USE OF INFORMATION TECHNOLOGIES IN PLANNING AND DESIGN

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NURBANU ÖZKARTAL

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PREFACE

In an era marked by the rapid advancement of technology, the disciplines of design and planning find themselves compelled to adapt to this transformative wave. As traditional methods make way for technological innovations, designers and planners face the responsibility of effectively harnessing computer technologies. This book aims to assist experts, students, and professionals in the fields of design and planning in understanding, embracing, and managing the opportunities that technology presents throughout the design and planning processes.

Comprising contributions from authors with diverse expertise, this book is organized into nine chapters. The chapters delve into various aspects of computer usage in design and planning disciplines. Emphasis is placed on digital tools and how they assist both students and professionals in the design process, underscoring the significance of technology use in the realm of education. Another chapter focuses on the increasing role and possibilities of digital twin technology in urban design. The section dedicated to artificial intelligence (AI) opportunities in urban planning provides insights into the use of AI applications such as big data analytics, prediction models, and decision support systems. Highlighting the importance of AI-driven strategies when envisioning future cities, this section underscores the pivotal role AI can play in shaping urban landscapes. The chapter on geodesign in landscape architecture explores the application of geographic information systems and digital mapping techniques in the design of natural and green spaces. In the section addressing the use of computer technologies in planning agricultural areas, the discussion revolves around guiding planners in addressing food security and implementing sustainable agricultural practices. Another segment of the book zeroes in on smart digital systems in surveying techniques, detailing the precise identification and analysis processes of existing spaces. The hope is that, through the use of smart digital systems, planners and designers can achieve more accurate and efficient measurements.

This book strives to aid professionals, students, and individuals working in related industries within design and planning disciplines in comprehending the opportunities provided by technology and effectively leveraging them. Each chapter is crafted with an interdisciplinary perspective, allowing readers to focus on their respective areas of expertise while simultaneously gaining a broader perspective.

It is our aspiration that this book serves as a guide in the realm of technology usage within design and planning disciplines, inspiring readers along the way.

CHAPTER I

ICT and SUSTAINABILITY in DESIGN EDUCATION

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INFORMATION AGE and ICT

The mass media that emerged with the second wave lost its effect with the third wave. With the third wave, differentiation instead of standardization gained importance, and an approach of individuality was adopted, moving away from mass. With the introduction of computers into human life in the 1950s, Alvin Toeffler's (1980) work, The Information Age called the Third Wave, emphasizes the importance of acquiring information. Information has always been obtained through communication from the past to the present. For this reason, this era also created a need for innovations in communication technologies.

Information and Communication Technologies (ICT) includes various technological equipment and resources used to produce, distribute, collect, and manage information and communicate (Sarkar, 2012). Within the scope of information and communication technologies, visual, audio, and printed tools can be shown to create, change, and access information. The core of ICT consists of software, hardware, networks, and environments used to manage the information, primarily through voice, data, text, and images, as well as provide other needs. ICTs are based on two foundations: infrastructure requirements that enable information communication and Information Technology, which is the management of information (Talebian et al., 2014).

Thanks to the cable system, satellite system and fiber optic technology, all communication channels have gained different dimensions. In the 1970s, mobile communication devices based on the Internet and the World Wide Web were also developed. Both mobile and Internet communications have grown rapidly since their introduction in the 1980s until today. Thus, great steps have been taken in the mutual exchange of information, which we call informatics.

Thanks to these systems, two-way communication is achieved by individuals actively participating in the meeting in a faraway place via mutual audio and video. In this way, space is no longer important for communication. It can be said that Information Age technologies make time and real space meaningless in working life and destroy geographical distances. Space moves away from its traditional meaning and becomes virtual.

It can be said that the Information Age has, become the age of communication for sharing information and knowledge. The change in communication technologies has affected not only the business world but also every aspect of life. Information communication in electronic and digital environments, which has become a focal point in working life with the Information Age since the end of the 20th century, has also affected the equipment used in education. Students' learning methods have begun to change and continue to change. In a learning environment where technology-equipped ICT tools and equipment are used, effective education can be provided and sustainability of education can be ensured (Robinson et al., 2013). However, the use of ICT in education is still a matter of debate. The environmental sustainability impact of ICT in education has not been fully clarified. In this study, the contributions of ICT to environmental sustainability in education are discussed.

DESIGN EDUCATION and ICT

ICT effects have been seen in education, as in every field. One of the areas that the digital age has indisputably strengthened is the management of information in education by eliminating the traditional obstacles of infrastructure, economy, and geography (Smartivity, 2020). ICT has started to be used in education since the 1990s. However, although there have been examples of the use of ICT in design education in the past, it has become widespread with the Covid-19 epidemic. The use of ICT in design studios, where learning by doing and experimenting methods are applied, has become mandatory with Covid 19, and educators and students have had the opportunity to experience these technologies.

The traditional design studio involves a physical environment structured around some fundamentally similar rules that have changed somewhat from past to present. Architectural education has used ICT tools since the 1990s (Reffat, 2007). ICT technologies such as augmented reality and virtual reality have made all kinds of information accessible to students and teachers (Smartivity, 2020). With the Covid-19 epidemic, lessons are held in online studios through channels that offer alternatives to the education model in physical environments, while online collaborative digital tools are used in the design process. It cannot be said that these tools are produced specifically for design studios, but the requirements can be partially met. At the same time, ICT tools supporting online studios have begun to be used more frequently than in traditional studios. Online tools more frequently used in design studios include

Miro, Canva, Youtube, Figma and Mural. Each can be used in different processes of design. At the same time, these applications also support participatory design. Participatory practices ensure that studios continue to be a social learning environment through online means. Learning media such as Canva, which helps students learn, is a virtual learning environment (Alsuwaida, 2023).

Design students are experienced in using digital tools due to the nature of design process (Muir and O'Neill, 1994). The fact that students are accustomed to digital environments helps these students adapt to digital learning environments. Although obligations and sometimes technological developments reshape design studio teaching and the tools used, some schools continue to carry out design education using manual sketching, drawing, and physical modeling, adhering to traditional studios and the tools used (Reffat, 2007). For the last two decades, there has been discussion about the pedagogical effects of the use of information and communication technologies (ICT) in university classrooms, and the lack of sufficient studies makes the subject controversial (Wang, 2010).

The study aims to discuss the contribution of augmented reality, virtual, online, and mobile studios and the digital tools used in these environments, in short, ICT hardware and software, to environmental sustainability in terms of reducing energy and material consumption while contributing to remote education.

ICT and SUSTAINABILITY in DESIGN EDUCATION

Sustainable Development 2030 planning targets were adopted at the United Nations Sustainable Development Summit held in 2015. The Sustainable Development Goals are a universal call to action that includes targets intended to be achieved by United Nations member countries by the end of 2030. Education is an important driving force in achieving these goals. It is important to use ICT technologies in education not as a goal but as a tool to achieve goals (Roig-Vila, 2020). Environmental sustainability began to be widely used after the 1980s. Education is seen as key in the process of achieving sustainable development. Technologies are also an important tool to achieve the Sustainable Development Goal (Nhamo et al.,2020). Researchers argue that

ICTs should be adapted to learning methods or learning environments should be adapted to ICTs (Paas and Creech, 2008; Tella and Adu, 2009).

The paperless design studio approach first emerged in the early 1990s, and highly capable drawing programs were developed to eliminate hand-drawn designs (Reffat, 2007). Researchers focusing on ICT technologies and mobile learning with COVID-19 show that mobile devices allow students to access learning resources at any time and place. They stated that mobile phones have many benefits in the field of education, structuring knowledge in learning outcomes and increasing students' motivation and commitment (Aliaño et al., 2019).

Traditional education models should be changed in line with sustainable development goals, and models that take environmental sustainability into account in education should be developed (Zhou et al., 2013). For education in design to contribute to environmental sustainability, traditional systems and methodologies need to be reconsidered.

DISCUSSION AND CONCLUSION

In his book The Third Wave published by Alvin Toeffler, he explains the differences of the information society compared to other past societies. While the second wave, which is the industrial age society, is based on mass production, consumption and education, mass media, the information age, which started to be experienced with computer technologies, in other words, the third wave includes experiences from mass to individuality. The author states that in the second wave, the school was an educational institution where students went to and from school at the same time. With the second wave, schools began to look no different than factories. We can say that education has become individualized with the third wave. New education models will need to be less formal, more personalized, realistic, humane, fun and lifelong (Miller, 1981)

Traditional education models enabled students to access past information to copy the past. Today, the role of the education system and the teacher must evolve from 'introducing students to the past' to 'empowering students to shape the unpredictable future' (Smartivity, 2020). To see the breakthroughs that technology will bring in education, new design processes compatible with ICT should be developed instead of traditional design processes.

ICT has had a transformative effect in many areas where information is processed. Information and communication technologies are the whole of software, hardware, networks and environments required to manage information in the form of voice, data, text and images (Talebian et al., 2014). ICT technologies are mostly used in distance learning methods. In distance learning, all these software, hardware, networks, and environments are ICT. Terms such as virtual, online, e-learning, mobile learning, and participatory learning can be used for distance learning. (Tella and Adu, 2009). However, the ICT hardware and software used in each may differ. Additionally, with the use of digital technologies, students' paper consumption can be reduced, thus adopting an environmentally friendly approach. By using digital platforms and applications, schools' registration and resource management processes can be made more efficient (Alp and Levent, 2020).

Educators need to improve the learning experiences of students and teachers by using digital technologies effectively and helping them develop their digital skills (Souza et al., 2022). John Kolko (2005) states that a new approach should be brought to Industrial Design education. In design education, when web technologies, ICT equipment, hardware, and software are created according to the requirements of the design discipline, they eliminate the problems between the instructor, the student, and the environment. Instead of using traditional studio and design education models with new technologies, environmental sustainability goals can be contributed by transitioning to paperless design education with ICT organizations and applications tailored to the needs of different stages of the design process.

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CHAPTER II

EXAMINING VARIOUS GRASSHOPPER PLUGINS FOR MULTISCALE ANALYSIS

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INTRODUCTION

The essential aim of the site analysis is to identify the distinctive and valuable aspects of the site and its context during the pre-design process (Lagro, 2011). Site analysis is crucial for designing a development that fits the conditions and context of the site. The site's characteristics significantly influence any development, making site analysis an integral part of planning and design ("Urban design site analysis," 2022).

The impact of emerging software technologies on planning and architectural design is continuously increasing. This growth has opened new opportunities for spatial analysis and design processes, which are being further expanded through various computational design techniques (Boumaraf & İnceoğlu, 2022). Computational design uses advanced computer technology to incorporate design parameters into an algorithm. The process involves creating and evaluating design options using computer software and mathematical operations. This results in a dynamic, repeatable, and sustainable process (EV Charging Energy, 2023). The design structure is broken down into meaningful components and processes using computational design tools, and input-output relations between these subunits are established using visual programming (Yüksel & Börklü, 2023). Using computational design and analysis techniques can significantly decrease the amount of manual work, effort, and resources needed. They also enable architects and urban planners to test multiple scenarios by making minimal changes in the algorithm (Boumaraf & İnceoğlu, 2022). This experimental approach helps to mitigate design risks and obtain accurate information, leading to the discovery of appropriate alternatives.

A broad selection of computational design tools is available to meet the demand. Rhinoceros 3D-Grasshopper is one of the software that provides powerful computational design capabilities. Rhino 3D (short for Rhinoceros 3D) is commercial software for "Computer-Aided Design" (CAD) and "3D computer graphics". Grasshopper is a tool for visual programming that integrates with Rhino 3D modeling software. Grasshopper programming is a powerful tool used for managing and modeling complex geometries. Most of the Grasshopper interface is focused on the canvas, where users can design multiple elements and connect them with wires. Grasshopper's components are written in Python, which is a widely used language in computational design due to its straightforward syntax and seamless integration with many 3D modeling software (Constantino et al., 2022).

Food4Rhino is a community plugin service for Rhino designed to assist users in enhancing their experience. It is a software module that adds features, capabilities, or commands to Rhino or Grasshopper. Rhino and its plugins collectively offer a wide range of modeling, analysis, and fabrication capabilities, which enable various tasks to be performed efficiently (Mohol & Bambawale, 2023). This process involved seeking existing research, scholarly articles, and relevant publications to better understand these plugin working systems. This research explores six commonly used Rhino/ Grasshopper plugins downloaded from Food4Rhino. These plugins facilitate the analysis process at different scales, such as terrain, urban, and buildings in urban planning and architectural design.

1. ESSENTIAL GRASSHOPPER PLUGINS for ANALYSIS in DESIGN and PLANNING

Analysis is a fundamental stage in planning and design, guiding the decision-making process precisely. In architecture and urban planning, a thorough analysis serves as the guide, directing designers and planners toward optimal solutions. Various factors, such as spatial functionality, environmental impact, and aesthetic coherence, are examined in this stage (Boumaraf & İnceoğlu, 2022).

Computational tools, including many Grasshopper plugins, enhance this analytical process by allowing designers to provide multiscale assessments. From micro-level difficulties to macro-scale considerations, these plugins provide various toolkits for professionals and students, offering insights that shape the conceptualization and refinement of projects. Grasshopper is a visual programming plugin for Rhino 3D that allows users to create parametric models and custom design workflows easily (Mcneel & Associates, n.d.). It offers a versatile platform where architects, designers, and urban planners can utilize various tools to evaluate different aspects of their projects. This tool allows one to visualize and analyze data in a way that makes it more understandable and facilitates informed decision-making. It can optimize projects for essential factors such as daylighting and energy efficiency (Tait, 2023). Grasshopper plugins serve as powerful computational analysis tools before the design process. Below is a list of some frequently used plugins at this stage, along with their features:

- **Docofossor:** This tool is for Rhino 6 + Grasshopper and is developed to analyze terrain modeling in landscape architecture. It is designed to simplify the modeling of cut-and-fill operations on digital terrain models without the need to acquire any coding skills (Hurkxkens & Bernhard, 2019).
- **Urbano:** The Urbano plugin simulates urban environments by analyzing urban activities, movement paths, and pedestrian, car, and bicycle movements (Ibrahim & Abdullah, 2023). Urbano add-on programs the creation of an urban mobility model by loading GIS (short for Geographic Information System), Google Places, and OpenStreetMap data (Dogan et al., 2020).
- **Ladybug:** The Ladybug plugin for Grasshopper enables importing and analyzing standard weather data, drawing diagrams like radiation and wind roses, and performing radiation analysis, view analysis, and shadow studies with customization options (Ladybug Tools LLC, 2021).
- **Honeybee:** The honeybee tool is Ladybug's extension, which offers detailed modeling for daylighting and thermodynamics, most relevant in mid to late design stages (Arfaei & Hançer, 2019).
- **Dragonfly:** The Dragonfly is an add-on that enables modeling large-scale climate phenomena like urban heat islands. It aims to provide access to many large-scale climate variables for CAD interfaces and other Ladybug Tools add-ons (Ladybug Tools LLC, 2021).
- **Butterfly**: The feature of the Butterfly plugin is designed to enable quick geometry export to "OpenFOAM," which is an abbreviation for "open-source software for computational fluid dynamics." and run several standard airflow simulations relevant to building design (Estrado et al., 2023). These simulations can model urban wind patterns outdoors and thermal comfort and ventilation indoors through buoyancy-driven simulations (Ladybug Tools LLC, 2021).

2. GRASSHOPPER PLUGINS USED AT VARIOUS SCALES FOR ANALYSIS

Table 1: Grasshopper analysis plugins that operate at different scales.

Plugins	**Scales**		
	Terrain	Urban	Building
Docofossor	✓		
Urbano		✓	
Ladybug		✓	✓
Honeybee			✓
Dragonfly		✓	
Butterfly		✓	✓

The table above demonstrates the scales at which the Grasshopper plugins mentioned in the previous section can work. The effectiveness of the plugins in providing data for terrain, urban, and building analyses is evaluated in the subheadings.

2.1 Terrain Analysis

Terrain is a fundamental topographical feature that plays a critical role in various physical processes (Xiong et al., 2022). The article "The Importance of Site Analysis in Landscape Architecture" (2023) mentions that the structure of the land, such as the slopes, curves, and elevation of the site, significantly affects design considerations. These features play a significant role in determining how water will flow, where structures should be placed, and how outdoor spaces should be arranged.

Standard techniques used for terrain analysis involve on-site surveys, constructing physical models, and creating contour maps (Millar et al., 2018). However, computational analysis accelerates this process and allows us to generate more scenarios about a landform. Docofossor, a computational analysis technology supported by the Grasshopper plugin, enables various landform analyses at this scale.

2.1.1 Terrain Analysis with the Docofossor Plugin

This plugin enables Grasshopper to modify, trim, and fill landscape architecture operations efficiently. It focuses on parametric transformations of a digital terrain model (DTM) by point, path, area, or surface (Hurkxkens & Bernhard, 2019).

Figure 1: Docofossor Grasshopper plugin toolbox
Source: Hurkxkens & Bernhard, 2019

As shown in Figure 1, Components are divided into seven categories that can be accessed from the Grasshopper toolbar. To perform calculations (Figure 2), Docofossor utilizes IronPython within Rhino Grasshopper (Docofossor, 2019).

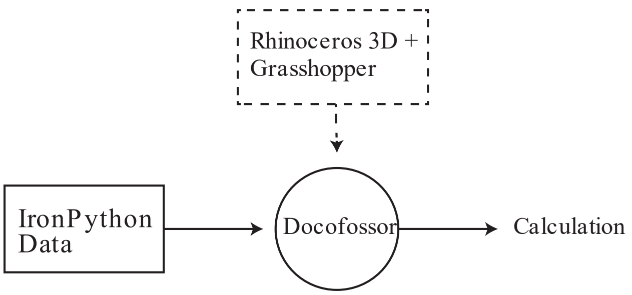

Figure 2: The calculation process of Docofossor Plugin
Source: Created using Docofossor, 2019

Hurkxkens & Bernhard (2019) explain how to use analysis tools in Rhino Grasshopper's modeling environment to explore topographic features. This is particularly beneficial in comprehending the performance of the terrain, including water drainage, visibility, and slope stability. Additionally, it helps to create parametric restrictions for self-governing robotic excavation.

Figure 3: Left: Determines the direction of the gradient vectors. **Center:** The visibility analysis. **Right:** The shortest path analysis.
Source: Hurkxkens & Bernhard, 2019

The Docofossor Plugin provides three useful tools for the analysis: dfSlopeVector, dfViewshed, and dfShortestPath. The dfSlopeVector tool calculates vectors that indicate the direction of the gradient (Figure 3, left). The dfViewshed tool analyzes the visibility in a 3D viewshed, which can be seen from a specific starting point (Figure 3, center). Lastly, the dfShortestPath tool computes the most direct route between two given points, always ensuring accuracy and efficiency (Figure 3, right).

Bison is another Rhino Grasshopper plugin specializing in mesh creation, analysis, editing, and annotation (Bison, 2018). Hurkxkens & Bernhard (2019) emphasize that the Bison plugin's precise topographic modeling needs improvement despite the potential for large mesh surfaces. Therefore, there are multiple digital terrain plugins, each with features, which can be used together or separately.

2.2 Urban Analysis

Urban analysis involves examining land use, transportation, urban form, infrastructure, and public space. The research in this area is based on rigorous theoretical and empirical analysis using a range of research methodologies such as mapping and GIS, remote sensing, and spatial statistics (Urban analysis, n.d.). In this process, data can be quickly obtained using computational analysis methods, and the collected data can be categorized based on the research's purpose.

