strip vent,' in soffited eaves (Division of Agriculture and Natural Resources).

Gable-end Vent

Gable vents (Figure 20) are strongly discouraged as they are more vulnerable to ember ingress. They should be installed only on the sides of the building that are not facing the prevailing wind direction (Montana, 2010). A hinged louver (Figure 21) that can be locked in the open or closed position is recommended for the gable vent (FEMA, 2008a).

Figure 20. Gable vent (Springs, 2020).

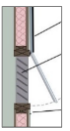


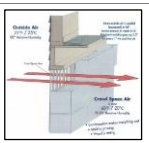
Figure 21. A hinged shutter (FEMA, 2008a).

Through-roof Vent

Through-roof vents (Figure 22) are not recommended (FEMA, 2008a). If a through-roof vent is used, a ¼ inch metal screen is effective to kepping out firebrands and embers. Screens larger than ¼ inch allow entry of embers and hot gases (Sonoma, 2005).

Figure 22. Example of a roof vent (Springs, 2020).

CRAWLSPACE VENTS



Crawlspace vent (Figure 23) is a vent spaced several inches above the foundation wall and allows air to flow into and out of the crawlspace. A ¼ inch metal screen cover is recommended for the crawlspace ventilation to keep the embers out. Screens larger than ¼ inch allow entry of embers and hot gases (FEMA, 2008a).

Figure 23. Crawlspace-vent (Inspection, 2019).

HVAC SYSTEM VENTS

Through-roof Vent

Through-roof ventilation is not recommended. Instead of running the duct system through the roof, extend the duct to an exterior wall where a wall shutter and louver can be installed (FEMA, 2008a).

Wall Lovers

Install metal shutters over the wall louvers. If there is an uncontrollable wildfire threat, wall shutters with adjustable tight-fitting blades should be installed, which can be closed (FEMA, 2008a).

Figure 24. Unventilated attic (Division of Agriculture and Natural Resources).

Unventilated attics (Figure 24) are better approach, since ventilation openings are not included in the unventilated roof, which certainly will not create a vulnerable area for the ingress of embers and hot gases during wildfire. But unventilated attic are controversial, because the impotance of ventilation is to ensure humidity control in the building. If the humidity control is not provided, excess moisture may occur and the materials in the attic may rot. And rotting components ignite faster during a wildfire. Unventilated roofs have 2 features:

- The thermal insulation has been moved from the ceiling between the living area and the attic to the roof line.
- Moisture movement from the living area to roof is ensured by the placement of an air barrier on the ceiling between the living area and the attic (Quarles et al., 2010).

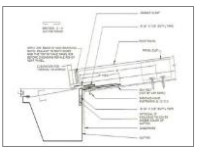
4.3.5. Gutters and Downspouts

Debris such as branches, leaves and pine needles can accumulate in rain gutters and downspouts. Debris can ignite due to windblown embers during a wildfire, and then the fire can spread to the roof and siding (FEMA, 2008a). Studies have been conducted to

evaluate the performance of gutters with both fire-resistant and combustible materials during a wildfire. Although gutter materials have an effect on the spread of fire, flammable debris accumulated in the gutters (leaves, pine needles, etc.) is a greater concern (Montana, 2010). Properly installed and maintained at regular intervals, rain gutters will not have a negative effect on the foundation and crawl space due to moisture, and provide significant moisture management for a building by collecting and carrying water (Quarles et al., 2010).

Table 12. Guidance for gutters and downspouts

Tablo 12. Continued

GUTTERS AND DOWNSPOUTS		It is standard practice to place a piece of metal flashing, known as a dropper edge, along the exposed face of the roof deck (Figure 27). This practice not only prevents moisture but also reduces the possibility of exposure to flame along the exposed edge of the roof decking (Montana, 2010). The edge of the dropper should be extended into the gutter (Springs, 2020) .
	Figure 27. Example of vegetation that is in close proximity to a structure siding (Springs, 2020).	
	A gutter made of combustible material melts quickly with ignition, leaves the rood and easily falls to the ground. Burning debris also falls along with the gutter and continues to burn on the ground. Flames can ignite the siding with embers came from the ground. Therefore, vegetation management (fuel reduction) around the building should be done well (Quarles et al., 2010).	
	It is best if the gutters are completely eliminated. Instead, the French Drain system can be used (Sonoma, 2004).	

4.3.6. Windows and skylights

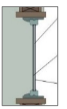
Windows that are vulnerable to wildfire have two main components. The first is glazing, the second is the frame construction (Montana, 2010). If the window glass is broken during a wildfire, embers and flames can easily enter the building. Likewise, it the window frame ignites, the fire will burn the frame material and may ignite other materials (such as curtains, furniture etc.) inside the building. In both scenarios, where two components of the window are damaged, causing the building to receive devastating damage. Therefore, windows must be resistant to the following exposures:

Figure 28. Rotted door frame (Division of Agriculture and Natural Resources).

- Radiation intence enough to break the glass in the window or ignite the siding above and below it.
- Flame exposure from fire, which may result from windblown embers igniting vegetation or from siding burning up to the window element.

During a wildfire, windblown embers may fall on the window sill or the sill of the entrance a (Figure 28). If the metarials of these components where the embers fell are rotten, they iginite at a lower temperature than solid material and cause the fire to progress faster (Division of Agriculture and Natural Resources). The importance of window materials and sizes in the spread of fire is great (Sonoma, 2004).

Table 13. Guidance for windows and skylights

Open windows are vulnerable to ember intrusion. Therefore, open windows shoul be closed during fire preparation (Sabrina L. Drill, 2009).	
Glazing	Mac Arthur (1991), tested framed windows with different materials (such as wood-and aluminum-framed) with glass and repoted that of the frame and glass components, glass is the most vulnerable component. These results are generally in line with researches conducted at the University of California Fire Research Laboratory and Australia (Quarles et al., 2010). Glass breakage occurs (Figure 29) as a result of the temperature difference between the frame protecting the glass and the glass exposed to the flame. Since the heat exposure is not homogeneous, the glass begins to expand at different rates and the temperature difference becomes larger. As a result, crack in the glass become larger and could potentially explode (Division of Agriculture and Natural Resources).  *Figure 29. Glass breakage (Division of Agriculture and Natural Resources).*
Recommended glasses (FEMA, 2008a)	Laminated glass  Tempered glass  Low-e coating  Fiberglass-reinforced translucent  Insulated glazing unit 
Not-recommended glasses (FEMA, 2008a)	Annealed glass Ceramic glass Plastic glass
Frames	*Recommended materials:* Metal, metal-clad wood (FEMA, 2008a). *Not-recommended materials:* Wood, plastic (Sonoma, 2004).
Exterior Window Shutters	During a wildfire, exterior window shutters can provide protection for windows and sliding glass doors. Instead of wooden or plastic shutters, solid metal shutters are recommended, which are unlikely to melt and ignite (FEMA, 2008a). Roll-down devices can also be mounted. In both cases, the devises should be checked and maintained at regular intervals to ensure that they are working properly (Division of Agriculture and Natural Resources).

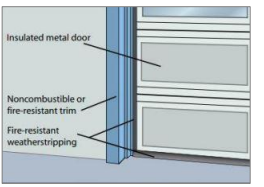
4.3.7. Exterior doors and garage doors

Exterior doors can leave the home vulnerable to the flames, windblown embers and radiant heat during a wildfire (Montana, 2010). Exterior doors are exposed to flames, windblown and radiant heat at the same level as exterior walls during a wilfire. As components properties, exterior doors are much thinner than exterior walls and have less fire resistance, so they can burn much faster and transmit fire to other components more quickly. Flames, embers and radiant heat can ignite the door and its surrounding components, as well as enter the building through the openings between the door and frame or door and threshold (or floor if no threshold exist). If the

door has a glass component, the glass may break because of the radiant heat (FEMA, 2008a).

Garage doors, like the exterior doors of the building, are vulnerable to flames, windblown embers and radiant heat during a wildfire (Sonoma, 2004).

Table 14. Guidance for exterior doors and garage doors

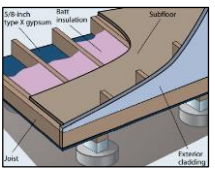
Exterior doors, garage doors and pet doors should be closed (not locked) before wildfire approaches the building. If necessary, the firefighters will find a way to enter the building (Sabrina L. Drill, 2009).	
EXTERIOR DOORS	At least two easy and safe exits should be designed at ground level so that users in the building have two alternative exits during a wildfire. For exteriors, Class A/one-hour-rated materials that can withstand fire at least 1 hour should be selected (Sonoma, 2005). Solid core doors provide better protection against both wing load and radiant heat than lighter weight hollow core doors (Springs, 2020). *Recommended materials:* Non-combustible materials such as metal or composites (Montana, 2010). *Not-recommended materials:* Wood doors are acceptable only when thay are solid core construction (Springs, 2020).
	An adjustable insulation board should be installed on the inside of the exterior door frame to prevent embers and radiant heat from entering the building between the door and the door frame (FEMA, 2008a). There shoud be metal thresholds instead of wood on the exterior doors and they should be installed at the same level so that the embers do not enter the building through the gaps (Sonoma, 2005).
	 The glass component of the decorative entry doors (Figure 35) must be made of tempered glass designed to withstand impact (Montana, 2010). *Figure 35. Example of an approved front door with tempered glass (Springs, 2020).*
GARAGE DOORS	*Recommended materials:* Insulated metal doors, steel clad model doors (Sonoma, 2005). To prevent embers and radiant heat from entering the garage, an insulating materials should be placed around the entire perimeter of the garage door (Figure 36). For the exterior that closes the opening between the door frame and the outer wall, non-combustible or fire-resistant materials such as fire-retardant-treated wood or fiber-cemet board should be installed (FEMA, 2008a).  *Figure 36. Garage door (FEMA, 2008a).*

4.3.8. Foundation and base of walls

The foundations of the building and the gaps between the siding and the foundation allow embers, flames and radiant heat to enter during the wildfire.