In this section, grasshopper add-ons and their usage areas that facilitate analysis on an urban scale are shown.

2.2.1 Urban Analysis with the Urbano Plugin

The Urbano plugin is a tool in the Grasshopper platform of Rhino that allows designers to create mobility models and conduct network analysis and transportation simulations using Rhinoceros 3D CAD. (Dogan et al., 2020).

Figure 4: The toolkit of the Urbano plugin
Source: Dogan et al., 2020

The article by Dogan et al. (2020) describe the plugin's toolset, which is composed of four steps, as illustrated in Figure 4. The plugin initializes the model in the setup phase by downloading essential metadata files from Open Street Maps, such as the road network. It then runs pre-processing functions to read and process the data. The diagram in Figure 5 illustrates the entire process of an Urbano simulation, including all its components.

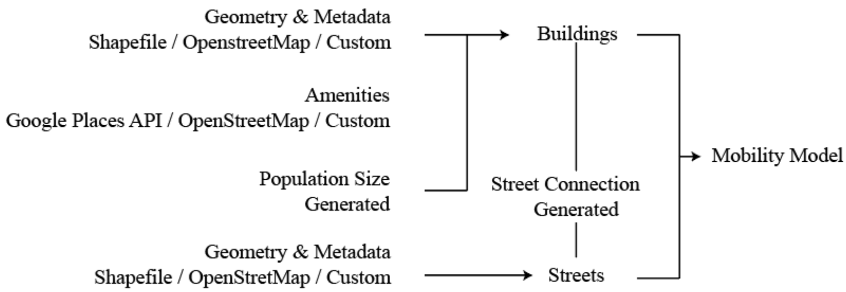

Figure 5: The data used in the process of building an Urbano model.
Source: Dogan et al., 2020

The Amenity Demand Profile (ADP) shows how urban amenities are used over time and space. Street Hits counts people on a street segment to reveal its liveliness. Walkscore rates walkability based on nearby amenities from 0-100 (Urbano, 2019). The tool assesses the accessibility and availability of amenities, streets, and public spaces. It introduces two new metrics for urban design - Streetscore and Amenityscore. Additionally, it offers an expanded version of Walkscore (Dogan et al., 2020).

2.2.2 Urban Analysis with the Ladybug Plugin

Ladybug is a plugin for Grasshopper that measures landscape performance and analyzes weather data. It collects global weather data and models site-specific climate conditions for hours, days, and months. Ladybug communicates temperature, outdoor comfort, wind, and sun position data (Sadeghipour Roudsari et al., 2013).

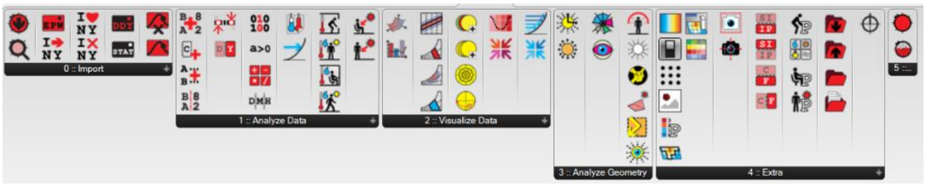

Figure 6: The Ladybug Grasshopper plugin toolbox

Ladybug is a free and open-source plugin for Grasshopper3D. It allows designers to explore the direct relationship between environmental data and the generation of design through graphical data outputs (Ladybug Tools LLC, 2021). Figure 6 displays several components of Ladybug in the Grasshopper platform.

Urban growth causes environmental problems. Cities concentrate energy, resource use, and waste generation, leading to system overload. A detailed methodology is necessary to analyze urban-environmental aspects and verify them at different spatial scales (Esparza et al., 2012). Ladybug plugin can be used as a computational design method for urban analysis to help reveal environmental features.

Ladybug is software for analyzing environmental factors. It generates 2D and 3D graphics to display weather-related information and assesses the impact of sunlight and radiation on design. This helps in making informed decisions during the design process (Sadeghipour Roudsari et al., 2013). The diagram in Figure 7 depicts the process and outcomes of the ladybug plugin.

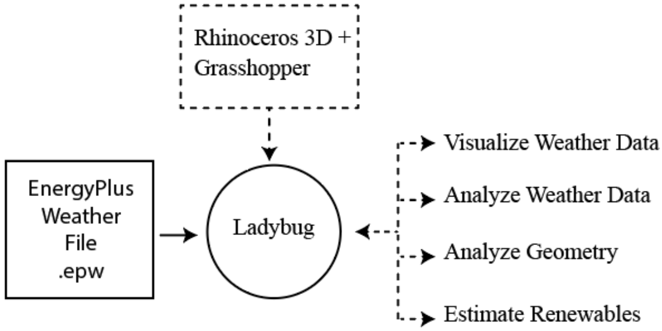

Figure 7: The Ladybug plugin operates the data during the environmental analysis process.

Source: Created using Tools, 2016

2.2.3 Urban Analysis with the Dragonfly Plugin

Dragonfly allows for district-scale energy simulation with URBANopt, electrical infrastructure simulation with OpenDSS, renewables optimization with REopt, and urban heat island modeling with the Urban Weather Generator (UWG) (Ladybug Tools LLC, 2021). Figure 8 displays various parts of Dragonfly within the Grasshopper platform.

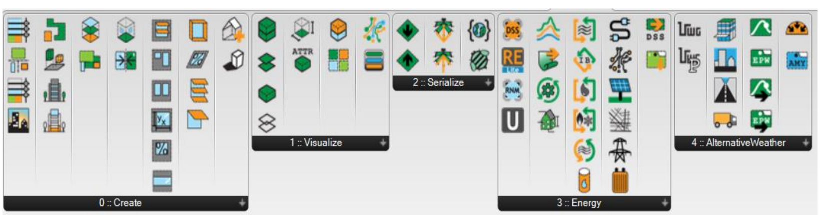

Figure 8: The Dragonfly Grasshopper plugin toolbox

Dragonfly plugin models urban areas using 70+ components that import Ladybug Tools core libraries. It converts raw geometry in CAD into fully simulatable models with energy properties assigned, ideal for energy simulations (Charan et al., 2021). Dragonfly simplifies the creation of large-scale EnergyPlus and Radiance models by using a 2D representation of building geometry, where all rooms are considered as extrusions of floor plates. Dragonfly software integrates with Rhino/Grasshopper 3D CAD and the URBANopt SDK (Figure 9).

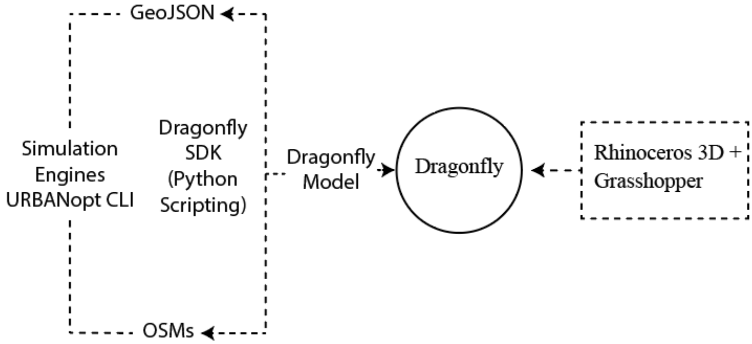

Figure 9**:** Integration of Dragonfly with Rhino/Grasshopper and URBANopt.
Source: Created using Charan et al., 2021

Dragonfly is a tool used for urban-scale analysis that enables planners and designers to create alternative scenarios using various Ladybug plug-ins, making it easier to optimize decisions.

2.2.4 Urban Analysis with the Butterfly Plugin

The Butterfly add-on connects the popular open-source Computational fluid dynamics (CFD) solver, OpenFOAM, to the Grasshopper plugin (Chronis et al., 2017). It quickly exports geometry to OpenFOAM and conducts several standard airflow simulations, including outdoor simulations to model urban wind patterns (Ladybug Tools LLC, 2021). Figure 10 depicts different parts of the Butterfly plugin toolbox within the Grasshopper platform.

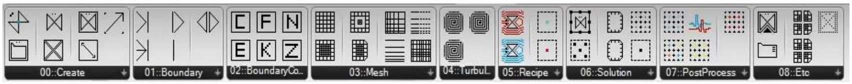

Figure 10: The toolkit of the Butterfly plugin

Butterfly is a computational tool with accuracy and time cost similar to OpenFOAM in airflow simulations. However, it is less functional than OpenFOAM as it cannot simulate porous media like trees (Brook-Lawson & Holz, 2020, as cited in Hu et al., 2023) .

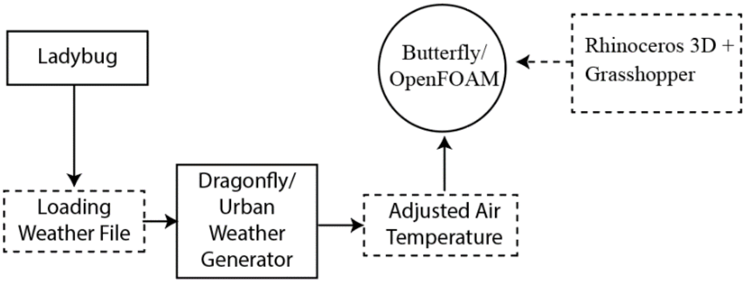

Figure 11: The process used by the Butterfly plugin to analyze environmental data

Source: Created using Hu et al., 2023

2.3 Building Analysis

Analyzing the performance of a building during the early design stage is paramount. This process requires a continuous assessment of the building's performance, identification of the factors that contribute to it, and finding ways to improve it (Lutheran, 2022).

Building analysis can become simpler and more accurate with the Honeybee, Ladybug, and Butterfly plugins in Grasshopper. These plugins provide designers with the data they need to make informed decisions and ensure your building is optimized for its intended use.

The Ladybug add-on was discussed regarding its use for urban analysis and functionality. This plugin also comprehensively analyzes a building's energy performance, daylight efficiency, and thermal comfort with the Honeybee plugin. This data can be used to pinpoint areas that require improvement and make informed decisions towards creating more sustainable buildings (Gibbs, 2023).

It has been explained how the Butterfly plugin operates and what it analyzes on an urban scale. Additionally, the plugin simulates wind performance by considering the location of the opening, the building facade, and the building layout (Liu et al., 2023).

2.3.1 Building Analysis with the Honeybee Plugin

Honeybee simplifies the creation of detailed daylighting and thermodynamic models by connecting the Grasshopper/Rhino CAD environment to energy models and simulations using EnergyPlus/OpenStudio and Radiance (Ladybug Tools LLC, 2021). The toolbox of the Honeybee plugin is shown in Figure 12.

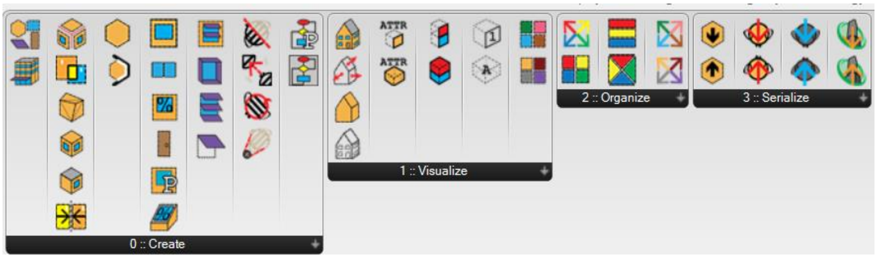

Figure 12: The Honeybee Grasshopper plugin toolbox

Honeybee is a tool that extends the capabilities of Ladybug. It allows for detailed modeling of daylight and thermodynamics, which is particularly useful in the mid to later stages of the design process. Honeybee achieves this by connecting simulation engines to CAD and visual scripting interfaces such as Grasshopper/Rhino and Dynamo/Revit plugins (Yang, 2020).

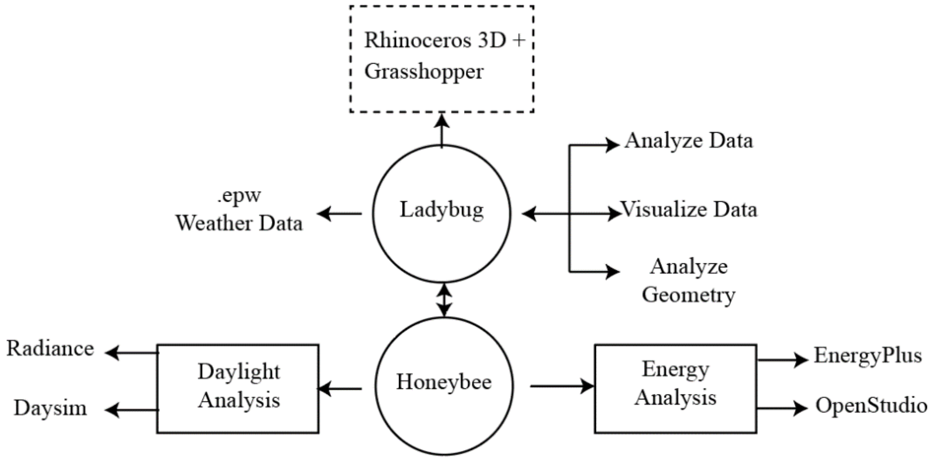

Figure 13: The Honeybee Plugin's Workflow.
Source: Created using Honeybee wiki home, 2019.

Figure 13 describes the connection between the Honeybee plugin and other simulation engines with which the Honeybee tool interacts. The Ladybug add-on offers a variety of useful features for the initial design stages. The

Honeybee plugin takes this further by allowing designers to perform a more comprehensive analysis (Honeybee wiki home, 2019).

CONCLUSION

The following Grasshopper plugins enhance the efficiency of the analysis phase in architecture and urban planning by allowing for the creation of different scenarios: Docofossor, Ladybug, Honeybee, Dragonfly, Butterfly, and Urbano. This study emphasized the function of the add-ons during early and late analysis phases at the terrain, urban, and building scales. The potential of the computational analysis method can be enhanced by using a combination of plugins. Some plugins can be used independently, while others are designed to work together to create an efficient system.

Docofossor and Urbano are two software programs for analyzing different spatial scales. Docofossor examines digital terrain models, while Urbano focuses on urban-scale analysis and provides mobility models and transportation simulations. Ladybug and Honeybee are essential add-ons for sustainable urban and building design. Ladybug measures landscape performance and environmental factors, while Honeybee enhances building analysis with detailed modeling for daylighting and thermodynamics. Dragonfly and Butterfly explore energy and renewables at district and urban scales. Dragonfly facilitates large-scale energy simulations and renewables optimization, while Butterfly uses OpenFOAM for computational fluid dynamics, enabling simulations of urban wind patterns and indoor-outdoor thermal comfort.

In essence, Grasshopper plugins offer users a comprehensive set of tools to optimize projects such as energy efficiency and daylighting, experiment with various designs, and reduce risks. Computational design techniques streamline the analysis process and enhance the ability to explore innovative alternatives, advancing architectural and urban design.

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CHAPTER III

THE PLACE AND IMPORTANCE OF COMPUTER-AIDED DESIGN IN LANDSCAPE ARCHITECTURE

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INTRODUCTION

Computers have become increasingly powerful in our daily lives and are being widely used to solve complex problems.

In the wake of the rapid and recent development of information technologies, computer-aided design programs have also gained importance in this process. These programs are used to highlight the visuality of the design, add aesthetic value to the designs, create quality drawings, and minimize technical errors.

As in any other field, one may also notice the use of computer applications in landscape design works since the 70s. In landscape architecture designs, computer-aided design, which is a sub-branch of information technologies, saves time and offers effective solutions. Visualization of three-dimensional works such as models made in the field of landscape architecture using computers creates important opportunities for presentation techniques. Computer-aided design programs play a role in creating realistic and impressive images in landscape architecture by saving time, cost, materials, and labor (Şahin and Önder, 2008; Olgun and Yılmaz, 2014).

According to Şahin and Önder (2008), computer-aided design in landscape architecture is used for three different purposes, which are given below:

- Landscape design works
- Landscape planning works
- Human resource development and training activities

Computer-aided design programs provide a high-level and fast environment for the animation of two-and-three-dimensional works. The opportunities that computer-aided design programs provide to architecture are as follows

- Creating realistic images: Light effects, material coating on objects, and a three-dimensional environment
- Creating a two-dimensional view as desired
- Creating animations
- Seeing details and desired parts and taking sections (Şahin and Önder, 2008).

1. COMPUTER-AIDED DESIGN

Computer-aided design emerged to facilitate designs, minimize errors in drawings, and save time. While it makes drawing easier, it speeds up the work and increases the quality. As long as the correct data is provided, drawings of two or three-dimensional objects are likely to be error-free and easy to reproduce (Megep, 2015).

An object designed within a computer-aided design system takes up little space thanks to its capacity to be copied and stored as many times as desired. Thus, the data create an orderly design process (Germen, 2002). Computer-aided design techniques allow for different drawing programs depending on user needs. CAD refers to the initials of the words "Computer Aided Design". Using the CAD program, technical drawings are drawn on a computer without using classical drawing tools (Megep, 2015).

CAD systems are based on the Interactive Computer Graphics (ICG) system. In these user-oriented systems, the computer creates, draws, changes, and displays data using symbols and shapes, according to the user's commands. In the system, the user is the designer and thus s/he ensures data communication and allows the creation of various images and sketches on the screen by issuing commands to the computer through various input units. In many systems, these images consist of basic geometric elements such as circles, lines, points, etc. In line with the user's commands, it is possible to make various changes in images such as reducing, enlarging, shifting to another area on the screen, coloring, shading, etc.. All of these enable the necessary details of the image to be formulated (Olgun and Yılmaz, 2014).

Computer-aided design systems are designed for using computers at every stage of the design process (sketching, design, modeling, application, animation). Among computer-aided design programs, some have very different features and are designed to meet the needs of different disciplines of the field of architecture (Aydoğan, 2006; Olgun and Yılmaz, 2014).

For some occupational groups, this includes computer-aided presentation and drawing. This concept includes the technical drawing, three-dimensional wireframe drawing, or surface-coated solid model of the design.

For some other occupational groups, on the other hand, computer-aided design is perceived as a network that supports computer-aided analysis or production conditions (Türkel, 2008; Olgun and Yılmaz, 2014).

2. COMPUTER-AIDED DESIGN IN LANDSCAPE ARCHITECTURE

In landscape architecture, computers are used in all stages of the design and office work. To carry out such operations, it is possible to use general-purpose software, advancing hardware, as well as a wide variety of application software prepared and offered to the user to meet specific needs (Şimşek, 1993).

As part of computer-aided design works in landscape architecture, professional application software packages, and other supporting software can be used in addition to basic graphics software. Autocad software, the basic graphics software, is the most used program in landscape architecture and other design fields. This program plays a crucial role in designs for reasons such as its ability to run with other systems, its constant renewal, its inclusion of landscape application software, and its ability to run on computer-aided design software. All operations from the beginning to the end of a landscape design can be realized with Autocad software. However, to reach results faster and find more advanced solutions, it is necessary to draw upon other computer-aided design programs (Şimşek, 1993).

2.1. Computer-Aided Design Programs Used in Landscape Architecture

In the field of landscape architecture, the most commonly used programs are Autocad, 3d Max, Photoshop, Archi Cad Sketch Up, and Photoshop.

Successful operations are mainly achieved in landscape designs, especially by using Autocad, 3D Max and Photoshop programs together (Güngör, 2015).

Olgun and Yılmaz (2014) point out that CAD software used in design and visualization of design within the disciplines of architecture and landscape architecture are examined under 3 headings. These are pixel-based software, vector-based software, and object-based software.

2.1.1. Pixel-Based Software

The screens that interface computers with the designer have a matrix structure called resolution. Each cell of these matrices consists of planar squares (pixels). Software that produces graphics by placing pixels, which are the smallest two-dimensional particles, side by side and assigning colors, falls in the "Pixel Based" software group. These programs allow for additions to the models created in architectural works and the addition of visual effects. Frequently used pixel-based graphics processing software are Adobe Photoshop, Corel Paint, and GIMP (Yıldırım, 2004; Olgun and Yılmaz, 2014; Güngör, 2015).

2.1.2. Vector-Based Software

Vector-based software creates drawings in wireframe and mesh format with line elements. Although the lines are straight-linear, they can also be curved (spline). By means of the relevant software, the traditional pen is replaced by input tools such as a keyboard, mouse, or digitizer. Designs in two-dimensional planar and three-dimensional space are modeled with lines and nodes. The most widely used vector-based computer-aided design programs are Adobe Illustration, Adobe Freehand, Adobe Fireworks, CorelDraw, AutoCAD, Xara Xtreme, and InkSpace (Yıldırım, 2004; Güngör, 2015).

2.1.3. Object-Based Software

Object-based software, on the other hand, is software in which basic geometric forms, and structural elements such as load-bearing systems, walls, doors, and windows exist in the software as block libraries, and the architectural composition is obtained after they are selected parametrically by the designer. XML, J#, ASP.net, and other web services are examples of this type of software (Yıldırım, 2004; Güngör, 2015).

2.1.4. AutoCad

Autocad is a computer-aided design program developed by the United States-based Autodesk company in the early 1980s. It is vector-based, like other software used for drawing technical drawings. In other words, CAD software is a dataset where 2-dimensional and 3-dimensional geometric objects are created, independent of resolution (Olgun and Yılmaz, 2014).

Figure 1: An example of landscape design drawn with the Autocad program (Anonymous, 2023)

2.1.5. Archi CAD

Archi CAD is a different software from the CAD programs developed in 1988. It has become ordinary and possible to design with the Archi CAD program, obtain all kinds of perspectives, 3D models including terrains, sections, and views, survey and quantity survey information by simply drawing plans, make revisions in any environment and prepare animations (Güngör, 2015).

Figure 2: An example of landscape design drawn with the Archi CAD program (Anonymous, 2023a)

2.1.6. Photoshop

Adobe Photoshop is the digital photo processing software of Adobe Systems, which is a uniform format for pixel-based images, artwork, and photo editing. The program, which has bit image processing functions as well as features in vector operations and text processing, has been developed under the name "Smart Object" since the Photoshop CS2 version, providing great convenience to users with a system that allows vector data to be transferred to the Photoshop environment without losing its quality (Güngör,2015).

Figure 3: An example of a landscape design project edited with Photoshop (Koyuncu,2023)

2.1.7. 3D Studio Max

3D Studio Max is a three-dimensional visualization, modeling, and animation program developed by Autodesk. With its advanced plug-in support and ease of use, 3ds Max is one of the most widely used applications among 3D modeling software. It is also widely used in areas such as movie special effects, architectural presentations, and industrial design presentations (Olgun and Yılmaz, 2014).

Figure 4: An example of landscape design visualized with 3D Studio Max (Anonymous, 2023b)

2.1.8. Sketch Up

Sketch Up is an easy-to-use 3D visualization program designed for users in almost every field that requires 3D modeling, such as architects, engineers, filmmakers, and game developers (Güngör, 2015).

Figure 5: Landscape design visualized with Sketch Up and Lumion (LandsArt, 2023

CONCLUSION

The goal of computer-aided design is to support architectural and landscape designs with creative and rapid problem solutions by ensuring the active use of computer technology in the architectural and landscape design process. The variety of alternatives and production speed that the computer can provide increases the possibility of creating designs.

The most important goal of computer-aided design is considered to be success in producing creativity and innovation. It is extremely important to strengthen architectural and landscape designs, facilitate visual perception, accelerate the design process, and question and monitor these processes.

Rapidly developing information technologies, computer hardware, and software have become an effective way to create successful and high-quality designs in the field of landscape architecture. Computer-aided designs are preferred as they accelerate the design phase of landscape architecture, reduce costs, create precise solutions, and provide the opportunity to see the designs in three dimensions.

Although there are a myriad of computer-aided design programs, the most commonly used programs, among which are Autocad, 3D Max, Photoshop, and Sketch Up, and which are also used in landscape architecture, have been evaluated with examples in landscape design. There was an emphasis on the importance of computer-aided design programs in landscape architecture design projects in terms of producing fast and visually attractive designs. Computer-aided design programs are crucial for the designs to be created in the future and the construction of a livable world. The reflection of computer technology on landscape designs and the creativity of designers are seen as conveniences brought to the presentation dimension rather than the imagination dimension in creating designs.

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CHAPTER IV

B USE OF COMPUTER AIDED DESIGN PROGRAMS IN ARCHITECTURAL EDUCATION and DESIGN IN DIGITAL MEDIA

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INTRODUCTION

The fact that the world is three-dimensional increases the 3D requirements of computer drawings. Today, three-dimensional models attract more attention and make visualization as close to reality as possible (Özdemir et al. 2013: 16). With the development of technology, copying tools have become more preferred by turning from simple production tools into more complicated production tools, and electrical mechanical systems have started to be replaced by digitally supported systems (Bulat, 2014: 549). After the second half of the 20th century, with the rapid development of technology, especially with the development of personal computers in the 80s, computer use has gained importance in all professional fields (Çetiner, 2006). According to educational experts, computer technology is the most important/leading factor that can meet the needs of contemporary education. When the computer is used correctly as an instructive and auxiliary tool, it can increase the efficiency in education. Computer education should be given to future professionals within the scope of university education.

The desire to realize and implement different designs has introduced the field of architecture to the computer and a brand new process of rapid change has begun in architectural practices and education. This rapid development in information technologies has made design and research opportunities in digital environment compulsory in both architecture and architectural design education (in institutions that provide education in the field of design and especially in faculties that provide architecture education) (Akrout & Roxin, 1999; Yıldırım et al. 2014: 3). Therefore, architectural education has also entered a process of rapid change in the last twenty years in line with the development in computer and communication technologies. In order to analyze the effects of this change on architecture and architectural education, application-based research has been conducted. The results of the interaction of computer technologies with architectural education are evaluated by considering the relationship between benefit and harm. As a result of the evaluations, the educational structure is reshaped.

The use of computers is becoming more and more effective in the discipline of architecture. While it is used for drawing, it has become effective in obtaining accurate designs. Computer technology is used as a useful tool in undergraduate education as a teaching, presentation and training tool. In architectural education, computers are used in a wide variety of fields, and the degree and magnitude of this use is mostly related to the differentiation of the process between technology and design (Moloney, 2001: 121). It has become necessary for universities to undertake this task in order to carry out the use of computers in the field of architecture effectively and efficiently. In architectural education, it is accepted that computer-aided design is a part of the educational process and its positive contributions to the design process. However, it is necessary to keep up to date with this technology, which is in constant development, and to constantly renew the relevant equipment (Çetiner, 2006). The emergence of new methods in architectural design has led to the emergence of the computer as a design tool. This situation has brought a new type of architectural knowledge and a variety of computer skills (Kotnik, 2010).Yazar Adı Soyadı kısmından önce mutlaka unvan eklenmelidir.

COMPUTER-AIDED (DIGITAL) DESIGN PROGRAMS IN ARCHITECTURE

The profession of architecture is one of the most important professional groups today. All kinds of living spaces are designed and realized by architects. Some programs are used while creating these designs. These applications are computer-aided design programs. Computer Aided Design is the use of computer systems to assist in the creation of a part or a construction that is intended to be manufactured. More simply, it is the creation of the part to be manufactured or the building to be designed in the computer environment first. CAD or Computer Aided Design is expressed by the term CAD, which consists of the initials of the words "Computer Aided Design", which is a general name given to the programs written to do this job in English. Different programs can be used for three-dimensional (Figure 1) and two-dimensional designs. Thanks to computer aided design, designers and engineers can realize their designs in electronic environments. In this way, they can make changes to their designs much more quickly and can put this electronic information on paper from the printer at any time.

With architectural drawing programs, which are computer-aided design products, drawings are put on paper in a faster and more practical way. The drawn designs or sketches can also be obtained as printouts at the same time. Drawings can be manipulated by obtaining more realistic and accurate measurement values. Thanks to these programs, it is possible to have information about the results before the designs turn into construction. It is possible to say that both people who are professionals in this profession and people who do not have the qualifications of the profession can have an idea thanks to these programs (Çil & Pakdil, 2007).

Architectural drawing programs are produced by many different software developers. Therefore, these programs are quite diverse. Each architect or architect candidate uses programs for their own wishes and needs. Programs that offer a more comfortable and unique workspace are selected. There are a wide variety of programs for architects to meet different needs and requests. Drawings are made through these programs. There are reasons why these programs are preferred rather than drawing by hand. These programs offer various advantages and benefits to their users. These advantages can be listed as follows:

- Providing assistance to people working on the program during the adaptation process
- To aim to finish drawings and projects in the fastest and most practical way
- Minimizing the margin of error, especially in large projects
- Analyzing projects down to the finest detail
- Facilitate the comprehension of drawings and projects and facilitate the study of all details
- Ensuring the highest efficiency and effectiveness in international projects
- Minimizing office and stationery costs
- To follow all developments closely
- Ensuring customer and employee satisfaction
- Increasing dynamism in the office and ensuring integration

Architectural drawing programs, which have countless advantages and benefits and are used with pleasure by their users, are indispensable for people in this profession. AutoCAD 3D, 3DS Max, Sketchup, SHAPR3D, Rhinoceros, Revit, Dynamo etc. can be given as examples of these programs.

Figure 1. Three-dimensional drawing prepared with CAD programs
Source: https://www.autodesk.com.tr/solutions/cad (URL 1)

The architectural drawing programs listed above support their users in various ways.

The first purpose of these programs is to make a three-dimensional visualization. Computer drawing programs work in the context of modeling the drawn designs or projects and are used especially to obtain all kinds of information necessary to have an idea about the outcome of the projects.

These programs are used to obtain sufficient and accurate technical information necessary for the realization and development of a project. For example; walls, columns, windows, doors and every fixed element in a living space is very important to reach the required size in planning and designing.

In order to make an architectural drawing, there is a need for a variety of architectural drawing programs that do both modeling and rendering design. Among the most commonly used programs are 3DS Max and Sketch Up. Among the rendering programs, the most preferred ones can be considered as V-Ray. AutoCAD is recommended for users who want to work with only one program.

For your architectural drawing works, you need to have at least one of these programs and know how to use it.

Among the programs used by architects, you can choose the program that best suits your own drawing and workspaces. You can also use more than one program. The adaptation process and your hand predisposition can be a determining factor in which program you choose. You can choose only one of the architectural drawing programs or you can work with multiple programs at the same time.

Some programs can give higher quality results when run together. Therefore, it is more accurate to work with programs that get along well with each other, support each other and give higher efficiency. The most preferred architectural drawing programs are:

<u>AutoCAD 3D</u>

It ranks first among the most preferred architectural programs. It is a program known by almost all people working in the field of architecture. The reason for this is that this program can be used not only for architecture but also for civil and mechanical engineering. It is extremely simple to use. After the first 2D program, it was released as a 3D version.

<u>3DS Max</u>

With this program you can work on visualization, modeling and animation. With its extremely easy use and improved plug-in support, 3DS Max has taken its place among the programs used by architects. Apart from architecture, it is preferred in the film industry, industrial designs and design presentations.

<u>Sketch Up</u>

Sketch Up, one of the most preferred architectural programs, is a program frequently used for three-dimensional drawings. This program, which provides the advantage of the easiest use, is especially suitable for students and beginners. This program with a simple interface and system provides plug-in support.

<u>SHAPR3D</u>

SHAPR3D program; It is an application preferred by users with Windows, Linux and MacOS operating systems. It is a type of software that makes three-dimensional modeling and design.

The best advantage of this program is that it is free. It is among the most powerful CAD programs.

<u>Rhinoceros</u>

Rhinoceros is among the programs used by architects thanks to the various advantages it offers to its users. It is an application with mesh system. It offers unlimited drawing opportunities. With this program, you can do unlimited number of drawings and modeling. It is a very useful program in terms of both revising the work done and performing its own operations according to the parameters entered.

Revit

Revit, which takes its place among the new generation architectural drawing programs due to its much more practical operation, is the choice of users looking for speed and practicality. Revit, which allows drawings and projects to be transferred to paper more easily, is among the new generation computer programs most used by architects.

Dynamo

It is often used for computational and repetitive tasks through Autodesk. Dynamo, which makes certain repetitive tasks more fluid and practical, makes all your operations easier. The system, which has an open source visual programming interface, works on Revit. It is used for conceptual designs, automation and solving design problems in an easy way.

Photoshop

Architectural visualization operations are performed in the Photoshop program, which is among the programs used by architects but used in every field. With this program, the highest level of performance is provided in correcting rendering errors, exterior cladding, landscaping or site plans.

V-Ray

V-Ray is a rendering engine. It is used in three-dimensional graphics application processes.

It allows you to do your work more professionally in the field of visualization. It has different usage options such as illumination mapping, light cache and photon mapping. It is among the most preferred architectural programs thanks to its photometric light support system.

Corona Render

Used both with other architectural drawing programs and independently, Corona Render is a new generation and modern photo-realistic rendering tool. Its high performance is among the reasons why it is preferred. It is a frequently preferred drawing program thanks to its very easy use and setup.

HISTORY OF COMPUTER-AIDED DESIGN IN ARCHITECTURE

In computer-aided programming, CAD software was developed first. CAD software is a design and technical documentation technology that replaces computer-aided design, drafting (CADD) and manual drafting with automated processes. Examples of CAD software are: VISI Machining Design, Autodesk, AutoCAD, Autodesk Inventor, Autodesk Fusion, SolidWorks, CATIA, Solid Edge, NX CAD, Creo (formerly ProEngineer) (Baykan, 1995). The first recognizable CAD system was SKETCHPAD, developed by Ivan Sutherland at MIT between 1960 and 1963. User input was done with a pencil drawn on the computer screen by the designer. Later in the 1960s, new software and programs were added, improving CAD systems (Ball, 2013). These software enabled a modeled object to be displayed in 2D. Later developed BIM systems, on the other hand, have the ability to simulate various scenarios that human beings cannot even imagine by offering 3 or 4 dimensional or even 5 dimensional imaging possibilities (Tarçın, 2007).

Especially today, when energy consumption in buildings is considered as a priority, computer software, simulation and modeling are used as analysis tools to evaluate different performances of buildings and there are programs that provide information about the performance of buildings before they are built (Baykan, 2001). Primary energy consumption elements for a building can be analyzed as a whole with simulation programs. Thus, energy efficiency in buildings can be increased.

Along with architectural design, structural analyses and structural system can be designed and modeled in computer environment.

COMPUTER ENVIRONMENT/DIGITAL MEDIA IN ARCHITECTURE EDUCATION

The computerized design environment consists of a collection of tools, resources, information and databases that enable different tasks to be performed in relation to each other.

The parts that make up the computer architectural design environment can be grouped as modeling tools, analysis programs, synthesis programs.

Modeling: Modeling tools are programs such as AutoCad, FormZ, ArchiCad and Photoshop used in 2D and 3D modeling, digital/virtual reality

(Figure 2) programs and two and three dimensional scanners, digital cameras and video shooters, presentation tools such as printing machines and database programs.

Analysis: As analysis tools, we can refer to programs that allow the evaluation of computer modeled buildings in terms of cost, feasibility, heat, energy, natural and artificial lighting or acoustics, and the simulation of the users' circulation in the space.

These programs allow the designer to use the specialized knowledge of another discipline and develop integrated designs that take into account the criteria of other disciplines under his/her control (Seebohm 2001).

Synthesis: Synthesis tools are computer programs that automatically generate layout, detailing or requirement program alternatives under the control of the designer.

Figure 2. Software system in digital/virtual environment
Source: https://www.tintmimarlik.com/mimari-cizim-programlari/ (URL 2)

COMPUTERIZED VISUALIZATION TECHNIQUES IN ARCHITECTURAL EDUCATION

In architectural education, computerized visualization techniques are introduced primarily by using CAD applications. The first applications in information technology started with two-dimensional drawings, which are still used today as the main drawings in application projects.

However, with the introduction of three-dimensional modeling techniques in the mid-1980s, visual expressions became more popular (Bilalis, 2000: 2). Creating a three-dimensional CAD model is the starting point for visualization, and the database containing the model can be realized in the form of two-dimensional presentations such as plans, sections, views and perspectives (Ünür, 2000). The computerized visualization and modeling programs in use today have significant advantages over traditional techniques (sketches, perspectives, models, etc.) (Harputlugil Ulukavak, 2007). These computer-based programs contribute to both the design process and the evaluation of the spatial relationships that reflect the designer's ideas (Ervin & Hasbrouck, 2001). Goldermens and Hoogenboom (2001), while defining visualization as "the transformation of a spatial object into two or three dimensional models in a way that the human mind can perceive after design, application and implementation".

The fact that visualization contributes to the designer at every stage of the design allows the products to produce the closest results to the desired ones. Visualization software is more preferred due to its advantages such as being fast, low-cost, easy to store, easy to revise, easy to draw with zero margin of error and easy to produce alternative solutions (Uğur et al., 2003; Yıldırım et al., 2010: 21). Three-dimensional visualization programs have increased especially in the last decade as facade surface design and exterior appearance have become more important in the architectural field. With the increase in polygon assignment and parametric surface designs on architectural surfaces used in the advertising industry, whether real or virtual, the interfaces of the programs and the capabilities of the commands have been improved. AutoCAD 3D, 3DS Max, Sketch Up, Maya, Cinema 4d, Rhino and SHAPR3D are the most widely known and used three-dimensional modeling programs (Uzun & Arıl, 2016).

THE PROCESS OF TRANSITION TO COMPUTER PROGRAMS IN ARCHITECTURAL EDUCATION

The contribution of technological developments to the architectural design process allows the presentation techniques used by students to express their designs to change. In architectural design education, traditional design and expression tools such as drawing on paper (with T-ruler and rapido) and producing models still continue today. Computer technologies are used as auxiliary tools. Therefore, a hybrid education system in which traditional and digital techniques are used together is applied today (Yıldırım et al., 2010). This hybrid education system is seen as a transition process to computer technologies.

Within the education period in architecture programs, computer programs start with two-dimensional drawings, three-dimensional modeling and conversion into visual objects are given in periodic course programs. The transition to computer programs in architecture education usually starts at the beginning of the 2nd year, in the 3rd semester of education. Therefore, students who have completed their 3rd and 4th semesters can practice with the approval of their advisors. Therefore, students who have passed to the 5th semester can draw their projects and prepare their presentations with the help of computer programs in studio courses.