The foundations can be listed as closed and open foundations. Embers, flames and radiant heat can enter closed foundations directly through foundation vents or broken basement windows. Embers entering through foundation ventilation can penetrate into the basement and spread to the exterior walls. Flammable materials stored in the basement become fuel during a wildfire and create a fuel path for the fire to spread to the other components of the building. Flame, embers and radiant heat can enter the open foundation directly from under the first floor and ignite the foundation. Flammable debris (such as firewood or gas in the container) stored here and wood lattice screens can ignite and cause the fire to spread to the first floor (FEMA, 2008a).

Table 15. Guidance for foundation and base of walls

Base of the Walls	There may be gaps in the base of walls (Figure 37), columns, posts, where siding and insulation are exposed. This gap provides an entry point for embers and flames to enter the exterior walls of the building. The stud wall, between the foundation and siding, can be ignited by windblown embers and the fire can spread into the building from there. Gap should be sealed with a screen, caulk or fire-resistant foam or mortar (Figure 38). Grout materials used should have openings no larger than 1/8 inch to allow for moisture control (Springs, 2020).  *Figure 37. Base of a wall that exposed siding (green) and insulation (blue) where the foundation meet at the base of the house (Montana, 2010).*  *Figure 38. Base of the siding properly sealed with stucco and flashing to prevent exposure to the fire. (Montana, 2010).*
Closed Foundation	 Foundation ventilation should be covered with a fine mesh metal screen (Figure 39) to prevent embers from entering (Sonoma, 2004). *Figure 39. Foundaiton vent that not covered, and vulnerable to fire (Sonoma, 2005).*
Open Foundation	 *Figure 40. Open foundation (FEMA, 2008a).* In a open foundation (Figure 40), when the pile/pier is made of wood, they must be thick enough to resist ignition. Install 5/8-inch thick gypsum board to the underside of the joint points (Figure 41). Attach fire-retandent-treated plywood, fiber-cement panels or metal siding panels over the gypsum board for fire protection. Instead of wood lattice screens use chain-link fencing with metal privacy slats. Combustible debris accumulating on the open foundation should be cleaned periodically and combustible metarials should not be stored here. If the building is exposed to wildfire, an engineer should evaluate the structural integrity of the foundation (FEMA, 2008a).  *Figure 41. A 5/8-inch gypsum board attached to the underside of the joists. (FEMA, 2008a).*

4.3.9. Decks and other attached structures

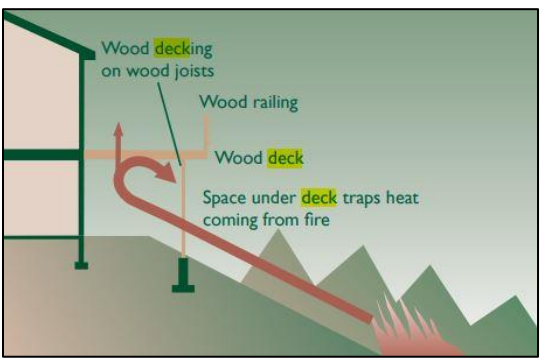


Figure 42. Conventional deck in a fire (Heat trap) (Slack, 2000).

Post-wildfire researches has shown that the initial firing point of many buildings is above or below a deck. An ignited deck endangers many components of the building and is often combined with large windows ad sliding glass doors that can break during a wildfire. So it allows the fire to enter the building and causes devatating damage to the building (Sonoma, 2004). Factors that affect decks vulnerability to wildfire are the material of the decking, combustible materials stored under or retained on the deck, the topography and condition of the vegetation (rotted wood is much more prone to ignite) leading to the deck (Quarles et al., 2010). Testing has shown that combustible deck materials are more likely to ignite from other fuel sources (firewood, debris, vegetation or ignition-prone furniture) above, below or near the deck (Sonoma, 2004). Decks and other attached structures are usually built into the slopes for the scenery (Figure 42), and when a possible wildfire moves uphill, the flames can spread under the deck and ignite the debris that accumulates there (Wilson, 2019). In this case, the deck becomes a heat trap (Sonoma, 2005).

Table 16. Guidance for decks and other attached structures

Combustible metarials such as firewood and lumber should not be stored on, under or near the deck, or debris such as leaves and needles should not be allowed to accumulate (Figure 43), and should be cleaned at regular interval (Sabrina L. Drill, 2009). The number of flammable materials such as door mats, plants in baskets, wicker furniture on the deck should be reduced (Sonoma, 2004).

Figure 43. Combustible debris under this deck ignited (FEMA, 2008a).

Embers tend to accumulate where the deck meets the exterior wall. To protect the siding, an 18 inch (45,72 cm) metal flashing should be installed between the edge of the deck and the siding, where the lap joint ends (Springs, 2020).

SITTING

Decks and other attached structures should oriented to avoid exposure to wildfire. Avoid building these structures near densely vegetated areas and topographical feature such as steep slopes, gullies, canyons, saddles, ridge tops, and narrow mountain passes (FEMA, 2008a). If the building is located on a slope and deck overhangs that slope, the defensible space should be increased so that it is not exposed to flame contact during a wildfire (Quarles et al., 2010).

MATERIAL

Heavy timber or non-combustible materials may be used in moderately hazardous wildfire zones. It should be covered with a waterproof membrane and 'one hour' rated material on it (Slack, 2000). For columns, use 6-inch x 6-inch timber, concrete block or stee; for floor joints and beams, use 3-inch to 4-inch fire-retardant-treated wood, concrete block or steel framing; for railings, use minimum 3-inch fire retardant-treated wood, metal, cables or tempered glass; for decking and stair treads, use fire-retardant-treated wood minimum 3-inch, brick, concrete pavers, see in Figure 44 (FEMA, 2008a). Wooden deck requires maintenance. Timber that is dry and split is very vulnerable to ember ingress and accumulation.

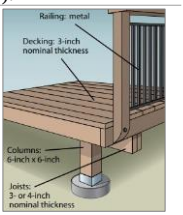


Figure 44. Deck constructed of heavy timber (FEMA, 2008a).

Composite deck is partially maintenance free compared to wooden deck. Won't rot or splinter (Montana, 2010).

Figure 45. Composite decking after the structure was lost during the Waldo Canyon fire (Springs,

FULLY ECLOSED DECK

No matter what kind of material is used on the deck, accumulation of flammable materials (such as grass, needles, debris) under the deck occurs. Covering the underside of the deck is one way to reduce the risk of ignition. Turning the deck into a solid form by completely surrounding it eliminates the risk of being a heat trap against fire (Slack, 2000). There are two ways to close the deck:

- It can be surrounded by applying a coating around it (vertical protection) or by covering the coating material on the base of the support elements (horizontal protection).
- To transform the under the deck into a enclosed space (Figure 46) (Quarles et al., 2010).

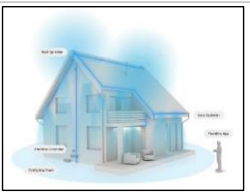
Figure 46. Above the deck is over the garage (Slack, 2000).

4.3.10. Sprinkler systems

During a wildfire, flames, windblown embers, and radiant heat can penetrate vulnerable gaps (such as gaps around the doors and windows, etc.), and airborne debris can shatter components with glazing. In a wildfire, there can be two situations in which the building acts as a fuel for the wildfire and affects the spreading

behavior of wildfire. Firstly, the fire starts from around the building and spreads into the structure, secondly, the origin of the fire is building itself. In both scenarios, internal and external sprinkler systems can prevent the building from receiving destructive damage and stop the spread of fire or interrupt its continuity (FEMA, 2008a). ‘Water can also effectively prevent fire spread onto unburned fuels, by acting as a ‘heat sink’.’ (Green, 2019).

Table 17. Guidance for sprinkler systems

INTERIOR SPRINKLER		The sprinkler system inside the building (Figure 47) is important in extinguishing endetected fires when the building is both occupied or unoccupied (Sonoma, 2005). Sprinkler should be considered in empty, enclosed spaces such as attics, as this can provide additional protection if the flames enters outside this area. For an interior sprinkler system to be effective, both water pressure and supply must be sufficent (FEMA, 2008a). *Figure 47. Interior sprinkler system (FEMA, 2008b).*
EXTERIOR SPRINKLER		Building-mounterd exterior sprinklers (Figure 48) can be configured to run water piper through the roof. If the internal pipes are used for the interior sprinkler system, the exterior sprinkler system can be installed with interior sprinkler to use the same pipes. A pressurized water tank can be considered to provide an adequate water supply (FEMA, 2008a). *Figure 48. Exterior roof sprinkler system (Frontline, 2022).*

4.3.11. Landscape fances, walls and gates

Landscape fences and walls are both functional (for security and privacy) and decorative architectural elements. They have many materials and configuraitons. Fences and gates can pose an access problem for firefighters trying to enter the yard of the building, unless they are well designed. There are several situations that cause fences to be vulnerable during a wildfire:

- The accumulation of debris (leaves, garbage etc.) at the bottom of fences.
- As a result of contact with the soil, wooden fences rot over time, and rotten wood combined with combustible debris and become a fuel for wildfire.

- The fact that a fence, wall and gate with a flammable materials are connected to the building (Division of Agriculture and Natural Resources).

Table 18. Guidance for landscape fences, walls and gates

LANDSCAPE FENCES, WALLS AND GATES

İdeally, fences and flammable components should be placed at least 10 ft (3 m) away from the building (Sonoma, 2004).

Non-flammable materials should be used for lanscape fences, walls and gates. Fences, walls and gates differ in shape, material and size, and these differences provide varying degrees protection or pose a risk during a wildfire.

Combustible materials for fences,walls and gate: Wood

Non-combustible materials for fences, walls and gate: Concrete, stone, masonry

Figure 50. Wooden framing with wire mesh (Division of Agriculture and Natural Resources)

Wood. White oak, red oak, hickory/walnut and walnut (dense hardwoods) are more resistant to fire than pine and other soft woods.

Figure 49. Plastic fences (FEMA, 2008a).

Plastic. Fences with plastic material are more resistant to fire, more durable and stronger than wooden fences in general, but plastic fences can melt during a wildfire (Figure 49), below the maximum temperature that a wildfire can generate.