In the 1st grade, in the 1st and 2nd semesters of education, traditional drawing methods are taught and then computer programs are used. In architectural education, architectural programs are listed in 5 different levels according to their usability and competence levels (Uzun, 2011: 843):

1. Basic level: It is the beginning level. It is the stage of recognizing and using the main menus of the program.

2. Intermediate level: It is the stage of producing an average product.

3. Advanced level: It is the stage of differentiating the resulting model in terms of form.

4. Advanced level: It is the stage of working with high level modeling and curvilinear surfaces on the product.

5. Photorealistic level: The ability to exchange data between all the programs mastered; the ability to use ready-made models or ready-made materials, to get different model outputs "rendering", and finally to reach "photorealistic" reality with the help of light and camera (Uzun, 2011: 843).

To summarize briefly; 'computer aided design or computer technologies' is also included in the content of 'Architectural Project/Design Course/Design Project' in undergraduate education. Compulsory and elective undergraduate courses are taught by faculty members. The courses are reorganized every year by evaluating the data obtained. Although computer-aided design courses are related to design project courses, there are few studio environments where computer-aided design and traditional methods can be used together. Although computer-aided design is applied with different methods and contents in universities, it is tried to be used with the most efficient method in undergraduate education. The fact that faculties approach this field on a course scale shows the importance they attach to computer-aided design in terms of quantity and quality.

DEVELOPMENT PROCESS AND SCOPE OF COMPUTER-AIDED DESIGN IN ARCHITECTURAL EDUCATION

Developments that started in the 1960s, the computer environment in the field of architecture applied science in recent years intensively in our country (Turkey) also shows a rapid development.

In the 1970s, Computer Aided Design (CAD) studies started in engineering and design processes with research and development studies such as PhDs etc. at universities. By the 1990s, software and hardware had reached a certain level of quality and the use of computer-aided design applications in universities increased. Apart from affecting the design method, these developments enable to reach the best design with data collection in design. Applications were first included in graduate and then undergraduate education programs. In the courses where technology is used, it is tried to ensure that the student develops professional skills and makes a good design/application. Design studios in architectural education require a systematic organization in terms of software and hardware.

Computer technology also finds the opportunity to be applied in other courses in architecture education. In building/structural elements courses, slide/animation presentation can be used to convey information about the coming together of building elements and structure. Joint courses, research projects, etc. between geographically distant universities can be organized.

THE BENEFITS OF COMPUTER-AIDED DESIGN IN ARCHITECTURE FOR THE STUDENTS IN THE DESIGN PROCESS OF STUDIO EDUCATION AND THE DESIGNERS

In the 1960s, computer support in architecture reduced the burden of architectural drawing and enabled people to be more involved in the design process. In the 1970s, they became intelligent assistants in relaxing the designer and increasing their decision-making abilities. Today, computers are increasingly included in the design process. Architectural information is transformed into computer-aided intelligent information hardware modeling. One of the future roles of computers will be to design a computer mechanism to which the idea of independent design is associated. Although a utopian idea, this envisioned role will show the development of computer support in architecture (Terzidis, 1992).

Computer use, internet, drawing programs and technological developments change the organizational structure of the architectural design process as in every field. The use of digital communication technologies in the architectural design process, to reveal the effects on design organizations, requires digital-synchronized work between all professional disciplines that make up the building design. It is often associated with many disciplines. Communication, which is necessary to ensure coordination between disciplines, gains more importance with the increase in information input (İnan & Yıldırım, 2009). Digital methods and architectural knowledge are transformed into modeling. Thus, the function of 'seeing' the whole in creativity becomes easier. In this sense, the form of a design object, its function, structure and even its sustainability can be 'followed' (Iordanova, 2009).

Architectural design can be done with two or three dimensional models such as drawings and models, and today it can be modeled in computer environment. Modeling provides the opportunity to see the product before the application. By using special purpose computer software and simulations during the design process; different performances of the building such as earthquake resistance, lighting, heat conservation can be simulated in a virtual environment (Eceoğlu, 2012).

CAD (Computer Aided Design) and VR (Virtual Reality) programs have become essential tools for architects who want to communicate the options produced to their clients through various design teams (Thalmann & Thalmann, 1992, Horne & Hamza, 2006: 312).

Considering the benefits of the computer for the designer, it should be considered as a tool for architecture students, enabling them to explore different areas of architectural design. While traditional tools allow architects to work only on objects, computers give them easy access to the processes and resources of creative activity (Asanowicz, 1998: 6).

With the use of computer technologies in architectural design education, students can use modeling programs to work on both two-dimensional drawings and three-dimensional models, use photorealistic visual tools and simulation environments using counter-interactive animation techniques, and use virtual reality software to experience their work in person. The fact that the given project subject is mainly handled in three dimensions, that all stages and situations of the building designed on the screen can be observed with different effects, and that its relations with topography and surrounding constructions can be monitored with three-dimensional rendering, animation and realistic image techniques has caused significant changes and developments in the knowledge capacity of the students.

After students start using three-dimensional drawing programs, their ability to think in three dimensions and their ability to make models gradually increases. Visual presentations allow the quality of work to increase in the professional field. They are also considered as tools that contain descriptive information that is reduced in order to clearly comprehend and process the information of the object while expressing a model. The creation of visual presentations using three-dimensional databases allows perspective views to be preferred frequently (Hamamcıoğlu Turan 2002; Hamamcıoğlu Turan 2004: 48).

The products obtained during and at the end of the study process help computer-aided design to improve the student's design skills. With the use of computers, being active in the learning process, directing to research, simulating real life, which are the basic requirements of contemporary education, can be provided.

In architecture, especially in studio education (project courses), students' use of computer-aided design programs helps them to understand the design process:

- understanding space,
- interpret and evaluate
- and reproduction (Yıldırım et al., 2014).

CONCLUSION

Schoon 1992; Moloney 2001 stated that creative solutions in the field of architecture usually come from students who are prepared to examine critically by making many repetitions (producing sketches). The computer's ability to memorize drawings and access alternative solutions more quickly and quickly increases students' interest in architectural drawing programs.

In architectural education, when digital design methods are used uninterruptedly from the beginning to the end of the design process, accompanied by a mentor, the possibility of reaching the final product in 3D is high. In this respect, when the prerequisites of encouraging, directing and guiding the use of digital design in education and the student's willingness to reach the beginner and advanced level skills of the program are met; digital design programs and digital methods become a successful tool that transforms the "design object" in memory into a "real" object (Uzun, 2011: 849).

According to the results of the research, it has been seen that the use of architectural drawing programs in architectural education is very important. Students are aware that it is important to know and be able to draw architectural drawing programs in their professional lives. However, even though knowing the program has an important place in architectural education and professional life, students also need to develop their skills in hand drawing and sketching. In this respect, it is better to start education with traditional drawing methods within the four-year education period. As drawing programs are repeated, they become more memorable and increase the speed of use. For this reason, the programs taught should not remain fixed with the commands taught in the course, but the students should also explore the programs by using them in their free time. The more a student is interested in a program and the more he uses it, the more his mastery of the program will increase.

Nowadays, considering that presentation and expression techniques in the field of architecture have an impact on revealing the quality of work in the professional field, it turns out that students should also be very interested in architectural drawing programs. However, instead of knowing as many programs as possible at beginner level, having a good command of one or two drawing programs will be more effective in revealing the quality and visual presentation of the work. With the introduction of technology into the architectural field, the easy solution of difficult and demanding projects has revealed the importance of digital programs in architectural education. In this respect, forward-looking and renewed design programs should be emphasized in architectural education life and students should be informed in this respect.

The new technology has two consequences. The first is that the same job can be done more efficiently with a new tool, and the second is that new technology changes practice thanks to its affordances. Computer environment has replaced traditional tools in architectural education, but the education method has not changed. Changes that can be made in education should include design studio, drawing, modeling and analysis courses using the computer environment, courses teaching the principles and methods of new tools in the computer environment should be opened, and as new tools are developed, they should also be included in the system. All benefits of computer technology need to be analyzed well and its appropriate use within architectural education should be increased.

Therefore, this environment, which has a dynamic structure, in parallel with technology; It also requires development and change in the method of architectural education in terms of hardware, software and user compatibility. New research aimed at increasing the content and efficiency of the educational process will be successful in producing creative solutions for design education.

Expected from computer aided design;

• Increasing intellectual quality,

• ability to perform computer-aided visual analyses,

• computer modeling of created and existing designs and environments,

• design rules can be reviewed,

• developing the ability to acquire vanished cultural values in a virtual environment,

• to benefit from its use in architectural teaching and practice (Çetiner, 2006).

As a result, with the use of these technologies, the computer environment has become a tool or an environment that can be experienced rather than just a means of expression, and the use of computer technologies in architectural education has begun due to the conveniences and superior qualities it provides. However, in order to increase the process, content and efficiency of education in the virtual environment, which is constantly changing with digital developments, and to benefit from technology at a high level, new research should be conducted and different methods should be developed.

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CHAPTER V

DIGITAL / ADVANCED DOCUMENTATION TECHNIQUES USED IN SURVEYING STUDIES (RÖLÖVE) IN THE MEANING OF CULTURAL HERITAGE PROTECTION

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INTRODUCTION

Cultural assets, which are tangible evidence of the cultural transmission of past civilizations, are damaged by environmental and structural factors over time and need to be protected. Thanks to the computerization of the documentation process, cultural assets are protected in virtual environments. With technological advances, new techniques have emerged for measuring and photographing buildings in order to ensure the most accurate and time-saving documentation of cultural heritage. In general, the working principle of all of them is based on the laser scanning method.

This method is frequently used in documentation studies carried out within the scope of the conservation and documentation of cultural heritage structures about the way of life, culture and beliefs, economic conditions and technical levels of ancient civilizations that have survived from the past to the present. Thus, with the documentation and conservation techniques developed in digital environments, both the original forms of cultural assets are preserved in the most accurate way and the opportunity to design a virtual museum environment is offered. In addition, the laser scanning method has been integrated into the LIDAR (Light Detection and Ranging) system within a certain discipline (Yakar et al., 2019).

The surfaces of the object form point clouds thanks to the LIDAR principle and laser beams, and the three-dimensional (3D) image of the object emerges precisely and quickly. This three-dimensional model is a basis for determining the architectural interior and exterior features of the building, determining the façade lengths and the width-length-height of the mass, making two-dimensional plan-section-view drawings, and preparing the survey drawings that are preliminary to the restoration project (Çelik et al., 2020; Duran et al., 2017; Ulvi, 2015).

In this sense, the accuracy of the point cloud to be produced is extremely important as it determines the accuracy of the resulting measurement results and must have mm measurement accuracy. The objectives of the study are to explain both traditional and technological documentation methods as surveying and cultural heritage documentation techniques that play an important role in documentation, to compare the traditional surveying technique, photogrammetry technique and laser scanning techniques from technological documentation methods in terms of cost, precision, accuracy and time.

THE FIRST STAGE IN PRESERVATION WORKS; CONCEPTS OF 'DOCUMENTATION' and 'RÖLÖVE' (RE-MEASUREMENT/RESCALE)

In addition to the protection of cultural assets, documentation is also required, for this reason, since the past, cultural heritage has been wanted to be transferred to future generations by preserving its originality, and this has led to the documentation of cultural heritage (Pakben, 2013).

Documentation:

- To convey the message and the cultural heritage itself to future generations,

- To ensure the survival of the building or group of buildings by evaluating them in today's contemporary use, - To have knowledge about the past of the building,

- To determine the current status of the building,

- To obtain sensitive data necessary for future conservation, restoration and restitution plans,

- To be able to identify all kinds of problems in historical buildings or building groups, - To have detailed information about the history of the building or building group,

- To obtain the necessary data to prepare the surveying projects that form the basis for conservation projects

- It is an action taken with the aim of raising public awareness and opening it up to their comments (Kuban, 2000).

Many national and international organizations carry out studies within the scope of various agreements in the protection, documentation and sustainability of cultural heritage and cultural assets (Ernst et al., 2021; Kaya et al., 2021). Some of the most popular organizations according to these agreements and their work are the Convention on the Protection of the World Cultural and Natural Heritage, the United Nations Educational, Scientific and Cultural Organization (UNESCO), the Convention on the Protection of the Architectural Heritage of Europe, the International Union for Conservation of Nature (IUCN), the Convention on the Protection of Intangible Cultural Heritage and the International Centre for the Conservation and Restoration of Cultural Heritage (ICCROM). In Turkey, institutions such as the Ministry of Culture and Tourism, the Ministry of Interior, and the High Council for the

Protection of Cultural and Natural Heritage (KTVKK) undertake and carry out this task.

Rölöve (surveying) is the description of the current condition of the building's interior and exterior architecture, original decoration, structural system and building materials with scaled drawings, documents and reports in order to closely examine, document, evaluate in terms of architectural history and prepare restoration projects for buildings or building groups, urban texture or archaeological remains (TMMOB, 2011).

Surveying of registered immovable cultural assets is a report containing the architectural definition of the work, construction technique, type of material used, current definitions of ornamental elements, carrier element problems, structural deterioration, deformations and interventions made to the work, and the description and documentation of the current state of the work with scaled drawings. Therefore, during the survey work, all dimensions of the buildings are measured and their plans, sections and views are reconstructed to determine the current situation. The survey study constitutes the basis for the protection of buildings and guides the experts who will carry out restitution or restoration work. It is possible to obtain detailed information about the buildings with the survey, which is mostly used in archiving. With the survey technique, it is aimed to protect the cultural heritage, that is, the buildings, and to carry them to the future in their original, original form.

In the surveying technique, scientific tools and methods are used to document the current condition of the buildings. Devices such as photogrammetric camera, laser meter, level, total station and laser scanner are used during the measurement. The survey work is prepared in digital environment with on-site measurements using 3D laser scanners, which are precision measuring instruments. Within the scope of surveying works, the documentation of cultural assets is done in three ways: written, drawn and visual:

Drawing Documents: The survey drawings should include the quality and scale of the drawing document that will fully describe the building and can be used in later stages. Survey drawings are prepared in sheets with measurements, material definitions, distortions and similar representations. Site plan, plans (floor plans, floor plans, ceiling plans, upper cover plan and roof plan), elevations, sections, system details, details of architectural elements, schematic representations of infrastructure, typological studies, survey intervention sheets constitute the survey drawings.

Written Documents: Includes research results, descriptions, explanations, analyses and reports on the spatial, architectural, structural and decorative features of the building.

Photo Album / Transparency Set: Transparencies and photographs reflecting the general view of the building, including all kinds of details from the interior, exterior and necessary parts of the building are prepared.

Rölöve (survey, re-measurement/rescale) is divided into 3 main groups according to the measurement method and the taken measurements:

Simple Survey (Rölöve)

They are studies that do not constitute a basis. They are carried out to get a preliminary idea at the project preparation stage. Traditional measurement methods such as span, step, stroke (fathom) are used. Surveys are superficial. Stages such as asking for the address of the immovable property, getting information from the people living in the neighborhood are included in the process. It is often used to understand the plan diagram and rough measurements. Not submitted or presented to the any institution.

Detection Survey (Rölöve)

It is a method applied to cultural and natural assets and ultimately used for registration applications to conservation boards. Technological opportunities are utilized in measurements. The study is supported by photographs. The survey work carried out for the maintenance, repair, documentation or archiving of the building includes plan, section and elevation surveys. It requires a sensitive work. It can be done quickly since it will only be used in repair or archived and the plan diagram will not be used in any other work. It is submitted to the institution (board) only for registration purposes.

Main Survey (Rölöve)

It is made to demolish and reconstruct an old work or to form the basis for restitution and restoration project work. The survey work carried out to create an archive about the immovable to be demolished is called the main survey. It requires very precise and careful measurement. The measurement process should be completed with minimum error. Details should be given a lot of space, more sources should be scanned for research and documentation. The work must be supported by photographs and videos. This work is presented to the committee with its details.

Rölöve/Survey Measurement Instruments or Tools

The measuring instruments (tools) used during the survey work are as follows: folding wooden meter, steel meters, electronic distance meter (EUÖ), vernier calipers, telescopic meter, fully integrated electronic takeometers (Total stations), compass, channel miter, profile comb, theodolite, aluminum telescopic miras, laser level, hand level, laser miter, spirit level, laser beam lamp, spirit level with hose, laser level, plumb line, laser plumb line, fishing rod, electronic and mechanical protractors and stands.

Folding rule Tape measure

Laser meter Digital caliper Telescopic meter

Figure 1. Rölöve measurement ınstruments or tools
Source: https://santiyede.com/rolove-nedir-rolove-cesitleri-nelerdir-nasil-yapilir/ (URL 1)

Rölöve/Survey Drawing Instruments or Tools

The drawing tools used during the rölöve and field work are as follows: flat (measuring) ruler, scale ruler, squares, protractors, pencils, erasers, compasses, drawing paper, sketch paper and tablet computer.

EMERGING TECHNOLOGICAL APPROACHES TO DOCUMENTATION

Developments in the technologies used in the documentation and representation of cultural heritage have forced specialists working in this field to think about the effects, benefits and possibilities of exploiting the results obtained with this technology. Digital documentation is the production of a simplified model of the object that contains sufficient information to allow the transfer of the necessary knowledge. In traditional methods, the model consists of drawings that define the geometry of the object, passing through reference sections that divide the space horizontally and vertically.

This type of representation allows to obtain metric information directly. On the other hand, these drawings force us to simplify the object, to select the most important parts, while facilitating our understanding of the object. The systems used so far, traditional surveying methods or photogrammetric methods, require specialists who can analyze the object, provide important data and create the representation. The current and emerging techniques require costly and difficult to manage systems such as computer systems and software.

These systems are also very difficult to use by end users. The processed data usually includes 3D coordinates of the points and color information related to the object point. In addition, photographs are used to create a representation of the object, but their practical use faces serious obstacles when applied to conservation. Making raw data usable is a specialized and time-consuming process. Most of the experts with traditional training state that they are better able to evaluate and interpret the information obtained from drawings prepared by traditional methods than from information obtained with new technologies.

Therefore, two areas are particularly important if these new technologies are to be used to real benefit in all areas of conservation. One is confidence and sensitivity to the appropriate technology (both computerized and in the field) and the other is the training and expertise required to understand the information obtained. Another layer of documentation users are experts (art historians, archaeologists, managers, administrators, etc.) who may not be technologically competent in this work. In addition, the public and experts from different fields with an interest in cultural heritage are also part of this process. For these users, there is often no need for detail and they are generally more involved in the evaluation process than in the data collection process (Almagro, 2007).

In a documentation project, the project manager must first decide on the relevant disciplines that should be involved in the project. In some cases, a late decision can lead to extra costs and delays in the project. Once the research part is clear, the experts should jointly decide on the appropriate method. Since documentation is a long and interdisciplinary process, the whole process needs to be handled by experts coming together and making joint decisions, rather than by one person. In some cases, simple methods can be used. But in comprehensive and complex cases, several different methods can be applied.

According to Unesco, a heritage is an arch between what we inherit and what we leave behind. The importance of documenting cultural heritage has become more recognized in recent years and there is a growing awareness of its preservation and documentation. The available technologies and methodologies provide 2D and 3D results for archaeological purposes, digital preservation, restoration, conservation, preservation, VR applications, catalogues, web geospatial systems and visualization (Remondino, 2009).

Two stages are very important in the process of documenting cultural heritage. The first one is data collection and the other is the decision-making process. The data collection phase is a process that also affects the decision-making process and should be followed carefully. While collecting relevant data in this process, the research process should include three important steps:

- Measurement: Performance of metric sciences in terms of accuracy
- Selection of the appropriate method: Understanding the size of the structure and selecting the appropriate method
- Communication: Sharing information and presentation in an open, continuous and easily accessible platform (Blake, 2010).

Experts are needed for the application of emerging documentation technologies (digital photography, Lidar, Laser Scanning and digital photogrammetry) and institutional support is needed for the acquisition of metric data. The following criteria should be taken into account in the application of the appropriate technique:

- Price
- Appropriate Sharing
- Continuity and flexibility

- Metric performance (Blake, 2010).

CONTEMPORARY/NEW GENERATION DOCUMENTATION TECHNIQUES IN CONSERVATION

Many documentation techniques have been used in the protection of cultural assets from past to present. With the development of technology, these techniques have diversified and gradually increased measurement accuracy, reduced margins of error, saved time, reduced labor burden and progressed to digital three-dimensional (3D) documentation (Pakben, 2013). These documentation techniques can be divided into two categories: traditional and technological:

Traditional Documentation Techniques

We can examine traditional documentation under three main headings; visual documentation, written documentation and studies carried out before the restoration project. Even before technology developed so much, people were concerned about protecting cultural assets and transferring them to future generations. This concern has led to the documentation techniques we now call traditional. However, traditional documentation techniques have begun to be abandoned due to their low precision and slowness in measurements in structures with complex geometry, damaged objects, and conditions where sensitive detailing is required. Some of the tools used in traditional documentation are tape measure, plumb line, compass, carbon paper, jalon, prism, mira, level and theodolite (Pakben, 2013).

Technological Documentation Techniques

With today's technology and developing scientific research, the use of modern techniques in surveying has provided great convenience compared to traditional methods. It is now easier, faster and more precise to take detail measurements, make drawings, take photos and videos and obtain 3D data from drawings. In addition to all these, modern techniques provide the opportunity to store sensitive and visually rich data in digital media for a long time. With the development of technology, many documentation techniques have developed, and if we examine these documentation techniques under three main headings;

- traditional surveying techniques [GNSS (Global Navigation Satellite Systems), total stations, advanced leveling and theodolites, etc.],
- photogrammetry technique and
- is a laser scanning technique.

Traditional Surveying Technique

In the traditional surveying technique, there are 3 survey studies, these are simple surveying, determination surveying and basic surveying studies. Simple survey technique is a working style with traditional measurement methods. Determination and basic surveying are working methods that utilize technological possibilities and are called traditional surveying techniques.

In the traditional surveying technique, which has certain systems and rules, the cultural heritage is first sketched. Then, the measurements obtained by triangulation and polygon formation method with continuous measurements taken on the scale line are written on the sketch. Measurements are obtained with laser meter, level, spirit level, level, tape measure, rope, t-ruler, compass, square, plumb line, theodolite, caliper, wooden meter, jalon, total station, GNSS and millimeter blocks. The data are either drawn by hand or transferred to a drawing program in accordance with the survey method.

<u>Total Station</u>

Total station is a universal, electronic measuring device used in many places such as land, buildings, roads, bridges, tunnels and dams; it is a universal, electronic measuring device that replaces electronic takeometers, theodolites, rangefinders and levelers for detail acquisition, angle, length and height determination. The total station has a display with a Turkish menu and clear menu guidance. Used with a prism, these instruments are capable of accurate measurements up to 3500 m.

Today's models can measure up to a certain distance with red laser light without using a reflector. It has a large memory for recording and storing data. The battery can be used for a long time and having a spare battery ensures that there is no loss of time and disruption in the work done. The recorded information can then be opened and edited with cad programs on the computer. The use of reflectorless devices that measure distance with laser has increased due to the benefits they provide. It is very useful in surveying, exterior facade manufacturing, measuring hard-to-reach places, restoration of historical buildings.

One-person operation and easy measurement with laser light saves time. The recorded information can then be transferred to a computer for further processing. The total station is a device that sends a laser or infrared beam. These beams are reflected back to the instrument by means of a reflector held in front of it. The distance is measured as a result of a calculation based on the travel time and speed of the beam. New models can measure up to a certain distance without a reflector.

A polygon point with known x,y,z coordinates is taken as a reference point. The device must be installed on a polygon point in plumb. For the station setting, the height of the device and the reflector, the values of the point where the device is installed and the point of view are entered into the total station. The point of view is measured and stored in the device's memory. The total station continuously and automatically measures in mm accuracy and displays the measurements on the screen. The measurements made can be saved in the memory and then transferred to the computer and can be worked on with cad programs.

Figure 2. Totalstation surveying (rölöve) ınstrument
Source: https://santiyede.com/total-station-nedir-nasil-calisir-ne-ise-yarar/ (URL 2)

Photogrammetry Technique

Today, with the developing technology, there have been developments in architectural surveying techniques. In general terms, the method of spatial photogrammetry, which can obtain two-dimensional drawings and three-dimensional models from the images of objects (pictures and photographs) with the help of digital evaluation systems and is widely used in architecture, has started to be widely used in our country. With the widespread use of computers, the increase in the application areas of close-up photogrammetry in architecture has also been reflected in architecture. Photogrammetry, which is based on the principle of producing accurate information by eliminating errors from photographs, is a technique almost as old as photography technology (Şenol et al., 2020). It is a technology that involves recording photographic images of an object or land structure, converting them into a model, measuring height, distance, coordinates, area and volume, and overlaying and interpreting two-dimensional photographs taken from the air or land. In this technique, which is based on control points of known spatial coordinates and triangulation between points, DEM (digital elevation model) analysis, orthophoto image and three-dimensional point cloud are also obtained.

Thanks to this technique, three-dimensional data is obtained very quickly and a representation is provided by integrating it with the images of the objects. The most important advantage of this method is that it obtains a more realistic representation of spatial objects than imaging techniques. These models are frequently used in historical heritage and land management applications. In the documentation of cultural heritage, three-dimensional models are very important tools for visualization (El-Hakim, 2001). Nowadays, photogrammetry technique is used for fast and reliable documentation of cultural assets (Yakar & Yilmaz, 2008). With the digital photogrammetric method, the documentation, promotion, protection of historical buildings, and the detection of deterioration that may occur in the works over time during and after restoration works by conservation experts can be done (Turan, 2004). Another important advantage of photogrammetry is that it allows 3D representation of objects by modeling them in accordance with the original (Asri & Çorumluoğlu, 2007).

In short, architectural photogrammetry aims to obtain and present information including visual data of the architectural object, geometric description of the object, planar and spatial position of the object, object size and shape, texture information and both planar and spatial details and properties of this information. National and international studies on architectural photogrammetry have increased the importance of terrestrial photogrammetry and expanded its application area.

Architectural photogrammetry:

- architectural surveys and facades,

- in the identification and determination of historical and archaeological sites,

- in shape and structure research,

- the construction of conservation zoning plans v e in its implementation,

- in documentation work carried out for the protection, maintenance and repair of cultural assets,

- determination of bending, twisting, sliding and collapse movements and deformations in structures and parameters about the magnitude of movement, if any, in the structure,

- to check whether the structure is as it should be after repair

- in city and regional planning studies,

- making models, busts, industrial models,

- It is used to record the facade and interior layout of important historical buildings and structures or to renovate an old building for any purpose (Yılmaz, 2007).

Figure 3. Photogrammetric three-dimensional model
Source: https://surveyhands.com/tr/hizmetlerimiz/fotogrametri/ (URL 3)

Laser Scanning Technique

Documenting the time between the laser beam coming out of the laser scanning device hitting the object surface and its reflection and return to distance measurement and overlapping it with the photographs taken is called laser scanning technique (Şenol et al., 2021; Kaya et al., 2021). Laser scanners (LT) are systems that can shoot thousands or millions of points per second, perceive them in three dimensions and convert them into data (Memduhoğlu, 2020; Polat et al., 2020). There are two systems in laser scanners: mechanical deflection and laser radar.

While the mechanical deflection system records the horizontal and vertical angles of the laser signal; The laser radar system calculates the time it takes for the laser beam fired from the scanner to return to the scanner from the surface where it hit the object. Thanks to these two systems, a global and 3D coordinate network is created. The laser scanning technique is further developed and used in underwater scanning and airborne laser scanning technology. The data obtained in the laser scanning technique, which is an object surface-based and 3D measurement technique, is in the form of a point cloud. The raw data obtained in the form of a point cloud can be processed and converted into a drawing and then into an animation video or three-dimensional surface model.

Aerial Laser Scanning

The laser scanning device is a system consisting of GNSS (Global Navigation Satellite Systems) and IMU (Inertial Measurement Unit) and placed on the aircraft (helicopter, plane, drone). Drone, which is generally an unmanned aerial vehicle, is the most common form of use. If objects and surfaces are scanned from the air with this triple system, a point cloud containing (X, Y, Z) coordinates and height values is obtained. Aerial laser scanning can be used in agricultural or forest areas, urban areas, industrial facilities, etc. large areas such as; In terms of cultural heritage, it is a fast, highly accurate and efficient method of capturing 3D data of large natural cultural heritages and protected areas.

Terrestrial Laser Scanning

There are four types of laser scanning as terrestrial laser scanning (ylt). These are handheld laser scanning, wearable laser scanning, mobile laser scanning and fixed laser scanning. Research has been conducted on the accuracy of laser scanners, many methods have been developed, and the results have been published scientifically. Considering these published results, laser scanners have a measurement accuracy of around 10cm at long distances, i.e. 1000m and above, and around 1cm at short distances, i.e. 300m and below (Ulvi et al., 2019). The most common ones used in the industry are terrestrial laser scanners. The products obtained by terrestrial laser scanning are: digital elevation model (DEM), digital terrain model (DSM), point cloud, orthophoto. The most important advantage of these scanners is their ability to capture 3D object geometry directly, quickly and in detail. Other advantages are as follows (Reshetyuk, 2005):

1. Impressive reduction in expenses in terms of cost.

2. Much faster project completion. The project can be completed in a few days.
3. Ability to measure very complex, inaccessible, dangerous objects and areas where traditional techniques fail.
4. Scanning operations are independent of environmental lighting. Scanning can be done even at night.
5. Completeness and comprehensiveness in scanning: It can capture everything at once.
This way, if new data is needed, the scanner doesn't have to go back to the field. This also increases the user's confidence in the outcome.
6. Multi-purpose data use now and in the future.

Figure 4. Three-dimensional facade ımage obtained by terrestrial laser scanning and point cloud technique
Source: https://www.deltalidar.com/Yersel-Lazer-Tarama.aspx (URL 4)

viDoc RTK Antenna

When we look at architectural documentation in today's technology, "viDoc RTK Antenna" has taken its place in the sector as the latest technology in this regard. With the developing technology, the classical method of documentation has been replaced by modern documentation techniques, which has enabled the rapid advancement of contemporary documentation techniques. Today's technology now allows historical artifacts and structures to be protected to be documented more precisely and faster and transferred to future generations. When we look at traditional documentation methods, it takes a long time and sensitive data cannot be obtained. viDoc RTK antenna has the ability to perform all the processing performed by devices used in traditional documentation methods. The most important features that distinguish the viDoc RTK antenna from known terrestrial laser scanners are:

• High resolution

• Duration
• Detail
• Possibility to work in areas where devices cannot be installed
• Light, practical and easy to use
• Contribution to the workforce

Figure 5. viDoc RTK antenna
Source: https://ataymuhendislik.com/blog/rolove-nedir-mimari-belgelemelerde-teknolojinin-onemi/ (URL 5)

When the high resolution orthophoto quality is compared with the orthophotos of other devices, the difference is clearly perceived. This device, which can display even the smallest hairline cracks, offers the opportunity to analyze problems and draw variations easily in a CAD environment. With the viDoc RTK antenna, survey drawings are prepared by producing point clouds and orthophotos using PIX4dmatic and PIX4dmapper software.

Figure 6. viDoc ile üretilen ortofoto/Diğer lazer tarayıcılarla üretilen ortofoto
Source. https://santiyede.com/rolove-nedir-rolove-cesitleri-nelerdir-nasil-yapilir/ (URL 1)

Smart Cell Phone Applications

With te advancement of technology, cell phones, which have entered our lives since the 1990s, have been integrated with computer software and have become high-capacity computers, enabling them to be used in many different fields. Studies conducted in this context show that add-ons such as accelerometers, digital compasses, gyroscopes, GPS, microphones and high-resolution cameras have played an important role in this step (Lane et al., 2010). In the identification and documentation of cultural assets, there are many possibilities for use in many stages other than surveying. These include graphic-based applications such as Adobe Illustrator draw or Paper, which can be used for sketching or sketching in the field, and perspective correction applications such as Capturefix and Photocorrection. In addition to these applications that can be used in fieldwork or for data collection, applications such as Archimeasure and Autocad360, which can be used to digitize measurements obtained by traditional measurement methods, are among the applications that can be used in the identification and documentation phase. Smart cell phone applications can be useful in the context of taking measurements of parts of the building that cannot be reached or approached due to security problems or that were previously photographed but are not available today. Similarly, it is possible to benefit from these applications in cases such as the inaccessibility of the necessary equipment in the field conditions and the lack of facilities such as electricity.

COMPARISON OF DIFFERENT DOCUMENTATION TECHNIQUES

Pehlivan et al. (2022) compared different documentation techniques based on the same points while documenting the Ancient City of Iasos located in Kıyıkışlacık Neighborhood, Milas District, Muğla Province. These points are a, b, c,... j and k. When the traditional survey technique, photogrammetry technique and local laser scanning technique are compared in terms of measurement accuracy, the following results emerge. The dimensions of the identified building elements were measured by all three techniques and the differences between these measurements were calculated. The maximum difference (b) was 0.5 cm in the paving stone. There were also measurements where there was no difference (0 cm). For facade measurements, the maximum difference was 1.9 cm and the minimum difference was 0.1 cm. All of these differences were found to be in accordance with the reference ranges of Letellier and CIPA. According to these results, all three methods give accurate results in terms of measurement accuracy and it can be concluded that these techniques can be used.

CONCLUSION

Traditional methods of documenting cultural heritage are slow, costly, low-precision and result in a limited number of datasets, and have been gradually abandoned and replaced by high-tech documentation techniques. One of these high-tech documentation techniques, laser scanning, has been developing and widely used in recent years. In cultural heritage documentation technique with laser scanning, one laser scanner, one computer with the necessary software and one staff with sufficient knowledge are sufficient for documentation. The laser beam from the scanner used in the scanning process is used for length measurement and imaging. In traditional methods, facade and detail measurements of the object can be made. Plan measurements of very large objects or structures are difficult. With Totalstation, facade, plan and detail measurements of large or small structures can be easily made, but it is insufficient in terms of time saving and accuracy. In the case of GNSS measurement, it is not possible to work indoors, but only in open fields and open areas. Nowadays, it is very important to have 3D models and visual information quickly and at minimum cost. In order to use 3D information for different purposes, very large amounts of data need to be collected quickly and in such cases, digital photogrammetric and traditional geodetic methods are insufficient. For this reason, the technology of terrestrial laser scanning can be used, which is capable of fast 3D measurement of object geometry with high accuracy. This system, which has become widespread especially in the field of cultural heritage documentation and construction, also provides significant advantages such as time, cost and labor burden reduction. Data that cannot be obtained in hours with traditional methods can be obtained in seconds with terrestrial laser scanners. In studies conducted to investigate the accuracy of laser scanners, it has been observed that accuracy is inversely proportional to scanning distance and directly proportional to scanning intensity. In this case, it can be deduced that the closer the distance to the object and the more intense the scanning, the better the results will be. Environmental factors and the characteristics of the object surface affect the data quality. Studies have shown that 3D point clouds obtained from flat and smooth object surfaces are irregular and distorted, and some regions of the 3D point cloud have little or no point data because black or dark surfaces either reflect the laser beam less or do not reflect it at all. When evaluating the point clouds obtained as a result of scanning, it should be taken into account that they may differ according to the physical (texture, color, reflectivity) properties of the object surface and may not reflect the object exactly. The laser scanner and high-capacity computer hardware required for the implementation of the ground-based laser scanning technique are quite expensive. Although it may seem expensive in terms of establishment costs, the costs of establishment can be covered many times over due to the accuracy, ease of use, lightening the workforce and saving time over time.

In short, when the data obtained with traditional methods and laser scanning technology are compared, it is seen that the laser scanning method is more advantageous in terms of process, performance, accuracy and cost analysis. The laser scanning technology, which brings a new dimension to 3D model creation studies in many fields, has started to be used at an increasing rate today. It is especially important in terms of being faster and more practical in the protection of historical cultural and touristic heritage, surveying and archiving studies. However, studies on this subject have shown that the use of terrestrial laser scanning technology together with digital photogrammetry gives better results in this process.

It is possible to say that smart mobile phone applications provide savings in terms of time and labor, and contribute to the safety of equipment or team members. In addition to these, other advantages of this method are that the measurement data and photographs obtained from the applications can be archived as documents; they can be easily accessed on any digital platform and at any time; changes and deterioration in the structure over time can be compared with the results in the archive in a short time and easily; and these data can be shared easily and quickly. However, it is important to make accurate and precise measurements with this method, which is advantageous in many respects. According to the acceptance criteria established by ICOMOS and R. Letellier, there is only one application (Tape Measure) with 'usable' results within the sensitivity range defined by the acceptance criteria, and some of the other applications are usable only in the context of preliminary determinations. There are also applications that do not fall within the scope of the acceptance criteria, regardless of all other requirements and conditions such as shooting distance, calibration, etc. For this reason, it can be said that this technology needs to be developed in such a way that more detailed and precise measurements can be made.

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CHAPTER VI

LANDSCAPE ARCHITECTURE AND GEODESIGN

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INTRODUCTION

Since the transition to settled life, human beings have developed different methods to understand the characteristics, location, shape and other formations around them and to understand the temporal connection between them. Spatial thinking, which is one of these methods, has enabled societies to adapt to their physical environment, survive and improve their living environments. Geodesign aims to find answers to all these efforts of humanity and to produce solutions for problems. Over time, these problems, which are increasing in rapidly developing cities, become a field of study for landscape planning and design studies. In this context, geodesign studies appear as the most appropriate method to create a more livable and sustainable environment, which has become the basic principle of landscape architecture. In this section, the concept of geodesign, its historical development and importance are mentioned and its relationship with landscape architecture is tried to be explained.

GEODESIGN

The concept of geodesign, created by combining the terms "Geo" and "Design", can be defined as "geographical area", which is formed by the abbreviation of the word "Geo" as "geographic" and refers to geographically referenced areas on the earth. There are physical, biological, social and economic systems and phenomena under, above and around geographically referenced two and three dimensional areas. The term "Geo" encompasses all life on earth, including soil, water, air, underground and above ground systems, rural and urban areas, events and relationships. The concept of design, another component of Geodesign, describes an object as a noun and stages and serial events as a verb. Design is the totality of the steps taken to form and establish something in the mind and to reveal that thing as a form, entity or plan, and the series of events that follow it (Akpınar, 2014).

Societies, especially after settling down, have been involved in planning and designing actions in order to understand the areas they live in and to make better use of them. Even before settled life, there were thoughts of trying to make sense of the environment related to living spaces and making use of it within their possibilities. In both periods, they tried to use the concept we call geodesign today with their own efforts to create the most suitable areas for shelter, hunting and production. Some of the most basic examples of this situation are; societies settled on the high hills of the city in order to be protected from possible wars, and they chose places close to water as settlements in order to easily meet their water needs. All these examples are the choices made by taking advantage of the possibilities of nature within the concept of geodesign and accepting that nature is stronger than the power of human beings.