Metal. Metal fences are more resistant to fire than plastic fences. Wire fences have a little or no effect on fire penetration. Though, if combustible materials have accumulated in or around the metal wire fence, the fence can act as horizontal fuel, and allow the fire to spread along the fence toward the building (FEMA, 2008a).

LANDSCAPE FENCES, WALLS AND GATES

The accumulation of debris at the bottom of fences should be prevented, reguarly maintained and make sure that the fences do not touch the soil (there shoul be about 1 inch of between the soil and the fence) (Division of Agriculture and Natural Resources).

Avoid fences with gaps, because flames is the air can get trapped in the gaps with wind and ignite the fence (Figure 51) (FEMA, 2008a).

If there is a wooden fence connected to the building, the continuity should be decayed with a fire-resistant element between the building and the wooden fence (Sonoma, 2004).

Flammable materials (such as firewood) should not be stored near the landscape fences, walls and gates (Division of Agriculture and Natural Resources).

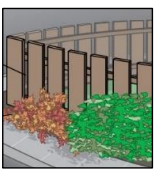


Figure 51. Debris that accumulate gaps between the wooden slats (FEMA, 2008a).

4.4. Infrastructure

Poorly or inadequate designed infrastructure hinders firefighting attempts and can put both users and firefighters at risk. In order to reduce the risk of damage caused by wildfire, measures

shoul be taken outside the building and its parcel. Emergency vehicles can both go to the wildfire area and leave the area for evacuation on the same roads (FEMA, 2008a). Firefighters need safe road acces to reach the origin of wildfire and to access to water sources. If the roads are clogged with vegetation, it poses a danger to both the user and the firefighter (Sonoma, 2004). There are two parts to access for equipment:

1. Sufficent space for firefighting equipment to access the building (the closer the better).
2. Access of emerceny vehicles to the parcel where the building is located (Division of Agriculture and Natural Resources).

Table 19. Guidance for infrastructure

ROADS AND DRIVEWAYS

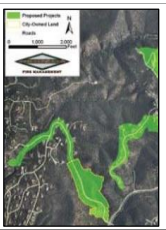
Roads should be wide enough to allow imultaneous access by evacuation and emergency vehicles. When calculating the ideal width and height of the roads, the standard dimensions of the fire trucks should be considered. The minimum width is 6,1 m for roads, 3,6 m for driveways and the minimum height should be 4,15 m, see in Figure 52. And the slope of the roads should be less than %5 (Division of Agriculture and Natural Resources).

Figure 52. Road dimensions for emergency vehicles. (FEMA, 2008a).

Street names and property addresses provide location information for firefighters at the time of critical responce. Street should be named and numberred on the sign at each intersection. The address of building should be write in bold, contrasting letters on the sign (Figure 53) at the entrance of the vehicle road or above the building (Sonoma, 2005).

Figure 53. Sign of address of the building (Sonoma, 2005).

ROADS AND DRIVEWAYS



Fuel Modification: Since wildland vegetation serves as fuel for a wildfire, reducing its colume and intensity reduces the spreading area of a wildfire. The strategic fuel modification (Figure 54), created for the path along which vegatative fuel will travel along the access and exits roads, increases safety for emergency fire equipment and evacuated citizens. Areas such as golf courses, schools and large parking lots ar very important for wildfire to be labeled as safe zones for citizens or firefighters who cannot evacuate (FEMA, 2008a).

Figure 54. Map depicting areas for planned fuel modification along evacuation routes/fire access

WATER SUPPLY

The architect can design a water element around the building (Figure 55) to interrupt the continuity of flames and embers in the fire's propagation path. In order to use the water supply during the fire spreading process, hoses should be provided that can reach to other areas of the building or other nearby buildings (Sonoma, 2004).

Figure 55. Pool deisgned by architect can provide access the water supply

Systems to provide emergency water supply:

Water tanks and pressure systems: Water tanks should be made of fire-resistant materials such as concrete, steel or ferrocement. Fiberglass tanks can be placed underground (FEMA, 2008a).

Dry hydrants: It is a non-pressured piping system to nearby water source (such as lake, stream, pond, residental pool), with a minimum water depth of 2 ft or allowing fire equipment to access the water supply (FEMA, 2008a).

5. Conclusion

Wildfire is one of the disasters that has existed since the beginning of the history and left devastating damage that affects humanity both indirectly and directly. In a good architectural design, it should give importance to function and durability as much as it gives importance to form. Because it is the durability that keeps the structure standing. The building is a rather important concept for a devastating disaster such as wildfire that affects people ad nature,

because the structure itself also serves as fuel for a wildfire. Architecture is one of the professions that is most associated with concepts such as fire resistant building, the survival of the user and building. As a result of the analyzes made, it can be seen that the environmental and building envelope components act as a chain reaction in wildfire and the weakness that occurs in each component is caused by design, and therefore caused by the architect.

As mentioned in the introduction, in the ethical codes that exist in many countries today, the relationship of the architect with the public, profession, the environment and responsibilities to them directly affect the designing buildings in wildfire zones and reduce the loss of life, property and damage to the environment caused by wildfire. In line with ethical codes, there are regulations and design guidelines on the building resistant to wildfires in most countries, as well as on buildings in general. The purpose of these rules is to minimize the spread and damage during the wildfires and to take precautions against the causes of damage seen in previous fires.

According to the FEMA P-737, components that affect wildfire spreading behavior and possible damage can be listed as site selection for the building considering slope of the topoghraphy, distance between wildland vegetation and the structure, defensible area around the structure, building envelope components and community infrastructure. These components work like an interconnected network during the wildifre. They form the steps of the diffusion process. If the resistance to fire is low in any of these components, the fire passing to the next component accelerates the spread and reduces the user's escape time and increases the damage seen by the structure. The building becomes fuel for the wildfire. Therefore, each component must be designed with fire resistance and its effects on fire spreading behavior in mind. To summerize, the place, destruction and effects of wildfires in human life are definetly not discussed, especially due to the apparent increase in the number of wildfires that occur with the increase in drought and global warming. Considering the damage caused to the environment and structure by wildfires, which are increasing every year, the architect

has a lot of responsibility in accordance with the design decisions he/she makes. In this context, the architect should take fire resistant design decisions for reduce loss of life, property and damage to the environment in wildfire zones.

As a result, it is observed that there are few studies on building design guidelines in the face of wildfires around the world. In this study, the existing deisgn guidelines for housing, which is one of the building groups affected by wildfires, were compiled in a collective way to examine interaction between architectural ethics that shape the building environment and the wildfire effects. In addition to the this study, the building groups most affected by wildfires can be identified and building resistant guidelines for building groups other than residental buildings.

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CHAPTER III

An Ideal Form for Developing Landscape Understanding in Interiors; Patio (Pasyo)

Feran AŞUR[1]
Elif AKPINAR KÜLEKÇİ[2]

Introduction

The concept of sustainability is increasingly becoming an important part of daily life. Basically, sustainability conditions can only be achieved by protecting the environment. A significant portion of environmental pollution and energy consumption is caused by buildings. Today, due to factors such as the increase in population in big cities, the increase in land prices and the advancement of technology, modern man has transformed the shape and structure of houses from old garden houses to apartments, compact buildings and skyscrapers. Therefore, the building sector is

[1] Assoc. Dr., Van Yuzuncu Yil University
[2] Assoc. Dr., Ataturk University

being reshaped and new solutions are being sought to eliminate these problems.

Traditional architecture has always provided practical solutions to ensure people's health and comfort. Human beings have met their needs by using these practical solutions. In the period when modernism and industrialization began, traditional values were replaced by architecture without identity (Aycı & Boyacıoğlu, 2012). This new trend was far from showing flexibility and adaptability to the environment in different climates and different needs (Sağıroğlu and Barkul, 2011). Today, with environmental pollution, the increasing importance of environmentalism and sustainability has emerged again.

When traditional buildings are analyzed, it is seen that these buildings are much more sustainable in terms of production and the energy they consume in the process of use, and that they are shaped in a way that is sensitive to the environment and controls environmental conditions. It is also possible to see environmentalist approaches in traditional Iranian housing solutions. With the special solutions introduced at the building scale, the buildings have provided healthy living conditions for people without the need for excessive energy consumption (Yardımlı et al., 2018).

In Mediterranean countries from 600 BC to the 17th century, arbors with vines and ivy plants attached to the walls of villas began to take place in people's lives. During these periods, climbing roses were considered sacred in places such as castles and mansions and found a place of use for themselves (Tong, 2013). In the first historical periods, farmers who cultivated plants brought plants indoors. Romans built primitive structures similar to greenhouses to protect their vines, vegetables or fruits (Yazgan et al., 2003). Başaran (2016) explained that plants designed to define a certain area and give identity can become an important element of indoor landscaping and that these areas decorated with live plants indoors can satisfy people's longing for nature, even if it is a little. According to Eroğlu and Başaran (2017), these areas in interiors provide

benefits in important issues such as air quality, heat and energy budget, appropriate natural lighting. At the same time, these spaces have the quality of providing visual comfort as a space that conveys the perception of space, positive impact and aesthetic feelings to users. According to Yazgan et al. (2003), bringing the natural landscape indoors is a fundamental goal for the integration of landscape with space. It is possible to achieve this goal with the intensive use of plants indoors.

The inclusion of plants in the concept of indoor landscape is based on a recent history. With the end of the Second World War, the understanding of landscape in interiors has developed (Eroğlu & Başaran, 2017). According to Conklin (1978), landscaping is necessary to ensure natural balance in enclosed spaces such as offices, residences and public buildings where a significant part of life is spent. The aim of interior design is to create a livable environment by reinforcing the functional, aesthetic and psychological aspects of interior spaces. At the core of the design process is the achievement of specific goals by each designed piece. In interior design, selected elements serve as functional, aesthetic and behavioral guides (Ching, 2004; Kahveci, 2023). The main functions of the plant used in interior designs can be shown as aesthetic concern, feeling of vitality, positive effect on people, contribution to air quality, etc. (Eroğlu & Başaran, 2017).

The importance of these elements is better understood day by day due to the change in the way of life, the decrease in green areas, environmental problems and the increase in human mental disorders. Architecture has always endeavored to bring the lost green areas of buildings back to homes. Kahveci (2023) listed the design approaches in indoor plantings as vertical gardens, water gardens, winter gardens, in-glass designs, terrarium, hanging-potted plant design, live plant tables (boards), conceptual plant designs.

In the face of depleting natural resources and environmental pollution, human beings should consider the concept of sustainability for a healthy life in the future. Sustainability

conditions can only be achieved by protecting the environment. A significant portion of environmental pollution and energy consumption is caused by buildings. Architecture has always been in an effort to bring the lost green areas of buildings back to homes. The design of interior gardens, which will contribute to making the interiors where we spend a significant part of our lives more livable and creating a quality landscape composition, has been considered throughout the history of architecture. For this reason, elements called "Patio", "veranda", and "Atrium" are encountered in contemporary architecture. In the related literature review, it was concluded that these structures are rooted in Iranian architecture and come from evolved gardens (Akbaripour 2017; Anonymous, 2023a).

In Iranian architecture, in order to provide sufficient daylight and visual comfort, a section called Pasyo (Patio) is usually built in the middle of the house as a semi-open area, closed on two, three or four sides, with ornamental plants that can grow indoors and usually with an aesthetic design that includes a water element. European architects recognized the value of these elements and took advantage of them by incorporating them into their architecture and adapting them to the tradition, culture and climate of each region. Today, in many modern designs, as in sustainable architecture, it has been widely recognized by the designers and users of buildings.

Architectural elements such as paseos, verandas and atriums create a sense of interaction, which is very important in interior spaces. Low height evergreens and seasonal flowers are often used to create a permanent and beautiful green space in the environment. This study focuses on the importance of the patio as an ideal form for developing a sense of landscape in interiors and explains its place in contemporary architecture.

Atrium Features

The construction of the first atrium in a house with a central courtyard around Mesopotamia dates back to 3000 BC, following the central courtyards of ancient Roman buildings called atria (Modirrousta and Boostani 2016). The atrium has been used for

centuries and since antiquity as a large, bright and common central space in non-residential centers (Gadi and Mahmoudi Zarandi 2016). In modern architecture, an atrium refers to a large space and openings, usually several stories high and covered with a glass roof or large windows or both. Nowadays, atriums create spaces protected from wind and rain, often built vertically several stories high, which provide light as well as allowing the planting of beautiful tropical trees (Wang and Abdullah 2012; Mofidi Shemirani and Madeni, 2018). With glass roofs, solar energy enters through the roof in winter and heats the building. In summer, it is possible to open the roof to take advantage of the exhaust absorption feature and make natural ventilation. In addition to capturing light and having indoor green spaces, the atrium is also used to reduce energy consumption and is considered in sustainable designs (Hung and Chow, 2001; Ziyayoun, 2011). Atriums are generally classified into five different categories: central, integrated, linear, connection and peripheral. The functioning of the atrium takes advantage of two natural phenomena: the greenhouse effect and the convection effect (Mofidi Shemirani and Madeni, 2018).

Ancient atriums were known as large interior spaces, central courtyards and enclosed spaces. In the Middle Ages, the courtyard of churches, the gathering place for religious groups, was called an atrium. The historical background of this element dates back to the open courtyards of Roman houses, whose main function was to provide controlled light and ventilation. In the 18th century, with the knowledge of the heat retention properties of glass, these spaces were enclosed with glass. In the 1980s, with the increasing need for light in interior spaces, the use of atriums in most public, commercial and office buildings became widespread for residents, travelers and gathering people and students (Madeni, 2015; Ziaiyoun, 2017). The atrium provides an impressive aesthetic space by exposing neighboring interior spaces to daylight, maximizing the benefit of direct solar gain, and enhancing residents' socialization and interaction (Saxon 1983; Bednar, 1986; Bryn, 1993; Pfafferott et al., 2004). It also provides air circulation and communication between

the different floors of the building. In addition, the atrium is considered as a factor that contributes to the increase in the market value of buildings (Laouadi et al., 2002; Encinas, 2004).

Veranda Features

Veranda (Spanish: Baranda), taraça or terrace (Italian: Terazza) is a large porch or balcony on the ground floor of buildings, flush with the ground or elevated, covered with a roof, with open or glazed sides. Today, the patio has become a highly preferred space in the world and is considered a semi-private space, a transition from public to private space. Verandas can have a water or plant element or both (Köse, 2007). In Brazil, a country with a predominantly warm-humid or semi-humid climate, the most common transitional space in architecture is the patio, a shaded area such as a porch or gallery that has been present in the country's architecture from the beginning. Characterized as a solution originating from traditional architecture, the patio has been firmly incorporated into the local architectural lexicon through the design strategies of Brazilian architects (Kapstein, 1988; Vieira Maragno and Coch Roura, 2010). The veranda was introduced by the Portuguese and gradually adapted to tropical conditions. It became even more widespread in the twentieth century with the introduction of modern architecture (Vieira Maragno and Coch Roura, 2010).

Verandas are a special type of transitional space, acting as filters of the myriad environmental conditions between inside and outside. They acquire many functions in shelter, family life, leisure, entertainment, social gatherings and events and even business. All these activities are protected from sun, wind, rain, natural light and contact with the surrounding environment of the city or nature. From an environmental perspective, a patio can be briefly conceptualized as a habitable, covered intermediate space attached to a building and open to the outside from one or more sides (Vieira Maragno and Coch Roura, 2010). Especially in detached reinforced concrete structures and modular structures, verandas are frequently preferred; they can be constructed using wood, concrete, steel and even stone

materials, or they can be manufactured ready-made in factories and presented to the user. Generally, in order to provide a permanent and beautiful green area in the environment to provide a quality landscape appearance, four-season plants with short stature and seasonal flowers are used (Anonymous, 2023 b). The veranda, which is the open space of the house, is generally a semi-public space; however, this situation varies according to the differences in cultures' social relations, privacy and sovereignty. For example, the traditional Chinese house has developed around an enclosed inner courtyard; this is the result of the desire to ensure family control, not privacy (Xu, 1998).

It is possible to list the advantages of verandas as providing extra living space for building owners, increasing property value, providing protection against the negative effects of sunlight (due to the roof on the top of the veranda), protecting from adverse weather conditions, and providing a sustainable structure.

Differences Between Patio and Terrace

Of these two elements that are different from each other, the veranda is the continuation, that is, the extension of a structure. The veranda, which can be built zero to the ground, can also be manufactured with a slight height. Although a suitable heating system is installed in the veranda, it is not possible for it to be a continuous living space. On the other hand, the terrace has a high platform structure. In short, areas that are higher than the ground can be called terraces. Even the top floor of a building can be a terrace. Also, a terrace doesn't always have to have a roof. But when it comes to a patio, it is mandatory to have a roof. In addition, unlike a terrace, a veranda can be heated with the appropriate heating system, while a terrace is not suitable for heating. Therefore, while the terrace is mostly used in the summer months, the veranda covers an area that can be used in all four seasons (Xu, 1998; Anonymous, 2023c).

"Pasyo (Patio)" Features and Elements

The Pasyo (Patio in French), nowadays mostly part of Iranian architecture, commonly found in houses, is a space that provides light to its surroundings, usually built next to the house hall (Figure 1), with a small pool in the center and an opening in the roof (Pirnia, 2004). In this space, the wind enters the building through the hole in the roof and can pass through the pool, helping to ventilate this space and providing moisture (Von Hardenberg, 1982). The patio is basically a light-absorbing space for indoor environments that makes it possible to increase the natural light of indoor spaces of buildings as an architectural feature. The function of the pelmet in the home is to provide sufficient light, green space and aesthetically visual comfort. The advantages of these structures are that they can reduce the need for electric lighting of a building, as well as provide an open space that can be used as an outdoor area or garden (Akbaripour, 2017; Sahebzadeh et al., 2020; Anonymous 2023a; Anonymous 2023d).

Figure 1. *Examples of patio next to the house hall, providing light*

The first examples of patios in history are the Andalusian patios. Andalusia is the name of a part of southern Spain, the beginning of the Muslim occupation, and it was in this part that most of the important Islamic buildings were built (Escudo, 2012). One of the signs of Patios (Pasyos) built during the Islamic period was the presence of metal or wooden windows, which were characterized by

having views from the inside out without being visible from the outside. These areas were reminiscent of the gardens of paradise (Paradays) in Iranian architecture, with elements such as fountains, water shows and the harmony of painting and relief ornamentation on the surrounding walls. Among the many extant examples of the first patios in Andalusia, the best collections are in the Alhambra Palace and the Caliphate Palace of Córdoba (López and López, 2000; Araujo, 2009). During the Renaissance, patios became a standard element of the home. In the 17th century and again in the 19th century in Europe, this central courtyard (patioo) was used as the entrance filter of the house (Cameron, 2016). The name patio has been heard since the 1900s in the city of Toronto, Canada, referring to the space in front of cafés or restaurants. The common type was the placement of tables and chairs in the open spaces of restaurants, usually connected to the sidewalk or alley. The patio traveled to Latin America in 1940 and adapted to the culture of that region with a change in structure (Bateman, 2015). In some of today's atriums you can see tropical plants, which many mistakenly call patios. However, according to the differences mentioned, not all places with flowers and plants can be called "Patio (pasyo)". For example, balconies of houses decorated with flowers are not patios, while backyards with plants or light and fountains, although somewhat similar, do not fit the general definition of patios (Akbaripour, 2017).

Advantages of Patios

The advantages of indoor patio units can be listed as follows:

- Helping to ventilate the indoor environment and provide fresh air,

- To make it possible to increase natural light in interior spaces,

- Visual improvement of the home in interior design,

- Creating a pleasant and green atmosphere inside the house,

- Adding value to the house when selling,

- Provide the possibility to use flower pots inside,

- Providing the opportunity to plant vegetables and similar greenery,

- Creating a space for recreational activity,

- Providing lighting for the house

As mentioned, plants and water are the main components in the Passios, while in the atrium any special elements may not appear. Atriums are empty spaces between buildings used only for lighting. In recent years, architects have been able to make the atrium one of the elements of sustainable architecture by taking advantage of the greenhouse effect in atriums and using them to heat the building. However, in addition to lighting in homes, passages can improve the air, calm the mind, and also serve as areas suitable for resting, gathering and eating (Anonymous, 2023e).