With the rapid urbanization of the world and the development of technology, some problems have started to emerge. The starting point of these problems has been the unplanned use and consumption of resources. In order to eliminate these negativities and to plan a more livable and sustainable environment, it will be useful to get support from the concept of geodesign, which has been used since ancient times, to manage the process correctly (Şenöz et al, 2014).

For example, it can cause destruction of forests to create settlements, habitat loss, air pollution, negative changes in climatic conditions, erosion, loss of soil fertility, and many problems caused by rainfall. It is obvious that every event that occurs has an impact on the earth in the short or long term. In addition, all living or non-living beings are interrelated within a system; affecting one affects the whole system (Değerliyurt & Çabuk, 2015). In order for this whole system to function properly, accurate planning tools are needed. Geodesign is one of these tools.

The theory is based on the idea of analyzing geographical information in the right way. It is obvious that knowing the geography well, understanding the conditions, advantages, constraints and risks, and comparing the possibilities are inevitable for the sustainability of life. As a result of the researches, we come across that the mentioned situations will be in the most appropriate way with sustainable planning and this is possible with geodesign (Çömert et al. 2016) In short, it serves to fully take into account all the characteristics of the place and the systems that make up the place in the design and planning process, thus creating human settlements that do not threaten the environment and are not threatened by the environment (Çabuk et al. 2013).

According to Akpınar 2014, Geodesign from a landscape architect's perspective can be defined as "the process by which the role of geospatial technologies is formulated and expanded by designers and planners to produce and visualize more accurate and better solutions throughout the analysis, design and implementation phases of a project so that politicians and local administrators can make and implement informed decisions".

GeoDesign enhances traditional Environmental Planning and Design activities by harnessing the power of modern computing, communication and collaboration technologies, resulting in simulations and impact analyses, and more effective and responsible integration of scientific knowledge and social values into the design process (Ervin, 2012).

When we look at the starting point of the idea of geodesign and the examples of plans and designs made with this approach, we see that Frank Lloyd Wright carried the idea of organic architecture (for example, using the use of the edges of the windows to bring the outer space inside and the inner space outside with the use of sliding glass doors) to his designs based on the concept of geodesign. In this design process, he considered the effects of the terrain and environmental factors on his design and used the idea of geodesign in his design. He is considered to be the first person to evoke the idea of Geodesign, although he did not use Geodesign as a name. While designing, Wright took into account geographical conditions such as topography, the location of streams and waterfalls, the placement of rocks that would provide the foundation of the house, the view of the house from the outside and the outside from the house, and the harmony of the house with the environmental conditions depending on the area where it is located. Richard Neutra, who worked with Wright in the 1920s, published "Survivor Through Design" (1892-1970), which emphasized the importance of designing with nature. In this design, he argued that while meeting the client's wishes and needs at the highest level, the design area and the surrounding nature should also be taken into consideration. Richard Neutra, like Wright, argued that a holistic approach is required in the designs to be made, and that designs should be developed in line with the opinions of the users, taking into account the natural and environmental conditions (Şenöz et al, 2014).

Landscape architect and educator Ian McHarg (1920-2001) is considered one of the main founders of Geodesign, although he never used the term Geodesign. Based on the ecological planning concept developed by landscape architect Ian McHarg in his book "Design with Nature", which brought a new idea and style to regional planning and design, Geodesign today is a process that connects geographical science and design, and as a result develops a systematic methodology for geographical planning and decision making (Esri, 2010). By bringing the geographical analysis of space into the design process, Geodesign ensures that designs are implemented in the most appropriate and least damaging way to nature. McHarg's pioneering work not only had a significant impact on environmental planning, but also contributed to the development of the newly introduced GIS support and information system (Akpınar, 2014).

Geodesign was first used by Kunzmann (1993) for a specific scenario; it has also been used by some small geography-related businesses. In 2005, Dangermond and his colleagues examined how users could use the ArcSketch program, a demo version of Esri, in landscape planning, and the term Geodesign was included in the Esri agenda when Dangermond said "Geodesign" during the process in which the working team drew points, lines and polygons, and the term Geodesign has now started to be used in the literature (Akpınar, 2014).

Jack Dangermond, a landscape architect and the founder of one of the world's leading GIS companies, played a major role in making geodesign, supported by technological means, so popular today. According to Dangermond's simplified definition, geodesign is designing with nature. According to Steinitz, geodesign is changing geography through design. Dangermond emphasized that McHarg's introduction and development of the model of overlaying maps paved the way for the use of GIS and that McHarg's thoughts on design formed the basis of geodesign. According to Dangermond, McHarg's work laid the first foundations for landscape architects and geographers to use GIS effectively (Şenöz et al., 2014).

The concept of geodesign was first heard around the world with the ESRI Users' Meeting organized by ESRI in 1981 and attended by 16 people. As a continuation of this meeting, the meetings, which were held for the first time in 2010 and continued in 2011, 2012, 2013, 2014 and 2015, started to be held in different parts of the world, including Europe and the Far East (Değerliyurt and Çabuk, 2015).

Carl Steinitz is recognized as the creator of today's geodesign approach. Steinitz briefly defines geodesign as "changing geography through design". This definition emphasizes the role of geodesign in shaping the environment for intended uses. When looking at the issue of changing geography, it is not enough to consider only the structures in the area or the immediate environment in order to better understand the landscape and the effects that will occur in the landscape; it is thought that much larger-scale plans should be considered (Çabuk, 2014). As Carl Steinitz (2012) states in his book, "design for change cannot be an individual activity. Rather, it is inevitably a team effort involving many participants (from design professions and geographical sciences)."

In another definition, Miller defines geodesign as "designing in geographical space". Therefore, the purpose of geodesign can be considered as facilitating life in geographical space and can be emphasized as a "decision-making method". Decision-making is a comprehensive process that requires the analysis and evaluation of natural and cultural factors in the geography designed in accordance with the intended use and strategies. Geodesign, which is an important tool for better understanding the interaction between settlements and the environment, enables existing settlements and local communities to adapt to the changing environment more easily and quickly, and new settlements to be sustainable. Geodesign helps to evaluate the risks in the design process, to define the changes that will occur, to develop appropriate strategies considering the changes, to take measures to adapt to the changes that will occur and to monitor the results (Çabuk, 2014).

Thomas Fisher emphasized that geodesign has a great potential when planning and design processes are viewed from a sustainability perspective and that geodesign will be a new guide to the planning and design process. Fisher emphasized that designers often do not work based on data and make decisions without knowing the consequences of their designs. Fisher also argued that the geodesign approach can prevent decisions that will cause economic crisis in the urbanization process (Şenöz et al., 2014).

Abukhater and Walker emphasized that geodesign is an approach that combines design and GIS technologies for planning, architecture, design and community development. Abukhater and Walker emphasized that smart growth plans can be made with the help of innovative technologies, GIS and geodesign, rather than traditional methods. Geodesign has enabled the planning process to be carried out more quickly, resulting in more rational and informed planning decisions (Şenöz et al., 2014).

Arzt defines geodesign as "the formulation and development of the role of geographic information technologies in the design process". The representation of geographic information in map form is seen as an indispensable part of the geodesign process. It is seen as a new version of a long-established practice of planning, designing, implementing and evaluating changes in the built and physical environment, supported by modern methods including software tools (CAD, GIS, BIM, etc.) that perform numerical databases, simulations and analysis; modern communication technologies including sensors, web-based interactions, mobile tools and social networks; and different interfaces. Understanding and analyzing the earth's natural resources also plays an important role in the development of this new design approach. In this context, geodesign supports traditional landscape planning and design activities with modern computer and communication technologies (Çabuk, 2014).

Decision makers such as politicians and local authorities, scientists, landscape architects, planners and other professional disciplines rely on and use GIS for data management and scientific analysis in different parts of the world. However, as the challenges facing natural environments and habitats have become more complex, it has become imperative to develop new tools (Esri, 2010). To this end, in recent years, planners and designers have been actively engaged in the development of Geodesign theory, concepts and tools using GIS (Akpınar, 2014).

Geodesign is a historical step in the field of GIS and although it has come to the forefront in land use and environmental planning, it applies to almost all professional disciplines and comes to the forefront in all works that require geographical thinking, need to create ideas for the future and require GIS infrastructure (Değerliyurt & Çabuk, 2015).

From the above information and definitions, it is clear that the idea of Geodesign is not new. Pioneered by McHarg, developed by Steinitz, associated with other studies by Fisher, Dangermond and other scientists and strengthened by the use of GIS, it is understood that the concept of Geodesy has a long history.

GEODESIGN AND LANDSCAPE ARCHITECTURE

For the development of geodesign as an interdisciplinary collaboration or as a methodological advance for specific disciplines, it is crucial to understand how knowledge and practice have evolved over time and how different disciplines have contributed to the emergence of contemporary geodesign. Geography encompasses a wide range of disciplines that investigate features, processes, phenomena and behaviors on the Earth's surface, such as ecology and hydrology, and professions that propose and make changes to the natural and built environment, such as architecture, landscape architecture, urban and regional planning, and civil engineering (Li and Milburn, 2016).

Concepts such as ecological design, sustainable architecture, and sustainable design, which have started to be talked about a lot today, especially in the field of architecture, essentially include strong applications of geodesign. However, the ecological perspective that the discipline of landscape architecture has been working on since the 19th century is now being integrated into different fields and design approaches, helping the emergence of new design theories. Contemporary landscape architecture approaches, which emerged especially after the Industrial Revolution, have long before kept the ecological aspect of these new design approaches at the center of landscape design and landscape planning. Especially in the 1960s, Ian McHarg's "Design by Nature" theory played an important role in this regard (Çabuk et al., 2013).

According to Goodchild, 2010; "The concept of science-based design lies at the interface between several disciplines. It includes disciplines traditionally concerned with design, such as planning and landscape architecture. It also includes disciplines that acquire and accumulate fundamental knowledge about how environmental and social systems function. These disciplines include geography, ecology, hydrology, geology, sociology, economics and political science.

In the transition to the design process, the landscape architect first identifies the natural, cultural and perceptual data that affect or exist in the area and analyzes them in line with these data. Creating databases of the data obtained as a result of the analysis in the GIS environment will provide both ease of work and a healthy and reliable analysis of the data. Thanks to the geodesign approach, the data of the area to be designed can be easily overlapped in the GIS environment and the necessary queries can be made. Ensuring the integration of all data layers that will enter the design process with each other through GIS will provide a great advantage in design. Many queries and overlapping made in the GIS environment in planning studies will also be carried out in the design phase, which will ensure consistent design with the field data (Şenöz et al., 2014).

Landscape architects have the knowledge and competence to lead teams in design and planning applications due to their education and working areas. As the population living in cities increases, the importance of the built environment also increases. Landscape architecture fills the ground between architecture and urban planning in many respects and has a field of study that overlaps with both disciplines. As a result, landscape architecture helps to build a bridge between the rule-making orientation of planners and the emphasis of architects on creating form (Çabuk, 2014).

Landscape planning and landscape design emphasize different values, such as transparency and creativity, and typically use different methodological approaches. Landscape design relies more on intuition and creativity in coming up with design ideas and concepts. It involves exploration and research, analysis, design, implementation and evaluation in an applied and ongoing process. The first stage in the landscape design process begins with exploration and research and the natural and cultural inventory of the area is taken. The climate, soil, flora, fauna, geology, topography, hydrology, topography, hydrological structure and existing buildings and settlements of the area and its immediate surroundings are investigated. This is followed by the analysis phase. One of the biggest benefits of the Geodesign process to landscape design is seen in the analysis phase (Akpınar, 2014). Landscape planning, on the other hand, is often constrained by legal and practical expectations and requires the use of transparent approaches such as standardized procedures and GIS analysis. Geodesign is an important tool in the integration of design and planning. Indeed, in some definitions of geodesign, both planning (GIS, spatial data, impact analysis, etc.) and design (feedback scenarios) elements are used together (Çabuk, 2014).

CONCLUSION

Today, thanks to the advancing technological possibilities, it is possible to design the environment we live in today in a way that minimizes the damage to nature and to benefit from nature and our environment at the highest level, which is a very important perspective in terms of sustainability. The idea of designing with the environment and nature has become more widespread with the development of GIS information and support systems. With the process called Geodesign, not only landscape planning but also landscape design has become possible. Geodesign, thanks to its rapid modeling technique, enables more accurate and more successful designs to emerge with rapid evaluation from the beginning to the end of the design process. Geodesign connects landscape design to GIS with advanced and data-based information, which contributes to faster and more accurate finalization of the design process (Akpınar, 2014).

As a result, the use of GIS is the most effective, fast and efficient way to manage the process in order to understand nature and natural processes from a broad perspective and holistically, to understand it and to make the most appropriate analyzes to meet the needs. Today, the idea of geodesign, which is a new application area of design with nature that is widely accepted, clearly reveals the relationship of the design process with planning and GIS (Değerliyurt and Çabuk, 2015).

In Turkey and the world, there are deficiencies in reflecting the plan decisions taken as a result of upper scale studies to lower scale design decisions. Failure to incorporate plan decisions into the design process leads to a lack of the desired sustainability and utilization on a city and regional basis. Geodesign approach provides an advantage in terms of incorporating the upper scale plan decisions into the design process. The database prepared in GIS during the planning process at the upper scale will form the basis for the landscape design to be prepared at the lower scale and will facilitate the understanding of the connection of the area with its environment, especially during the survey phase (Şenöz et al., 2014).

To make an assessment from the perspective of our country, geographical information technologies are of great importance in the process of understanding the environment and its characteristics and accordingly making physical design and planning in a healthy way. Especially in rapidly developing countries like Turkey, where urban investments are high and urban environments are shaped rapidly, it is absolutely necessary to analyze the characteristics of the environment well in design and planning processes in order for decision makers to make much healthier decisions on issues related to space. It is inevitable to make use of geographical information systems in order to make these analyzes in the most effective way. Utilization of geographical information technologies in planning and design processes in our country will enable planning and design decisions to be made by better understanding the place and the systems that make up the place, and thus opportunities will arise for reducing disaster damages and environmental problems caused by cities in the urban areas created. In this context, the geodesign approach developed on the basis of effective utilization of geographical information technologies in the planning and design process will be important in terms of reducing the increasing environmental problems and disaster exposure risks in our country (Çömert et al.,2016).

As a final word; the necessity of introducing and teaching Geodesign, especially in our country, has become increasingly important in the developing century. In this context, Geodesign programs should be created and taught not only at the doctoral and master's level, but also at the undergraduate level. For this reason, studies such as workshops, workshops and congresses should be organized.

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CHAPTER VII

EVALUATION OF OPEN GREEN AREAS IN CITIES IN THE CONTEXT OF DIGITAL TWIN OPPORTUNITIES

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THE CONCEPT OF A DIGITAL TWIN

VanDerHorn and Mahadevan (2021) characterized the concept of 'digital twin' as "a virtual representation of a physical entity and its environment and processes. Digital twins are updated through the exchange of information between these physical and virtual entities. In other words, a virtual imitation of a physical entity connected through real-time data exchange can be called a digital twin (Singh, 2021). The concept emerged as a product lifecycle management model in a presentation at the University of Michigan in 2002. During the presentation, data from a real domain was mirrored in a virtual and digital domain with information and connections transmitted in the form of a mirror (Grieves & Vickers, 2016). The concept was called 'mirrored space model' at the time and later evolved into the concept of digital twin (Grieves, 2005). NASA's Apollo program can be considered one of the first uses of the digital twin. In this program, the twin of the vehicle sent into space was on Earth and was used to simulate the conditions that could occur in space (Wang, 2020). For this reason, the most common use of the digital twin is in aviation. Although digital twins are mostly used in industry and product design outside of aviation, their use is becoming more diversified and widespread. Real-time monitoring, remote access, optimization, recycling, agricultural production, architecture, construction, design and planning are among the prominent areas in the use of this technology (Wang, 2020; Shahat & others, 2021; Haw & others, 2021; Hejtmane & others, 2022).

The basic technology that enables the realization of GPS technology, which has become widespread and known by almost everyone today, is the digital twin. Digital twin is a technology that combines, integrates and simulates many multi-scale and multi-probability physical quantities with data obtained from tools such as operation history, sensor update, physical model (Alshammari, 2021). When the concept was first proposed as a model in 2003, it did not attract much attention from scientists. The main reason for this was the difficulty of obtaining the data that needed to be processed into the model online and in real time and processing it into the system. In addition, the products and software that could serve the model were not widespread and affordable at that time. The capacity of existing computers was also not sufficient to process big data quickly (Grieves, 2014).

The basic model of the Digital Twins consists of three parts: real space entities, virtual remote entities, and the data and information interface between real space and virtual space entities. This technology differs from the twin concept in the Apollo program in that the twin model here is digital and virtual. The virtual twin is introduced to the virtual space and information and data from the real space is transferred to it, creating an interaction between the two spaces. Thus, the real entity is integrated with the virtual entity and the real entity can be controlled through the virtual entity (Grieves, 2006).

In 2011, the US Air Force's work on digital twins marked the beginning of the development and maturation of the concept. Aviation studies formed the basis of the work done here. Digital twin technology includes the processes of transferring and modeling the behavior, performance, formation processes and life cycles of physical objects to a virtual entity by creating a virtual entity (Wang, 2020). One of the biggest innovation areas of digital twin technology is the possibility of modeling and simulation in a virtual entity, as well as the possibility of exploring an unknown space, time and possibilities.

The adoption of technology by industrial activities has played an important role in the widespread adoption of digital twins. In these activities, the potential of the technology to shorten operating costs and times, improve system capacity, maintenance and optimization, easy accessibility, and improved security have been explored. For this reason, although the technology is new, it is making rapid progress. No technology can make progress on its own. The development of technologies such as virtual reality, 3D printing and artificial intelligence has been supportive in the development of digital twin technology. Considering the rapid progress of all these technologies in the last decade, future expectations for digital twins have also increased (Singh & others, 2021). Future expectations for digital twins are that physical space will be fully transferred to virtual space and virtual personalities will be able to engage in certain activities in virtual space. For example, the virtual presence of a human being can work in a virtual factory (Tao & others, 2017). The main advantages that digital twins can provide for today's world and the future can be listed as increasing the amount of production, reducing vulnerability, increasing remote access, reducing production costs, and preventing spatial inequalities. On the other hand, like any new technology, there are problems that need to be identified and prevented for digital twins. These include cyber security issues, inequalities in regions deprived of technology, and the tendency of machines to serve certain private groups and capitalists.

THE USE OF DIGITAL TWINS IN URBAN AREAS

The development of digital twin technologies has begun to be considered as a technology that can be used in the field of urban and regional planning and the first examples have emerged (Schrotter & Hürzeler, 2020; Caprari & others, 2022; Ferre-Bigorra, 2022). This is because most people live in cities and it is projected that two-thirds of the world's population will live in urban areas by 2050. This means that more urban problems await humanity. Utilizing new technologies to tackle these problems has become an inevitable necessity (Bhupendra, 2023). Large and accurate building information models, big data generated from IoT sensors, the learning capacity and speed of machines, GPS data have made it possible to build an online 3D model of a city. This has led to the concept of the urban digital twin (Kaur & others; 2020).