Considerations in Patio Design

In general, according to building design rules in terms of urban standards, on plots of less than 200 square meters, it is appropriate that 6% of the main area of the house (at least 12 square meters of the house) is exposed to sunlight and illuminated, and in the secondary parts of the house this amount is considered to be 3%. In order to convey the different feeling of the Patio part of the house, various methods can be used to separate this part from the other areas of the house. Different floor coverings can be used to add aesthetic value to these areas (Figure 2). Wooden poles, metal fences, bamboo wood or water surfaces can be used to separate the patio from the rest of the house. During the design and construction of the patio the prerequisites for installing plumbing, such as laying pipes and placing the pump, etc., must be fulfilled (Akbaripour, 2017). Another important and fundamental practice in patio implementation is the ventilation of this space. Accordingly, in order to use certain plant varieties, it is necessary to take into account the necessary information about the growing conditions and ecological requirements of these plants. In addition, the paseo floor should have

a suitable slope and surface water drainage system (Akbaripour, 2017; Rostamzad, & Khanmohammadi, 2021; Anonymous, 2023e). In addition, if the kitchens or rooms of two independent housing units receive light from one podium, the windows of these units should be 4 meters away from each other.

Figure 2. Various patios (Pasyos) with aesthetic values

Patio Roof and Ceiling Lighting

With the advancement of technology, new materials and compounds have entered the construction industry and among the most important of these are polycarbonate compounds. These structures have many applications in patio roof construction and their use will provide many benefits. These structures are lightweight and durable and can be produced in different patterns and colors. In addition, polycarbonate structures benefit from a very high resistance to water and sunlight, and with proper ironwork, they

become an ideal roof for different parts of the house. These structures transmit light well and the combination of this feature with other properties has made polycarbonate roofs an outstanding option for patio roof construction.

Structures made of fiberglass, polycarbonate or light-reflecting bubble sheets are often used to cover these roofs, and the distinctive features of these sheets increase the durability of the patio roof. Skylights are considered a good option to take advantage of natural sunlight, but these points should be taken into account in their construction: The transparent surface of the skylights should not be less than the required surface of the house windows. The minimum level of skylight in staircases should be 9% of the area of each floor and not more than 4.5 meters per floor (Akbaripour, 2017; Anonymous, 2023e).

CONCLUSION

Sustainability is a development plan that meets the needs of today's people but without destroying the resources that future generations will need to meet their own needs. Sustainable architecture is a general term for buildings designed to limit humanity's impact on the environment. When traditional buildings are analyzed, it is seen that these buildings are much more sustainable in terms of production and the energy they consume in the process of use, and that they are shaped in a way that is sensitive to the environment and controls environmental conditions. This approach brings an environmentally friendly perspective to modern buildings. The term sustainability covers every aspect of the planning and construction process, including the selection of construction materials.

The design of interior gardens, which will contribute to making the interiors, where a significant part of life is spent, more livable and creating a quality landscape composition, has been considered throughout the history of architecture. For this reason, today we encounter elements called "Veranda", "Atrium" and "Patio". In this study, the role of Patios, which can improve the

quality of life of interior spaces in houses, is emphasized. In general, in Iranian architecture, the Patio is a semi-open area in the house and mostly in the middle of the house, closed on two, three or four sides, which includes ornamental plants that can grow indoors and aesthetic design that usually includes water element, this unit can take its place in the houses in many regions of Turkey.

For this reason, it is suggested that intermediate spaces such as patio should be included in the architecture of houses by playing an important role in providing natural lighting, providing indoor comfort conditions, creating a moderate microclimate and spatial articulation in buildings by taking its place in apartments and detached houses.

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CHAPTER IV

Architectural Value Analysis for Boutique Hotels*

Zehra Nur ÖNCEL[1]
Fatih SEMERCİ[2]

Introductıon

Accommodation structures are defined as residences programmed in line with the needs of people such as temporary rest, entertainment and work. After the second half of the 20th century, tourism activities, which have diversified depending on changing

[1] MSc Architect, Necmettin Erbakan University, Institute of Science and Technology, oncelzehranur@gmail.com, Orcıd: 0000-0001-5468-7395
[2] Assoc. Prof. Dr., Necmettin Erbakan University, Faculty of Fine Arts and Architecture, Department of Architecture, Konya/Türkiye, fsemerci@erbakan.edu.tr, Orcıd: 0000-0002-1017-5141
* This study is based on Zehra Nur ÖNCEL's master's thesis **entitled "Architectural Analysis Proposal for Renovated Boutique Hotels in the Context of Innovation: An Example of the Mevlana Region"** is derived from her master's thesis entitled.

user demands, have led to the diversification of accommodation facilities. At the same time, the realization of innovations in many fields in the tourism sector and the spread of technology have made it necessary for accommodation establishments to incorporate these innovations. The fact that users spend a long time during their stay and prefer them again according to their satisfaction causes businesses to constantly renew themselves and make innovations that will bring them to the forefront (Emir, 2007). The continuous use of similar products, services, processes or technology in hotels negatively affects user satisfaction and leads to alternatives. As a result of all these developments, boutique hotels have emerged as a type of accommodation need.

CLASSIFICATION OF HOTELS AND BOUTIQUE HOTELS

Today, accommodation structures have diversified according to the type and location of the service provided due to the change in the service sector. They have become places that provide services to meet many different expectations. In our country, accommodation establishments are classified as Hotel, Boutique Hotel, Motel, Apart Hotel, Holiday Villages, Pension, Camping, Camping, Apart Hotel with the "Regulation on Certification and Qualifications of Tourism Facilities" (T.C. Official Gazette, June 1, 2019, number: 30791). The classification of hotels, which constitute an important part of tourism facilities, is determined according to their types in the world and according to their qualifications in line with the conditions determined by the Ministry of Tourism in our country. Many factors are taken into consideration when classifying hotels. The main criteria are the location of the building, its size, interior design, decoration, service standard, the comfort it offers to the customer and the understanding of management (Özer, 2017). According to the specialized services they offer, hotel structures offer innovations

such as personalized services and unique space designs. Boutique hotels stand out among these hotel types.

Boutique hotels are generally defined as hotels with interesting, luxurious, unique, sincere and innovative designs. They have a unique identity that differs from large chain hotels by offering personalized service (Baş, 2003). It serves with the understanding of hotel management in line with the needs of consumers with high expectations in search of difference.

The main features of boutique hotels are listed as unique identity, modern character, details, high quality architecture and stylish interior design (Karacaer, 2013). These hotels have a modern character with a unique identity, are designed with a combination of advanced technological solutions and contemporary design, attach importance to user satisfaction, and have a friendly atmosphere (Forsgren & Franchetti, 2004). At the same time, boutique hotels, where different cultures, flavors and places are experienced, are in a different position from other hotels.

METHOD

In order to provide a basis for the study, the design decisions in the exterior, interior, lobby and rooms of the hotels were reconsidered holistically within the scope of the boutique hotel. In line with this information, architectural value criteria were determined in the sample building.

In the field study, firstly, the building identity of Hich Hotel, one of the boutique hotels in Konya Mevlana Region that have been re-functionalized or converted from traditional buildings, was created by making a preliminary assessment of the extent to which it meets the physical conditions listed in the Regulation on the Qualifications of Tourism Facilities (Table 1). At this stage,

interviews were made with hotel reservation websites, the owner and staff, and information about the building was collected.

Table 1 Boutique hotel regulation analysis table

NAME OF BUILDING:	**BUILDING NO:**
NUMBER OF ROOM: NUMBER OF BEDS:	
BOUTIQUE HOTEL REGULATIONS	
Number Of Room (10/60)	
Special Design / Antique furnishing, decoration, decoration, equipment materials	
A la carte restaurant	
Reception - seating area in the lobby at a rate of 25% of the bed capacity	
Management room	
Air conditioning in general areas	
Wifi in public areas and rooms	
5-Star hotel quality comfortable bedrooms	
Illuminated mirror in room bathrooms	
Luggage room	
Laundry/ironing service	
Car parking service	
Experienced administrative staff	
at least one of the units of multi-purpose hall / meeting hall / theatre hall / cinema hall / restaurant / cafeteria / breakfast hall	

For the proposed methodology for determining the architectural value of boutique hotels, the buildings were first divided into two groups as interior and exterior. This classification is due to both the difference in space and the fact that the interior space is more important in user preferences.

In the literature research, it was seen that the exterior space and design of boutique hotels are affected by location, orientation, transportation, accessibility, distinctiveness, harmony with the urban

texture, legibility, landscape and identity. In this direction, the definitions of exterior design criteria and how they can be achieved are summarized in the table (Table 2).

zTable 2 Analysis criteria for the exterior of a boutique hotel

EXTERIOR DESIGN CRITERIA OF BOUTIQUE HOTELS	
LOCATION EFFECT	The boutique hotel being in the city centre (a), being in the historical texture (b), being close to historical buildings (c) (Can, 2014).
ORIENTATION	The recognisable location of the hotel and its entrance, with images that will be a reference around them (Sönmez & Önder, 2015; Yum, 2021).
TRANSPORT ACCESSIBILITY	Easy access to the hotel by public transport etc., improvement of access facilities (Keskin, 2015).
DISABLED ACCESS	Creating necessary distances, areas and ramps for disabled people (Opak, 2009).
DISTINCTION	The façade character of the hotel should be clear and striking. (Sönmez & Önder, 2015; Yolcu, 2006).
HARMONY WITH THE URBAN FABRIC	The hotel's mass and vinim values should be in harmony with its surroundings (Enç, 2009).
READABILITY	The character of the facade represents the hotel (Kancioglu, 2005; Sönmez and Onder, 2015).
VIEWS	The relationship of the rooms with the landscape (Öztaş, 2019; Pinar, 2009).
CHARACTER/IDENTITY	The hotel has a unique identity (Öktem, 2007).

The interiors of hotels are designed with a holistic approach that can meet many needs, offer different solutions and have an attractive image. Image, style, comfort and environment factors come to the fore in interior design. The design of the characteristic features of the decoration, form and details with the reinforcement elements in the space is very important (Opak, 2009; Yıldırım et al., 2008).

In the study, four different approaches to interior space were realized in terms of functional, aesthetic, semantic and physical aspects. Accordingly, the design criteria classified as spatial organization, visual design, visual perception and physical comfort are shown in the table (Table 3).

Table 3 Analysis criteria for interior space in a boutique hotel

INTERIOR DESIGN CRITERIA FOR BOUTIQUE HOTELS		
SPATIAL ORGANISATION	FLEXIBILITY	Having flexible spaces that allow a wide range of functions within the hotel (İslamoğlu and Usta, 2018; Opak, 2009).
	FUNCTIONALITY	Functional design of the spaces in accordance with the needs programme of the hotel (Bayram, 2011).
	CIRCULATION	Meaningful and uninterrupted circulation and circulation between spaces (Yolcu, 2009).
	SPATIAL COMFORT	Ergonomic solutions in the lobby (a) and bedrooms (b) (Altınok, 2007; Bayram, 2011).
VISUAL DESIGN	COLOUR	Creating a positive, inviting effect with the use of warm colours throughout the space (Opak, 2009).
	MATERIAL / TEXTURE	Flooring and wall materials are original, decorative (a) and functional (b) (Kozak and Emeksiz, 2002)
	ARMONI / SENSATION	The dimensions of the space (a), the reinforcement materials in the space (b), the colours in the space (c) are compatible (Canbolat, 2017, Orhan, 2019)
	CONTRAST	Providing contrast with different sizes/forms (a), materials (b) and colours (c) in the space (Şentürk 1999; Kaptan, 1997)
	REPEAT-RHYTHM	Providing mobility with regular repetition of visual elements in the space (Kaptan, 1997, Özkan, 2007)
	ORIGINAL REINFORCEMENT ELEMENT	Use of modern, antique, etc. original furniture and decoration (Aggett, 2007; Kervancıoğlu, 2019)
VISUAL PERCEPTION	INTEGRITY UNITY	Boutique hotel spaces in accordance with the general concept, visual integrity (Orhan, 2019).
	SIMILARITY	Designing the forms used in space in harmony with objects and other forms (Kaptan, 1997).
	CONTINUITY	Providing continuity between spaces with form, colour and texture (Öktem, 2007)
PHYSICAL COMFORT	SAFETY	Taking security measures in and around the boutique hotel (Durna and Babür; 20 11;Opak, 2009)
	LIGHTING	Preferring innovative lighting devices and light sources (Sümengen, 2003: Kozak and Emeksiz, 2002).

	HYGIENE/CLEANLINESS	Cleanliness of rooms and dining areas (Öztürk and Seyhan, 2005)
	THERMAL COMFOR	Use of technological systems for heating and cooling (Opak, 2009)
	ACOUSTIC COMFORT	Use of materials to prevent noise (Opak, 2009; Ünlü, 2003)
	TECHNOLOGY EQUIPMENT	Mobile applications, social networking services and smart technological applications (Çolak and Karakan, 2021; Dubey, 2016).
	SUSTAINABILITY	Environmental sustainability (a), economic sustainability (b), social sustainability (c) (Ayaş 2007; Vatan and Poyraz, 2016).

FIELD STUDY

Mevlana Region in Konya is a region where tourist activity is intense and there are many historical buildings. There are many qualified and unqualified hotels around it. Boutique hotels in the region stand out from other hotels with their unique design, quality service understanding and innovative practices and are preferred primarily by foreign tourists coming to the city. Since these businesses follow the change in the sector by considering customer satisfaction and are open to development, Hich Hotel in Mevlana Region is analyzed in this section.

Located on Celal Street in Aziziye Neighborhood, Hich Hotel is very close to Mevlana Tomb. The rear façade of the building faces Amil Çelebi Street, which is located to the south of Mevlana Dervish Lodge. There are hotels and commercial spaces for touristic purposes in the immediate vicinity of the building located in the city center within the historical texture. Two adjoining traditional Konya Houses with a special location were re-functionalized in 2012 and started to serve as a boutique hotel. It is thought that the houses were built in the first half of the 20th century (Aydın, Yaldız and Sıramkaya, 2019).

The 415 m² building consists of basement + 2 floors. It has an interior room plan type, which is frequently seen in the traditional residential architecture of the city. However, during the restoration, interventions were made to its original facade, material and plan scheme, and changes and arrangements were made according to boutique hotel standards. The originality of the building was distanced from the originality of the building with inappropriate interventions (Ceylan, 2019).

The first residence known as Serkan Vanlı-Recep Altınok House is block A, and the second residence known as Mustafa Yıldırım House is block B. On the ground floor of Block A, there is an entrance and reception area accessed by a staircase from Celal Street, two guest rooms and a large sofa opening to the garden. The basement of the building has a kitchen, technical spaces and an administration room. The first floor serves as a bedroom with 3 rooms.

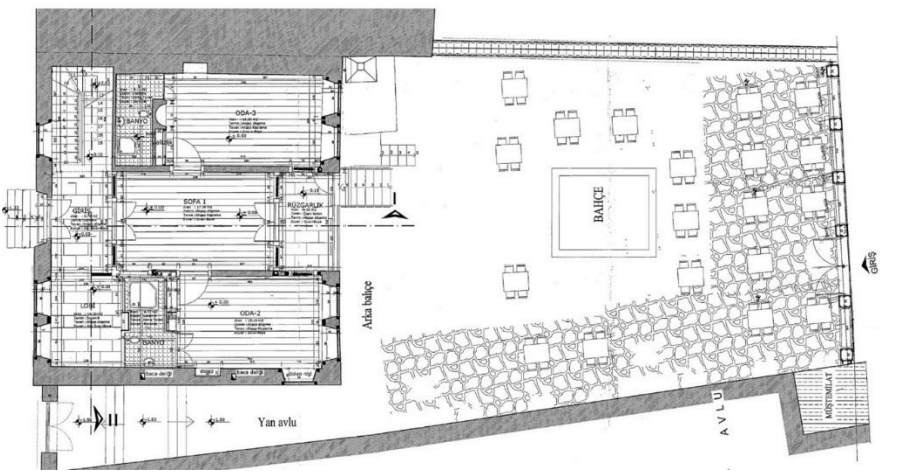

Figure 1 Hich Hotel A Block ground floor plan diagram (Karatay Municipality archive)

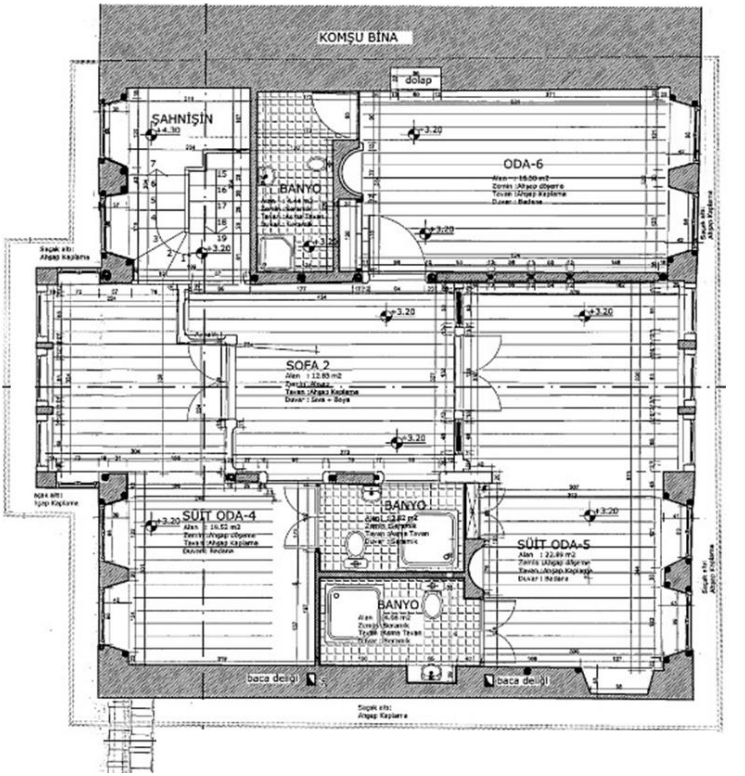

Figure 2 Hich Hotel A Block first floor plan diagram (Karatay Municipality archive)

Celak Street entrance of block B was closed and this section was included in the suite room. The entrance to the hotel is provided from the side courtyard. The buildings are connected to each other in the dining hall illuminated by skylights in the basement (Aydın, et al, 2019). There are hotel rooms of different sizes on the ground floor and first floors of both buildings. There are 5 rooms in Block A and 8 rooms in Block B, totaling 13 rooms. Some interventions were made in the plan scheme of the historical houses in order to create bathroom-toilet spaces in the room and to make room arrangements (Ceylan, 2019).

According to the boutique hotel regulation, the criteria provided by the hotel are shown in the table as follows (Table 4).

Table 4 Analysis of Hich Hotel according to boutique hotel regulations

NAME OF BUILDING: HICH HOTEL	
NUMBER OF ROOM: 13 NUMBER OF BEDS: 13	
BOUTIQUE HOTEL REGULATIONS	
Number Of Room (10/60)	**X**
Special Design / Antique furnishing, decoration, decoration, equipment materials	**X**
A la carte restaurant	**X**
Reception - seating area in the lobby at a rate of 25% of the bed capacity	
Management room	**X**
Air conditioning in general areas	**X**
Wifi in public areas and rooms	**X**
5-Star hotel quality comfortable bedrooms	**X**
Illuminated mirror in room bathrooms	**X**
Luggage room	**X**
Laundry/ironing service	**X**
Car parking service	**X**
Experienced administrative staff	**X**
at least one of the units of multi-purpose hall / meeting hall / theatre hall / cinema hall / restaurant / cafeteria / breakfast hall	**X**

Hich Hotel Outdoor Review

The boutique hotel has two entrances from the back and front facade. The garden entrance faces the Mevlana Museum and the rose garden. The dining hall in the basement, which serves for common use, is also open to outside customers and the courtyard is actively used for this purpose. The building is successful in terms of directing the user to the hotel and attracting attention with its location, garden

and facade. The storey height, façade elements and materials are compatible with the historical texture. However, due to its traditional architecture, the facade character is insufficient to represent the hotel. It has an eclectic identity where many styles coexist, especially in its interiors. The building establishes a relationship with daylight and landscape. The steps at both entrances pose a problem for disabled individuals.