The foundations of the use of digital twins in urban planning can be considered as urban models. With the emergence of computers in the 1950s, the first examples of the use of urban models in urban planning are seen. The model made in the field of transportation planning in Chicago in 1955 is considered as the first urban model (Ferre-Bigorra, 2022).

Common uses of urban models include: transportation, logistics, land use, urban growth, urban infrastructure, disaster simulation, sewerage systems, energy supply and distribution, economic development, urban participation (Ferre-Bigorra & others, 2022; Schrotter & Hürzeler, 2020).

In recent years, with the use of technology tools such as geographical information systems, smart city and GPS in planning, opportunities such as visualization and 3D modeling have also developed. However, since real-time data cannot be processed and integrated into the system in these models, the connection between the designed models and the real city cannot be established efficiently. Digital twins have the potential to overcome these shortcomings. Because the basic operation of the digital twin concept is to transfer real data to the virtual environment in an organized and real-time manner. It is thought that the data obtained by utilizing the Internet of Things technology in smart cities can be integrated into the digital twins of cities through machine learning and deep learning. In addition, it has been stated that thanks to digital twins, not only the physical structure of the city but also its social and economic aspects can be transferred to the virtual environment (Wan & others, 2019).

The more comprehensive and accurate the data processed into the virtual universe, the more useful the resulting digital twin (White & others; 2021). With continuous data transferred to the virtual twin, systems and mobilities in the real city can be accurately represented. The availability and accuracy of this data enables planners and decision-makers to produce accurate solutions to the real problems of the city. Today, digital twins of many cities are being produced. Urban digital twins have become widespread in the last five years. The most common applications for digital twin cities are in Europe (Ferre-Bigorra & others, 2022). However, when the applications are analyzed, the way each city handles and uses digital twin technologies is different from each other. For this reason, there is no common understanding of exactly how the digital twin will be used in practice and which modeling will be done. This can be considered normal since the scale and needs of each city may differ. However, since the digital twin is a relatively new technology, it is important to define the concept, identify current developments and follow good practice examples. Because there is a positive correlation between countries investing in smart city policies and developed countries (Caragliu and Del Bo, 2019).

Virtual digital twin cities consist of 6 layers (White & others, 2021). These layers are land, building, infrastructure, mobility, digital/smart city and virtual layers. The terrain layer represents the land on which the city is built. Information such as slope, water availability, soil structure are processed in this layer. The building layer contains data on the built physical environment of the city. Data such as the number of storeys, size and condition of buildings are processed in this layer. In the infrastructure layer, data such as sewerage, road structure and power transmission lines are processed. The mobility layer processes the movement of goods and services. This layer contains data on the accessibility of facilities such as motor vehicles, pedestrians, bicycles, public transportation. The digital layer includes data integrated with IoT sensors, smart city data, urban land uses, and the capacity of functions in the city. The last layer, the virtual layer, is the digital city twin. The data from the smart city layer is processed in this layer and connected to the other layers. Simulation and modeling possibilities are possible in this layer.

The implementers and users of urban digital twins are usually local governments. However, in some cases, systems open to the participation of local people have also been developed (Lehtora & others, 2022). Local governments use urban digital twins to plan the city and determine operation and maintenance activities. In addition, potential common uses are for urban issues such as decision-making on the location and size of buildings, urban participation, disaster simulation, and flood planning (White & others, 2021).

Presenting urban digital twins to the public as open data is very important for ensuring public participation in planning. Showing a planning decision to the public through simulation before it is put into practice and allowing citizens to have information and a say about this decision is seen as a very important tool for participatory planning. In addition, testing multiple plan alternatives in a virtual environment can prevent major damages that can be caused by wrong planning in cities (Barresi, 2023).

In Urban Digital Twins, data is obtained from existing databases and GPS sensors. Data processing is done with a centralized cloud technology for ease of distribution and processing. Since this technology is not yet fully developed, virtual cities currently affect the real city indirectly rather than directly. It has been widely used especially for visualization, 3D modeling and mapping (Ferre-Bigorra & others, 2022).

Though they are still in their early stages, urban digital twins have the potential to significantly enhance urban government. First off, using a city's digital twin allows for the integration of management and urban planning into a single tool, doing away with the necessity for many management systems. Second, quicker reaction times are made possible by urban digital twins' ability to move autonomously. Thirdly, by being aware of the city's current state, city administration can become more effective. Still, there are problems with urban digital twins that need to be fixed. The most important is that their usability and data evaluation capabilities may be compromised by a lack of interoperability. Urban digital twins may have technological difficulties in addition to interoperability problems, such as problems with data quality and a lack of computing power for real-time analysis of all the data a city may produce. In addition, the financial resources allotted for the establishment and management of urban digital twins are restricted, so requiring a compromise between expenses and features. Moreover, the literature documents problems regarding this technology's security against cyberattacks (Ferre-Bigorra & others, 2022).

THE IMPORTANCE OF OPEN GREEN SPACES IN URBAN PLANNING

The world's population is concentrated in cities and this trend continues to increase. One of the main objectives of urban planning is to develop reasonable land use patterns while maintaining a balance between urban functions and nature. Maintaining this balance ensures the improvement and protection of urban living conditions. In this context, urban green space utilization and their location within the city have an important place. Open green areas in cities and the plant assets in these areas improve the quality of the environment. In addition, green spaces are areas that beautify and make the space attractive for almost every culture (Sangwan, 2022).

Urban green infrastructure has an important place in urban planning in recent years. The concept of green infrastructure has been frequently used in both academia and local governments to mitigate the inevitable problems caused by urban growth. In urban planning, green infrastructure stands out as an important strategy for mitigating and avoiding the effects of climate change. It is also known that urban open green spaces are used to prevent urban growth (Barbosa & others, 2022).

Open green spaces in urban areas are important key points for sustainable cities. These areas serve both the physical structure and social structure of the city. Urban dwellers need recreational activities for their physical and mental health. Urban open spaces are the most accessible and easy way to fulfill these needs in urban areas (Reyes-Rivero & others, 2021).

Urban open and green spaces help to maintain the connection between human beings and nature with the natural elements they contain. In addition, landscape elements in green areas can be used as a tool to prevent urban air pollution. Urban green areas also contribute to the optimization of climatic characteristics. Especially trees that provide shade can become comfortable resting areas for people. In addition, with the aesthetic value they create, they can become attractive focal points for people and become a socializing place (Nitidara & others, 2022; Bakri & others, 2023).

Urban open green spaces are one of the most important areas of use for the natural and built environment in cities and for urban residents. Considering the impact of climate change, these areas need to be rethought and reconstructed. Countries such as Turkey address urban green spaces only quantitatively in their legislation. However, the qualities of these areas, their accessibility, the usage preferences of local people, and the effects of plants in preventing climate change should also be taken into consideration.

ADDRESSING URBAN OPEN GREEN SPACES IN THE CONTEXT OF DIGITAL TWIN

Numerous applications have been developed to measure the accessibility of urban green spaces in today's widespread urban modeling. Thanks to CAD and GIS applications, network and accessibility analysis of urban open spaces and walking distance and time of people of different age groups can be measured. On the other hand, when we look at existing examples of urban digital twins, there are detailed data in the virtual twins of public green spaces. Data such as plant inventory, number of seats, shading areas, water requirement and irrigation frequency are not processed in digital twins.

A review of the literature on the concept of urban digital twin reveals that there are very few and insufficient studies on urban open green spaces (Corrado & others, 2022). In particular, data such as public participation, mobility data, land use measurements provided by digital twins can play a key role in the redesign of urban open and green spaces. Because it is known that most open green spaces are passive, not designed with appropriate landscape elements and built without public consultation. Digital twin technology may emerge as a single solution to all these problems.

The first application for digital twins of urban green spaces is the 'dynamic green information model', a collaboration between Tallinn University of Technology, Aalto University and the City of Helsinki. In this application, a tool for sustainable mobility, public participation and urban management has been developed and is being tested. The project, called GreenTwins, has two main objectives. The first is to create user-friendly and understandable interfaces for the urban digital twins of Helsinki and Tallinn. In this way, to transfer and visualize the vegetation layer to the virtual twin with dynamic data. The other is to create user-friendly green spaces in physical and virtual environments by enabling public participation. With the GreenTwins project, the importance of urban vegetation has been emphasized, temporal and seasonal changes in urban vegetation have been identified and become predictable. In addition, since public participation was ensured, it was aimed to involve city residents in the design of green spaces (Url-1).

Gholami & others (2023) introduced a digital twin model for the city of Imola based on microclimate data. In the digital twin virtual city where real-time microclimate data is processed, studies are carried out to develop green infrastructure. The project aims to develop an urban green space system that increases the thermal comfort of Imola and meets the sustainability and livability criteria. Project actors are local authorities, university and local stakeholders. Urban climate mapping was realized by collecting, processing and transferring micrometeorological data to the virtual city in real time. The main objective is to mitigate the impact of climate change on cities through green space (Gholami & others, 2023).

Apart from this, one of the indirect benefits of digital twin technology for urban open green spaces is to improve the quality of the living environment through feedback. Citizens can walk around the virtual city, test plans that have not been put into practice in advance, and provide feedback, enabling the public to live in a city shaped by their own will. In addition, the location of green areas in the city can be tested in advance with urban digital twin technology. With the data obtained from information such as air pollution, land structure, sunbathing, transportation preferences, lighting obtained from smart cities, both the quantity and quality of open green areas can be brought to the best version. With GPS data obtained in an environment where cyber security data can be provided, it can be tested whether urban open and green spaces are used effectively and new plans can be made for improvement in this direction (White & others, 2021).

Another study on the use of digital twin in urban green spaces is a study on the greening of train stations. In this study, alternatives for the landscaping of the station were presented in a virtual digital twin environment. The subjects were presented with 6 different landscaping options and the economic feasibility of each of these options was determined through simulation. It is aimed to find the most reasonable landscape option in line with both the preferences of the subjects and economic data. It was suggested that digital twin technology should be accepted as a method of biophilic design (Kalla & others, 2023).

A similar study was conducted for the Nancuiping park in China (Luo & others, 2022). In this study, a participatory planning approach was adopted. A digital twin of the park was created based on aerial photographs obtained by UAV, existing problems of the park were identified, and changes in the built environment were simulated. A design proposal was developed through visualizations and public participation through surveys. Another prominent result of the study is that very high quality images can be obtained with the digital twin and that people are interested and curious about this technology.

CONCLUSION

This study focuses on urban digital twin technologies, which have been applied in the last 5 years, mainly in Europe. Urban digital twins have emerged with the technological developments in the field of urban planning and the development of the digital twin concept. The origin of the digital twin concept dates back to NASA's Apollo program. In this program, the aircraft to be sent into space was replicated and operated under different conditions while on earth to prevent problems that its twin in space might encounter. Although the concept has changed over time, the basic functioning is not much different from the starting point. Although the concept of a digital twin is explained with many different definitions today, in short, it is the transfer of all the features, real-time data and life cycle of a real physical object to a virtual object in space. This technology, which was developed in the aviation industry, is now used in areas such as industrial production, social media, construction, architecture, planning/design and optimization. One of the biggest advantages of digital twin technology is that it enables simulation to prevent possible damages and make improvements.

Most of the world's population lives in cities and it is projected that by 2050 one third of the world's population will live in cities. This means that we have to face new urban challenges. There are many emerging technologies to cope with new challenges. Digital twin technology is one of them. In fact, in the development of technologies such as IoT, GPS, artificial intelligence, smart cities, sensors, these technologies have all contributed to each other and accelerated the development. Computer technologies, which entered our lives in the 1950s, have made great progress today and continue to advance. Digital twin technology is one of the prominent technologies in urban planning. Although its application examples date back to the last five years, various possibilities of the technology can be predicted with different approaches. With urban digital twin technology, it is possible to make future predictions about the city, create alternative urban plans, make disaster predictions and develop plans for transportation, urban growth and urban infrastructure. For the digital twin to work efficiently, it is important that the data entered into the virtual environment is accurate and useful. It is thought that urban digital twins will develop and become widespread in the future with technologies such as GPS, smart city, machine learning and deep learning.

In this period when we need to combat climate change, urban areas stand out as the areas that both affect and are affected by climate change the most. One of the most effective tools for climate change in urban areas is open green spaces. Open green spaces are important for both the natural environment, built environment and social environment. Urban open green areas should be protected and developed both quantitatively and qualitatively in terms of determining/restricting the direction of urban growth, enabling recreational activities, providing thermal comfort environments, creating aesthetic value, and providing socializing areas for urban residents.

When urban digital twins are evaluated in the context of urban open green spaces, the most striking result is that there is a gap in the literature. Since the use of the digital twin concept in urban areas is relatively new, there are very few studies focusing on this field. When the studies are analyzed, it is seen that a common understanding of the use of digital twins in open green spaces has not yet been adopted. In one of the case studies, the main objective is to determine the temporal and seasonal change of vegetation cover and to ensure public participation, while in another study, the main objective is to limit the impact of climate change in urban areas and to ensure public participation. Looking at the limited number of data in the literature, public participation was emphasized in all studies on the use of digital twins in urban green spaces. In some studies, it is stated that the public is interested and curious about this new technology. This is likely due to the rich visualization and mapping offered by digital twins.

There is a positive and significant relationship between states' investments in smart technologies and their level of development. In this case, countries that embrace this digital transformation in the world will also act in the name of development. For urban digital twins to become widespread, specialized personnel, equipment and therefore time are needed. However, cities need to adapt themselves to new technologies as soon as possible. In this way, the consequences of wrong planning decisions can be seen in advance in simulation, disaster risk assessments can be made, the public can be a real actor in the planning of the city, and many other benefits can be achieved. In line with all these developments, measures should also be taken for the fair distribution of technological power and cyber security.

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CHAPTER VIII

FROM PAST TO FUTURE: UNVEILING THE EVOLUTION OF ARTIFICIAL INTELLIGENCE IN URBAN PLANNING

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INTRODUCTION

The definition of artificial intelligence was first used by John McCarthy at a conference held at Dartmouth College in Hanover in 1956. After this event, artificial intelligence research accelerated and various artificial intelligence programs were developed. The first human-like intelligent robot, WABOT-I, was successfully produced in Japan in 1972 (Coşkun & Gülleroğlu, 2021). However, between 1974 and 1980, many publications criticized artificial intelligence studies and these criticisms caused governments to stop funding artificial intelligence research. This period is referred to as the "Winter of Artificial Intelligence". However, the field was revitalized in the 1980s when the UK started funding artificial intelligence research in order to compete with Japan (Öztürk & Şahin, 2018). In 1997, a program called "Deep Blue" developed by IBM defeated world chess champion Garry Kasparov in a chess match and this event caused a great resonance. This event showed that computers can be superior to humans in some areas. After this period, artificial intelligence studies accelerated in both states, universities and public institutions. These days, data collection and exchange, as well as speed and accessibility, are growing at a rate never seen before thanks in large part to the usage of digital platforms, social media, and the internet.

All human-made systems that can infer, learn, or find an effective and right solution technique when the problem's definition is known but the solution's method (algorithm) is unknown are referred to as artificial intelligence systems. To put it briefly, artificial intelligence is the ability of an automated system to generate algorithms (Köroğlu, 2017). The ability of a computer or a machine assisted by a computer to think like a human is the general definition of artificial intelligence (Nabiyev, 2012). According to an approach based on heuristic programming, artificial intelligence includes the ability of computers to accomplish human-like tasks (Andrew, 1991). A variety of cutting-edge technologies that demonstrate intellect like to that of humans are encompassed under the term artificial intelligence (AI), according to Furman and Seamans (2019). Machine learning, autonomous cars and robots, computer vision, language processing, virtual agents, and neural networks are some of these technologies.

Urban planning is a discipline that ranges from upper scale plans to lower scale plans in a wide range and aims to design future cities in the most effective way based on existing data. The discipline of Urban and Regional Planning considers the city as a whole, and it tends to form a series of decisions and policies from the distribution of urban functions to density decisions, from transportation and access arrangements to the planning of green and open spaces, and from the city's relations with other cities (Meşhur & Tekin, 2018).

Artificial intelligence technologies are of great interest in urban planning as well as in all fields of science. In particular, areas where artificial intelligence is widely used, such as smart cities and intelligent transportation systems, come to the forefront in the digital transformation process. In this process, it is of great importance to identify the opportunities and potential problems offered by artificial intelligence and to conduct studies on these issues. Numerous studies on the applications of artificial intelligence in various fields can be found in the literature. The use of artificial intelligence in the field of urban planning has been studied in the past, present, and future. Furthermore, the potential applications and constraints of artificial intelligence in the field of urban planning are explored through a thorough analysis of its present applications. The working areas of AI in this discipline are also covered.

A HISTORICAL OVERVIEW: AI IN URBAN PLANNING

From the 19th century onward, urban planning has sought to improve people's quality of life, focusing largely on the economic functioning of cities and the promotion of social fairness. In antiquity, urban planning was primarily concerned with the arrangement of houses, public buildings, and streets. Artificial intelligence (AI) and urban planning are acknowledged as two domains that evolved independently in the past but are now combined (Wang et al., 2023). This transformation has evolved over time along with other technological changes and scientific studies have played an important role in this evolution. In this section, we will focus on previous studies on the use of artificial intelligence in urban planning.

Since the 1960s, several urban planning professionals have been developing artificial intelligence (AI) techniques (Langendorf, 1985). AI was viewed during this time as a specialist and scientific undertaking that professional planners typically did not apply. However, there has been significant advancement in the adoption and effective use of numerous cutting-edge planning techniques over time.

In terms of urban planning in the 1990s, almost no tools were developed to show how artificial intelligence could be used to improve our advanced technology (Yeh and Batty, 1991In the early days of computer technology, urban planners found the computer to be a useful tool for solving problems because of its speed and enormous store capacity. However, compared to other fields like commerce and engineering, urban planning was seen to have a smaller significance for computers. This is because the data utilized in urban planning (public goods and services, for example) are large and indivisible, making it challenging to identify them independently for computer processing (Dueker, 1982).

The contribution of information technology to problem solving and decision making has generally focused on three main areas: gathering information from databases, supporting actual decision making and improving communication between decision makers. Expert systems have played an important role in supporting the actual decision-making processes of information technology. In particular, they are able to transfer expert knowledge to non-experts. These systems are computer programs specialized in certain subject areas and can summarize specific problems that experts use to solve. In the 1990s, comprehensive resources for expert systems in planning were limited and expert systems were technical and complex for beginners (Rodrigues-Bachiller, 1991).

Han and Kim (1989) examined how urban information systems combine data from multiple sources to offer insights for decision-making. It claims that interest in artificial intelligence (AI) in current urban information systems has grown as a result of recent advancements in AI technology. The study highlights that planners will be able to use more computer-based solutions for less structured problem solving activities because to advancements in computer technology. Hang and Kim state that artificial intelligence is not seen as a magic bullet that would solve all urban planning problems, but rather as a new technology that needs to be incorporated into existing systems. The study emphasizes that using expert systems in urban planning is one way to overcome the limitations of computer-based techniques. This implies that planners can construct more intelligent information systems by adding expert system techniques to computer-based systems that already exist. It is observed that planners usually utilize computer models that deal with ordered obstacles, even though urban planning commonly incorporates semi-structured and unstructured problems. The many types of information systems are categorized into four groups: DBMS (Database Management Systems), GIS (Geographic Information Systems), DSS (Decision Support Systems), and ES (Expert Systems). It should be mentioned that there can be functional overlap in these systems. It was observed that the examination of concrete applications in this field has not received much attention in the literature.