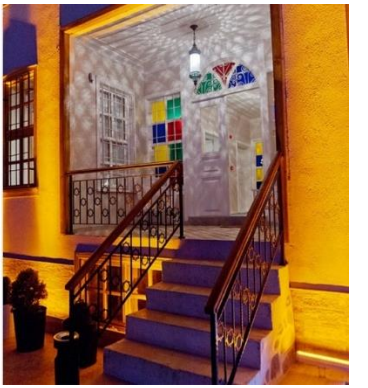

Figure 3 Hich Hotel facade (URL-1 and URL-2)

Hich Hotel Spatial Organization Evaluation

The reception area, which was used as a room before being converted into a boutique hotel, is located in a narrow area to the right of the entrance hall. While there is a lobby area in Block B, there are no seating areas except in front of the reception desk in Block A, where reservation procedures take place. This block, which has intense circulation during the day as it serves common use, is more disadvantaged in terms of privacy and noise. The dining hall of approximately 90 m² on the basement floor, which is used as a café and restaurant, is suitable for communal use. The bedrooms ranging between 15 and 22 m² meet the spatial requirements. Fittings are placed in a way to allow circulation. Built-in wardrobes and

niches facilitate the use of the space. The 4 m² wet areas are small but functional (Figure 4).

Figure 4 Hich Hotel wet areas (URL-2)

Hich Hotel Visual Design and Visual Perception Evaluation

Wooden ceiling tiles and walls painted white create a sense of spaciousness in the space. The contrast effect is enhanced by the use of colored stained glass on the ground floor entrance doors. The geometric Seljuk patterns of the ceramic floor coverings at the entrance customize the space by providing a repetition/rhythm and contrast effect (Figure 3). While nostalgic and local architecture is felt in the reception and dining room, the bedrooms are designed in a more modern way. These fittings can be listed as lighting elements, desk and chair with metal surfaces (Figure 6). Wood and stone texture details on the walls of the room draw attention. The woven carpet consisting of Anatolian motifs leaves an intimate effect unique to the boutique hotel. A harmonious design approach is dominant in the whole. By maintaining these design decisions in other spaces, integrity is ensured within the hotel.

Figure 5. Hich Hotel reception and dining hall (URL-2)

In the dining hall, the stone walls, wooden ceiling, columns, beams and horizontal beams were preserved as they were. The space, which combines the new and the old, draws attention with its original fittings, modern and classical furniture, decoration materials and lighting elements (Figure 5).

Figure 6. Hich Hotel individual usage areas (URL-2)

Hich Hotel Physical Comfort Rating

The rooms have air conditioning, coffee/tea maker, iPhone docking system, mini bar, safe deposit box and LED TV (URL-3). In addition to in-room security measures, there are security cameras, smoke alarms and fire extinguishers in common areas and outside the facility (URL- 4). Insulation measures have been taken against sound and noise. The lighting elements used in the common areas and rooms are innovative and modern. Floor lamps are used for the general lighting of the rooms and movable spot fixtures are used at

the head of the beds. A mystical and soft effect is created by avoiding intense lighting. The accentuating light effect provides aesthetic and functional lighting design in the space and on the objects.

The hygiene, thermal and acoustic comfort features of the boutique hotel were examined in line with the comments and ratings on web pages and mobile applications created for accommodation facilities; it was found that the hotel was clean (9.6/10), well-maintained, hot water and heating-cooling systems were sufficient, quiet and environmentally friendly (9.6/10) (URL-5). Social sustainability is ensured by the café/restaurant service that is open to the public**.**

CONCLUSION

It is very important that new or improved ideas are implemented in the tourism sector, which focuses on human service. Accommodation businesses, one of these areas, are constantly renewing themselves with changes in their spaces and services. With the creation of different design approaches, spaces are being customized and hotels are increasing their identity and memorability. With the development of accommodation services, classic hotel services have been replaced by a boutique hotel approach that prioritizes customer needs.

The results are presented graphically with the numerical analysis method developed as a suggestion to handle the buildings systematically and holistically. As a result of this analysis method, it has been reached that the score equivalent of the architectural value of Hich Hotel is 89/100. The following conclusions were reached regarding the architectural value of the boutique hotel: The relationship with the customer is at the forefront with innovative approaches and other design decisions. It is seen that the hotel meets all the requirements for product and service. Old and new textures

have been successfully brought together with materials, equipment elements and design decisions in line with the expectations of the users.

It has been observed that innovations have been made mostly in terms of visual design in the interiors of the boutique hotel. In terms of smart technologies, it has been determined that the technological equipment of the hotels in the room is insufficient. The quality of accommodation structures, especially in touristic regions, is increased by maintaining their innovations by using the existing potential correctly.

In boutique hotels; it is thought that a more aesthetic and innovative service environment will be created in line with remarkable facade designs, the use of contemporary materials, the creation of flexible spaces, the use of innovative lighting elements and original equipment elements, and ergonomic solutions. In order for the hotel to be remarkable and distinguishable, importance should be given to the design of the general spaces that are in contact with the outside. Technological innovations are also important in terms of shaping the spaces and making the customer feel the comfort in the hotel spaces. By keeping up with technology, the best possible service should be provided for the needs. At the same time, accommodation spaces should be designed in a way that is thermally and acoustically comfortable, relates to the landscape and prioritizes spatial comfort. In determining the re-functionalized buildings as boutique hotels, care should be taken to ensure that they are suitable for the demands of the environment in which they are located.

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BÖLÜM V

Urban Agriculture and Sustainable Cities

Fatma AŞILIOĞLU[1]

Introduction

Today, it is recognized that approaches to reduce the negative impacts of urbanization on the environment are critical for a sustainable city (SC). The impacts of environmental problems in cities tend to expand both geographically and temporally. This impact process results in environmental degradation, air and water pollution, threats to biodiversity, excessive energy consumption, climate change, etc. (Kyoi, 2023). In this context, the concepts of sustainability and sustainable city development are the subject of research in many fields, discussed and accepted as a necessity (Nowysz et al., 2022). In recent years, the question of how to meet

[1] Assoc. Prof. Dr., Ankara University, Kalecik Vocational School, Landscape and Ornamental Plants Program, Ankara / Turkey, fatma.asilioglu@ankara.edu.tr, ORCID: 0000-0001-9869-9638

the food needs of the growing urban population (Sanyé-Mengual et al., 2019) has led to the approach of minimizing food transport (Ortiz et al., 2021). However, in the case of SCs, the phenomenon of urban agriculture (UA), which has existed in different forms throughout history (Sanyé-Mengual et al., 2019), is discussed as a current solution (Ackerman et al., 2014; Nowysz et al., 2022). Although UA practices have a wide variety in terms of their components, starting point, objectives and scope, their main purpose is to provide the food production needed by the urban population (Sanyé-Mengual et al., 2019). The reason for the increasing interest in UA in recent years (Dorofieieva & Vugule, 2021) is the level of social awareness in returning to natural life, producing and consuming quality agricultural food locally (Nowysz et al., 2022).

As a result, the debate on the relationship between UA and SC is evolving beyond sustainable cities towards renewable cities, which can be useful in solving social, economic and environmental problems (Nowysz et al., 2022). This is because in our era, global development and urbanization growth are clearly fueling problems of health, environment, community resources and inefficient land management (Dorofieieva & Vugule, 2021). There are current studies in the literature that address this and examine the level of benefit that UA will provide for SCs (Azunre et al., 2019; Dorofieieva & Vugule, 2021; Ebissa et al., 2023; Kanosvamhira, 2023; Kolagar, 2019; Kyoi, 2023; Maćkiewicz et al., 2019; Sanyé-Mengual et al., 2019; Tapia et al., 2021; Van Tuijl et al., 2018). The main motivation for these studies is that the role of UA in building SCs is blurred and insufficient in the literature (Kanosvamhira, 2023). This section aims to provide an easier-to-understand reading on the concepts of UA and SC and the causal relationship between these concepts.

Urban agriculture concept

UA is generally defined as agricultural activities carried out in and around urban areas to produce food (Azunre et al., 2019; Kyoi, 2023; Rogus & Dimitri, 2015; Tornaghi, 2014; Van Tuijl et al.,

2018). There are various classifications of UA applications (Bretzel et al., 2018; Ferreira et al., 2018; Kyoi, 2023) and a broad scope that involves many disciplines such as food safety, food law, economics, engineering, human geography, etc. (Opitz et al., 2016; Tornaghi, 2014; Van Tuijl et al., 2018).

In their study, Van Tuijl et al. (2018) defined the types of UA as shown in Table 1, compiled from various studies and excluding hobby residential gardens. They also state that there are no clear distinctions between species and that different species can co-exist.

Table 1. Types of UA

Types of UA	Description
Community gardens	Demonstration, therapeutic, vocational training gardens, neighborhood gardens, intercultural gardens with health, social and educational purposes
Institutional gardens	Gardens run by non-profit organizations (schools, hospitals, prisons, etc.)
Guerrilla gardening	Legal and illegal horticultural activities in public spaces
Urban farm	Agricultural production by specialized producers using technological methods and systems
Vertical farming	Indoor cultivation activities using soilless agriculture technologies
Plant factories	Indoor agriculture using artificial lighting, combining resource utilization efficiency and closed production systems
Zero-acreage farming	Agriculture where agricultural land is not used and has its own various technologies
Agro-park	Production clusters where the principles of industrial ecology are adapted to agriculture and where various links of the food chain co-exist
Agro-tourism	Farming activities that offer recreation, entertainment, leisure time, etc. for the urban population

Menteş (2019), examined UA activities by dividing them into three groups as non-commercial, commercial and hybrid according to whether they are commercial or not. Accordingly, non-commercial UA types are private gardens, hobby gardens, community gardens, gardens belonging to various institutions,

demonstration gardens, edible landscape applications, etc. Commercial UA types are farms established within the city and on the urban periphery to offer surplus to the market or to produce directly for the market, soilless agriculture and practices that use the inefficient and idle lands of the city for organic agriculture. Hybrid practices include UA types that include activities by various institutions and organizations to provide social, environmental, economic and educational contributions, where production, distribution and marketing are generally carried out on a voluntary basis.

Van Tuijl et al. (2018), categorize types of UA by location as "city center versus peri-urban, farming on the soil versus soilless farming, outdoor versus indoor farming". First, UA can take place in different locations, ranging from small private gardens in neighborhoods to commercial urban farms and can be located in urban and peri-urban areas. It can take the form of a rooftop farm or an indoor office farm. It can be carried out in the city center or in vacant urban areas outside the center. It can appear as agro parks established in places that are advantageous in terms of transport such as motorways, harbors and airports. They can be businesses that combine agriculture with tourism around the city or commercial initiatives within the scope of social projects targeting disadvantaged groups. Secondly, in cases where agricultural lands are insufficient in terms of area, in the air and on the water can be oriented towards production in small areas without soil or with little soil. Examples include balconies, roof gardens, vertical farming practices and floating plant and animal farms. Thirdly, UA practices can be carried out in closed farms equipped with modern technology within the urban area or where idle buildings are utilized.

Sustainable city concept

Urbanization and urban expansion often occur on fertile land and agricultural land is suppressed. This often results in the inability of the city to feed itself and the need to bring food from other production regions (Callau et al., 2018; Menteş, 2019). SC is a city

that can feed itself, has a good quality of life, a strong economy and a healthy society, and contains clean and renewable environmental components. The concept of SC has brought ecological planning into the discussion and it has been accepted that only an urban development based on ecological basis is sustainable. In this way, cities can be living spaces with a high quality of life in the future and where the natural, artificial and cultural environment is protected (Menteş, 2019).

The United Nations World Commission on Environment and Development (UNWCED) considered sustainable development on the basis of meeting today's needs without threatening the needs of the future. The concept of SC has its roots in this idea (Azunre et al., 2019). There are different definitions of sustainability and sustainable development in the literature (Lew et al., 2016). The way to achieve unity among them is to use economic, social and environmental dimensions as a template. The increasing importance of SC is due to the rapid urbanization in the world and the resulting pressures on the environment (Azunre et al., 2019).

The basic principle for SC is to balance basic needs such as social infrastructure, transport, nutrition and shelter, income generation, economic development, environmental protection, etc. (Azunre et al., 2019; Hiremath et al., 2013). Researchers and organizations have tried to establish various sets of criteria to define SC. The Green City Index is one of them and categorized the criteria under the main headings of environmental governance, carbon dioxide, buildings, transport, water, waste and land use, energy, and air quality. The criteria are generally related to the environmental dimension (Azunre et al., 2019; Huang et al., 2015). Another set of criteria is the Global City Indicators Facility and focuses more on the economic and social dimensions of sustainability. It works with the topics of city services (education, health, recreation, safety, waste management, transport, water, energy, finance, urban planning and management) and quality of life (representation, economy, culture, environment, housing, equality, technology and innovation). The Global Compact Cities Circles of Sustainability method is based on

a number of criteria within four broad categories: economy, ecology, politics and culture (Azunre et al., 2019). Azunre et al. (2019) presented a framework that combines indicators for measuring a sustainable city, covering economic (debt, income, savings, employment, capital), social (education, civic participation, gender equality, social security, healthcare, life expectancy, nutrition, amount of public open and green space, population, informal settlements) and environmental (water and energy efficiency, renewable energy, car-free transport, greenhouse gas management, waste management, green plans and policies, traffic, air pollution, organic agriculture) dimensions.

The causal relationship between urban agriculture and sustainable cities

Current literature considers UA as an opportunity for sustainable cities. This is because population growth in cities and the associated pressures on land have prompted researchers to look for new ways to feed cities while adhering to sustainability principles. According to Sanyé-Mengual et al. (2019), a significant part of the research on this topic emphasizes that UA creates new food networks and supports social regeneration by opening communication and learning channels between consumers and producers. Some studies focus on technological innovations to reduce the impact of UA on the urban environment and increase efficiency in resource use. In the studies where the economic dimension is discussed, it is pointed out that the distance between producers and consumers is very short in UA, resulting in new business models that offer unique and exciting experiences. The multifaceted benefits of UA for SCs are generally analyzed under three main headings: economic, social and environmental. Table 2, compiled from various studies, contains a list of these benefits.

Table 2. Contribution of UA to SC development

Contribution	Description	References
Economic	Reduction of energy consumption	Ackerman et al. (2014); Kyoi (2023); Maćkiewicz et al. (2019)
	Supporting the local economy	Ackerman et al. (2014); Dorofieieva and Vugule (2021); Kyoi (2023); Maćkiewicz et al. (2019); Orsini et al. (2013)
	Providing easily accessible agricultural food	Ackerman et al. (2014); Dorofieieva and Vugule (2021); Ebissa et al. (2023); Hara et al. (2018); Kyoi (2023); Tapia et al. (2021)
	Encouraging savings, providing income	Dorofieieva and Vugule (2021); Kanosvamhira (2023); Maćkiewicz et al. (2019)
	Efficient use of land	Dorofieieva and Vugule (2021); Ebissa et al. (2023); Maćkiewicz et al. (2019)
	Promoting marketing initiatives	Dorofieieva and Vugule (2021); Maćkiewicz et al. (2019)
	Providing agro-tourism opportunities	Ebissa et al. (2023)
Social	Urban resilience enhancement	Kyoi (2023); Langemeyer et al. (2021); Tapia et al. (2021)
	Improving the health and lives of city dwellers	Dorofieieva and Vugule (2021); Kanosvamhira (2023); Kyoi (2023); Maćkiewicz et al. (2019); Madureira et al. (2015); Tapia et al. (2021); Van Tuijl et al. (2018)
	Providing recreation opportunities and landscape diversity	Kyoi (2023)
	Poverty reduction	Dorofieieva and Vugule (2021); Kanosvamhira (2023); Tapia et al. (2021)
	Increasing food supply	Ebissa et al. (2023); Kanosvamhira (2023)

	Providing job opportunities	Kanosvamhira (2023); Maćkiewicz et al. (2019)
	Providing access to healthy and fresh food	Dorofieieva and Vugule (2021); Maćkiewicz et al. (2019); Tapia et al. (2021); Van Tuijl et al. (2018)
	Supporting feelings of belonging to a place or a community	Dorofieieva and Vugule (2021); Maćkiewicz et al. (2019); Tapia et al. (2021)
	Developing personal skills and abilities	Dorofieieva and Vugule (2021); Maćkiewicz et al. (2019); Tapia et al. (2021)
	Supporting disadvantaged groups	Dorofieieva and Vugule (2021)
Environmental	Preventing climate change and mitigating its impacts	Artmann and Sartison (2018); Demuzere et al. (2014)
	Reducing greenhouse gas emissions	Dorofieieva and Vugule (2021); Ebissa et al. (2023)
	Improving the microclimate	Dorofieieva and Vugule (2021); Maćkiewicz et al. (2019)
	Improving air quality	Dorofieieva and Vugule (2021); Kanosvamhira (2023); Maćkiewicz et al. (2019); Orsini et al. (2013)
	Reducing the urban heat island effect	Ebissa et al. (2023)
	Reducing the amount of waste and supporting recycling	Dorofieieva and Vugule (2021); Kanosvamhira (2023); Kyoi (2023); Maćkiewicz et al. (2019); Orsini et al. (2013)
	Soil and water conservation	Dorofieieva and Vugule (2021); Kanosvamhira (2023); Maćkiewicz et al. (2019)
	Support flow control	Ebissa et al. (2023)
	Increasing biodiversity	Ebissa et al. (2023); Maćkiewicz et al. (2019)
	Raising environmental awareness	Maćkiewicz et al. (2019)

There are various initiatives at various levels of government, especially local governments, to bring contemporary cities to SC status. One of the most noteworthy of these is the creation of a green network system in and around the city. Within this system, which includes agriculture, forest and recreation areas, it is necessary to include and encourage UA areas that directly support the city. Because UA is an effective mechanism for future cities to become resilient and self-sufficient ecosystems (Maćkiewicz et al., 2019). Ebissa et al. (2023) analyzed a large number of studies and focused on the impacts of UA on environmental sustainability and revealed that it has broad spectral benefits. These benefits are included in Table 2.

In some studies, the disadvantages of UA have also been pointed out, and it has been mentioned that sustainability is not possible due to the excessive use of resources and energy in these activities where high efficiency is aimed (Sanyé-Mengual et al., 2019). Unconscious use of water, fertilizers and pesticides in poor agricultural practices that can be carried out within the scope of UA may cause unwanted accumulation of organic toxins, pesticides and heavy metals (Tapia et al., 2021).

Discussion and conclusion

When the concepts of UA and SC are analyzed with all their dimensions and components, it is encountered that UA should be a central policy for cities with self-sufficient and stable development and reduced negative environmental impacts (Ayambire et al., 2019; Azunre et al., 2019; Clinton et al., 2018; Kolagar, 2019; Kyoi, 2023; Viana et al., 2022). UA should be included in spatial, economic and social development plans and legislation due to its contribution to different pillars of SC development (Maćkiewicz et al., 2019). UA activities should be determined according to the potential and characteristics of the cities themselves and planning should be made for suitable agricultural land (Kolagar, 2019). Land in cities can be much more valuable when used for non-agricultural purposes, and therefore people may not take good care of UA. Planners and

politicians should endeavor to encourage, raise awareness and raise consciousness of urban people and landowners about UA (Ackerman et al., 2014; Ebissa et al., 2023; Kyoi, 2023; Langemeyer et al., 2021).

In conclusion, it does not seem to be a choice to continue living in cities, cities and urban life will continue to exist in the future. Each generation is obliged not to consume the resources that the next generation needs now, and there is no other way to do this than to build SCs. The potential of UA should be used as an effective tool in urban development strategies and planning with all its advantages in a way to eliminate its disadvantages.

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