In their subsequent work, Han and Kim (1990) noted that artificial intelligence (AI) may be used to create intelligent computers that are able to reason, pick up new skills, and comprehend spoken language. The usage of information systems in urban planning is reviewed, along with certain expert system applications and the possibilities of incorporating AI technology into currently in place urban information systems. It is anticipated that the use of computers and computerized information systems in urban planning would increase as planners' duties become more sophisticated. The need to integrate artificial intelligence with urban information systems is indicated. Artificial intelligence is defined as a tool that can improve the existing urban information system.

Urban modeling is an area where information technologies are widely used in urban planning. Urban modeling studies have paved the way for the use of artificial intelligence in urban planning. Factors such as the spatial extent of a complex urban system, its physical development phases, and the size of each development phase can be accurately measured and validated through urban modeling techniques (Aydın, 2015). The urban modeling process has a history dating back to the late 1950s and 1960s and was initially developed in the US and European countries. But since the late 1970s, there has been a noticeable decrease in the application of these techniques. During this time, static, linear, cross-sectional, and deterministic methods including input-output analysis, mathematical programming, and regression analysis were frequently employed in urban planning. These methods, however, fell short of explaining intricate, dynamic, and non-linear elements. In light of this, a novel strategy for contemporary urban modeling has surfaced. Moving from macro to micro, static to dynamic, linear to nonlinear, structure to process, and space to space-time is necessary for this method. The goal of this change is to better adjust to the dynamic and intricate nature of urban systems (Jain, 2011). It is well known that artificial intelligence may use machine learning to acquire knowledge of complex systems. Because of this, there is a greater likelihood than ever before that artificial intelligence will be used in urban planning, and the outcomes could be better.

In the 2000s, Li and Yeh developed an urban model based on limited cellular automata. This study aims to contribute to planners' search for more effective urban forms in line with sustainable development goals. The issue of how this model based on cellular automata can be extended and integrated with Geographic Information Systems (GIS) is addressedThis paper addresses the question of how to extend and combine this cellular automata-based model with geographic information systems (GIS). A framework for evaluating compact cities and sustainable urban growth scenarios based on local, regional, and global restrictions is provided by the proposed model. The paper suggests using cellular automata and GIS together as a versatile engine for creating and executing dynamic urban models. In the 2000s, the GIS architecture was rigid and insufficient for handling spatial data. Urban systems contain a variety of spatial objects that interact with each other in complex, non-linear ways. Cellular automata, on the other hand, are homogeneous and synchronous. It has been emphasized that the adaptation of cellular automata to this complex structure of urban systems may be limited. At a time when artificial intelligence was not yet fully developed, this study emphasized the need to develop more complex cellular automata systems to solve geographical and urban problems (Li & Yeh; 2000). Since the dynamic and temporal changes of urban planning need to be integrated into GIS-based applications, a GIS application extended with Artificial Neural Networks was developed. This study is important as it emphasizes the integration of artificial neural networks into planning at an early stage.

In his 2013 study, Baydoğan developed a software that can plan in accordance with the Turkish Zoning Regulation. This software is a software that can easily comply with the regulation, facilitate planners to make density calculations, make complex calculations quickly, verify calculations, offer different alternatives, and easily process variables such as plan notes. Since this software can easily implement the legislation, the planner can spend more time on design. The use of software similar to this software has become widespread in many CAD and GIS programs in the same period.

Looking at the literature, it can be said that the first studies on the use of artificial intelligence in planning focused on data processing and analysis. The common point in the literature is that artificial intelligence cannot be used completely for planning in the early days. Because too much and different data should be integrated in planning. At the same time, there is a need for data that needs to be constantly updated in planning. In this period when machine learning is not fully developed and data cannot be collected automatically, the large amount of data that needs to be manually defined to artificial intelligence is shown as a problem that needs to be solved.

CONTEMPORARY INTEGRATION: AI IN TODAY'S URBAN PLANNING PRACTICES

Urban planning is becoming more and more interested in artificial intelligence technologies, much like other disciplines are. It is well known that various urban studies have experimented with AI applications. Nonetheless, there is a lack of knowledge regarding AI technologies and the concepts or application areas that are popular in urban development and planning (Yiğitcanlar et al., 2020). Furthermore, there is a lack of understanding of the public's perception of AI technologies, their potential applications, and the laws and procedures governing AI in our cities (Hengstler & others, 2016).

The shift in artificial intelligence from knowledge-driven to data-driven has piqued the interest of a wide range of academic disciplines, including the humanities, economics, and social sciences. These fields are now following the rapidly expanding field of data sciences. The techno-economic paradigm has undergone a significant shift as a result of technological advancement, impacting not just the economy but also the structure of society at large (Perez, 2002). However, there is still a lack of knowledge on how the social sciences, and especially the regional sciences, would be impacted by this new paradigm (Lazeretti & others, 2023).

The world has stepped into the digitalization process and advances in technology are also affecting urban planning. Intelligent systems are becoming more prevalent in computer-aided urban planning systems (Feng & Xu, 1999). While other systems, like database management systems (DBMS), expert systems (ES), planning support systems (PSS), decision support systems (DSS), and geographic information systems (GIS), have also attained varying degrees of acceptance and recognition, GIS has been a major player in these developments (Kontokosta, 2021; Yiğitcanlar et al., 2020). Urban planning nowadays tackles many different issues, such as traffic system management, water leakage control, street safety, and transit efficiency. In the framework of urban planning, specialized technologies are being employed more frequently to address concerns related to infrastructure, governance, safety, transit, sustainability, and community. Artificial intelligence tends to automate the world and this naturally leads to inventions in urban planning and design for applications that accelerate the development of smart cities. These trends have given rise to the concept of urban artificial intelligence. The term urban artificial intelligence refers to artificial intelligence embodied in urban spaces and infrastructure (Yiğitcanlar & others; 2020).

An enormous amount of data is required for the correct application of artificial intelligence as it is currently utilized. Data on how people live in cities and how they have changed over time can be obtained because modern cities have been digitalized through the installation of sensors, CCTV cameras, and extensive telecommunication networks. Data regarding buildings, open spaces, and land areas can be obtained. The knowledge about the urban fabric, or the logistics of the city, is revealed when this data is fed into an artificial intelligence system, particularly machine learning models. Urban planners can use this information by using appropriate reasoning and design. With the use of this data from numerous digital sources, urban government can also be achieved. With the use of insights from an AI model that processes data, politicians can better implement policies that benefit urban residents (Jha & others, 2021).

The most widespread use of artificial intelligence technologies in today's cities is smart cities. Participatory mapping apps with online tools and data-driven processes that assist "smart cities" are increasingly used to help planning efforts (Afzalan & others, 2017). As of 2017. (Afzalan & others). Smart cities are associated with technologies such as artificial neural networks, big data, text mining, machine learning, deep learning, and data mining. Smart cities also involve additional issues including smart infrastructure, governance, and automated urban mobility (autonomous cars, human mobility) (Lazeretti & others, 2023).

Smart cities are local governments that leverage Internet of Things (IoT) and information and communication technology (ICT) to share information with the public, boost operational efficiency, and enhance the standard of citizen welfare and government services. These cities aim to maximize service efficiency by collecting data from people and devices in real time and optimizing the use of information and technology. The development of smart cities is based on optimizing city services, promoting sustainability and enhancing public safety with tools such as sensors and communication networks offered by IoT technology. These cities are composed of various elements such as smart infrastructure, smart government, smart environment, smart living, smart security and smart mobility. Smart infrastructure, in particular, forms a priority part of these structures. However, the implementation of smart city technologies brings challenges such as inequality, discrimination and oversight. This highlights the need for governance and intervention at the institutional and infrastructure levels (Nuami & others 2015; Sucitawathi & others, 2018; Tititn & others 2022; Adilkhan & others; 2023).

One of the most important technologies in smart city studies is the 'internet of things'. In the first studies on the use of artificial intelligence in planning, the main problem was the processing of large and complex data. However, today, with the development of I4.0 technology, effective solutions to this problem have started to be produced. Industry 4.0 (I4.0) is a paradigm that involves the integration of the Internet of Things (IoT) into the manufacturing and production environment. It supports connecting physical elements such as sensors, devices and organizational assets to each other and to the internet. I4.0 is adaptable to human needs and involves a large number of heterogeneous devices (Velez-Estevez & others, 2021).

When looking at artificial intelligence technologies from a spatial perspective, the relationship between different technologies is important. Technologies support each other and develop together. Without the Internet of Things, I0.4 would not have been realized and thus the smart city concept would not have emerged. In addition, big data, machine learning and autonomous vehicles are other technologies that contribute to the development of the smart city concept (Lazeretti & others, 2023).

One of the most common areas for the use of artificial intelligence in urban planning is transportation systems. Today, traffic densities can be calculated with instant GPS data. This enables the data that would take a long time and effort for transportation planning to be obtained in a very short time. In the development and management of the smart city, great importance has been given to public and private transportation studies (Larson & Zhao, 2020).

On the other hand, more sophisticated technologies are required to address some urban issues including urban sustainability and to increase the effectiveness of several services that have a direct impact on people' quality of life, such as healthcare, communication, and energy supply (Kummitha, 2020). Given the speed at which technology is developing, it is notable that applications across a variety of industries have expanded recently. As a matter of fact, artificial intelligence is increasingly being used in planning—first for data analysis and planning, then for decision-making or city development. The increased adoption of AI in the field of planning is a result of its attraction to a wide range of disciplines, including humanistic, economic, and social sciences. Big data, for instance, is frequently used to profile consumers and residents for both public and private purposes. In addition, it is used to research land use, comprehend urban transportation patterns, and forecast the geographical and spatial evolution of cities. One of the most popular sources of massive volumes of data in this context is social media, and it is from this source that these studies draw significant insights (Lazeretti & others, 2023). According to Liu et al. (2020), this data provides a real-time information repository that can be used to study the geographic distribution of human activities throughout time and place. With the use of urban network analysis (Fang et al., 2020), social media analysis (Olson et al., 2021), and an evaluation of the built environment's influence on the survival rates of neighborhood-based social organizations (Wang & Vermeulen, 2021), this data can be utilized to comprehend urban density.

Lazeretti et al. (2023) conducted a bibliometric analysis in their study on the use of artificial intelligence in spatial sciences. According to this analysis, the use of artificial intelligence in spatial sciences is divided into 3 periods. The first phase, which began before 2014, is when the notion originally emerged, with less than 20 research conducted annually. The second phase, which spans from 2015 to 2017, is referred to as the growth period because 20–100 articles are released annually. There are around 100 research conducted annually during the "boom" phase that ended in 2018. One of the important results of the analysis is that the places where the studies are conducted are mostly developed countries. While the most studies were conducted in the USA and China, it has been observed that interest in this subject has recently increased in Europe. An additional deduction drawn from the analysis is that the utilization of IoT, big data, social media analytics, cloud computing, open innovation and crowdsourcing, remote sensing, GIS, and global positioning system technologies should be employed to establish a completely automated smart environment for regional development. This will enable the integration of all components and guarantee the optimal application of numerous technologies involved in the execution of the smart city environment.

Another important enabler of AI in urban planning is smart governance. Smart governance is needed to enable more efficient and integrated urban management (Caprotti and Liu, 2020). According to Du et al. (2023), there is still room for improvement when it comes to integrating AI technologies with participatory planning. This study shows that AI can be used to gather local information through unstructured data, facilitate stakeholder communication, educate participants using scientific evidence, predict the results of alternative plans, and automate the plan formulation process.

Artificial intelligence has also been used to create policies in urban planning that reduce the impact of climate change and also to create policies that help mitigate climate change, as climate change is of great importance in the modern world and designing cities that mitigate the negative impacts of climate change (Jha & others, 2021).

Visualization is one of the facilities provided by artificial intelligence in terms of planning. Given a detailed description, artificial intelligence can produce a large number of visualizations, and the alternatives produced can be used in different versions. Below, a Google Earth image (figure 1) uploaded to a publicly accessible artificial intelligence application is given the command "Re-plan the neighborhood in this satellite image from Google Earth so that there is at least 500 meters of access to each green area" and the image in figure 2 is generated.

Figure 1. Google Earth Image of Van Akköprü Neighborhood

Figure 2. Plan prepared by artificial intelligence
Source: mnml.ai

As can be seen in Figures 1 and 2, the plan was made and visualized in seconds by considering the built environment data. Data such as existing regulations, city plan, soil structure and ownership structures were not taken into account in the plan. On the other hand, the use of artificial intelligence in such an accessible and fast way raises expectations that more accurate planning can be done with more diverse inputs in the future.

FUTURE HORIZONS: PROSPECTS OF AI IN SHAPING TOMORROW'S CITIES

Looking at the historical development of artificial intelligence in the field of planning, it is possible to say that it has developed by accumulating and accelerating. This situation shows that artificial intelligence will be used more in the field of urban planning and its usage areas will diversify. Today, there are some pilot applications, but more studies are needed for their reproducibility and generalizability. In this section, we will discuss the applications that have been sown today and are expected to become widespread in the future.

Integrating disciplines that require different skills, such as design, into automated systems with AI seems difficult in the short term. AI can increase our understanding of the real-time functioning of the city, especially with advances in the form of machine learning. However, it is difficult to predict how quickly these methods will be integrated into planning and design. It is likely that AI will contribute in a similar way to the plan-making process, with the use of various computer tools at the core of planning support systems. However, what we need now is to identify how AI can be used in the fields of urban analysis, urban science, urban planning and design. This requires a concerted effort to understand the limits of AI, to explore new ways of automating city functions, and to consider urban planning in a broader context (Batty, 2018).

Though numerous deep learning models have been experimentally added as stand-alone parts to the planning process, an AI-generated plan has not yet been demonstrated. When it comes to creating and comprehending the physical, social, legal, and political characteristics of the areas subject to planning implementation, AI cannot replace planners at this point in its development, even though it can help them by making alternative designs easier to develop (Du & others, 2023).

Artificial intelligence can contribute significantly to the planning process by combining key dimensions such as culture, macroform and governance and ensuring their success. Today, data from many neighborhoods has the potential to provide a more comprehensive view of the urban fabric. This can allow planners and policy makers to shift their focus from closed systems with the effects of interconnected urban elements to open, fragmented and tangible effects such as density, cohesion and compactness in the fabric of the urban environment (Yiğitcanlar & others, 2020). When community meetings are poorly attended, it might give planners insight on the land use preferences and place-based values of the local population. Additionally, it may be scaled up to infer requirements and preferences from a sample that represents a much larger population (Du & others, 2023).

According to studies, AI-based data processing can help better predict livability by creating a clean, healthy and convenient living environment, tackling urban challenges, for example, pollution and traffic congestion (Huang & Liu, 2021). Furthermore, cities leveraging AI can boost economic returns by supporting globally competitive business environments as well as offering greater support to talented and knowledgeable workers by providing connectivity, energy and information processing capabilities (Hui & others, 2020).

Assessing how people see expansive urban areas can also be done using street view photography. By considering people's opinions of the target region, planners can enhance its design (Zhang & Orhers, 2019). Providing important data sets with street views to save time and money, especially in urban analysis, can make planning healthier and more dynamic.

Huang and Liu's (2021) study takes the potential of using augmented reality to increase brand love of tourist destinations as an example on the tourism industry. The analysis shows that revolutionary technologies such as augmented reality can play an important role by making the digital experience more human-like and increasing the brand love of tourist destinations. This emphasizes that the virtual environment can mimic the real experience, especially when visitors are unable to experience the real thing due to Covid-19 constraints. When combined with the digital twin concept, this suggests that virtual cities can also provide economic opportunities for tourism.

A virtual reality tool designed to illustrate the intricacy of geographical system data was examined by Ma et al. (2020). Through three-dimensional scenarios that overlap with spatial datasets used in the gaming industry, like 3D Geographic Information Systems, they demonstrate in their analysis how this virtual reality tool can be integrated into spatial planning processes, suggesting that it can help stakeholders better understand the urban environment.

Urban planners and urban researchers do not yet have enough knowledge about AI methods. Many contend that the lack of a uniform methodology is the reason why urban planning is still fragmented and that it is still challenging to share and use new data and methodologies across disciplines. For instance, in educational programs, architects and planners seldom work together (Malczewski & Jankowski, 2020). Education in urban planning frequently falls short in providing future practitioners with an understanding of AI. Thus, in order to provide future planners with the skills necessary to apply AI approaches in urban planning practice and effectively disseminate their findings to the public, curriculum centered on AI education ought to be included (Du & others, 2023).

LIMITS AND ISSUES REGARDING THE USE OF ARTIFICIAL INTELLIGENCE IN PLANNING

With the widespread application of artificial intelligence in planning, some questions and problems have also emerged. In particular, there are some ethical issues related to centralized control, data privacy, biased data, evaluation of the balance between benefits and costs, and inequalities between individuals (Caprotti and Liu, 2020).

The use of data obtained instantaneously through artificial intelligence to monitor and control individuals, especially by organizations such as social media platforms, credit reporting agencies and insurance companies, has been criticized. Urban planning has the potential to harness these technologies to bring new insights and efficiencies to communities. However, along with these advantages, it must be sensitive to potential biases and negative social impacts and continue to emphasize data privacy (Sanches & other, 2023). As large amounts of data need to be collected and stored for AI models to work, the privacy of citizens living in smart cities may be at risk. Storing data in a centralized location can increase the risk of unauthorized access attempts by hackers. Therefore, it is important to put in place specific policies and techniques to protect people's data (Jha et al., 2021). Without careful governance of the regulation and production of information, smart cities run the risk that big data can lead to undemocratic behavior and generate vast profits for private companies (Cooke, 2020). Such situations emphasize the urgency of a regulatory framework, as AI processes may favor private rather than public interests. Moreover, although the impact of AI in industrial production has been widely applied, its impact on local economic development has not yet been sufficiently explored (Russell & others, 2015).

By focusing on culture, creativity, and culture-driven development models, Lazzeretti (2020) explored the advent of artificial intelligence and how it is changing society in his study on the role of culture in the digital revolution. He noted the potential dangers that this culture's "algorithmic society" may encounter. Among these hazards include social amnesia, the devaluation of natural language, individual estrangement, and the absence of protection for fundamental rights. Socioeconomic disparities are also highlighted as potential hazards for people and society that lag behind in the digital transition.

One of the constraints in planning is limited resources. Planning procedures including plan designs, stakeholder and public discussions, and institutional approvals must be completed by municipal planning offices—often under tight financial constraints and with hectic deadlines. AI models are often very complicated, and many fields are still in their infancy. The narrow application regions and short technology lifespan make it difficult to provide enough proof of effectiveness and high performance. Thus, establishing trust with AI is also challenging. Problematic is the reproducibility of empirical research on AI integration in planning procedures. It is challenging to simulate human behavior in a participatory planning workshop due to the intricacy of these models. Given that it depends on the distinctive qualities of every person and the dynamically shifting nature of social interactions, this is a major problem that needs more investigation (Wilson et al., 2021).

Another problem with the use of AI in urban planning is that it is extremely costly to produce a high quality AI model. Moreover, problems can arise due to the use of data that is not representative of the whole society, creating bias and harming underrepresented categories of society. More research is needed to explore the implications of adopting AI technologies for spatial inequalities. In this context, the role of giant corporations in economic development should be examined and the costs and benefits in development should be assessed (Du & others; 2023).

CONCLUSİON

The discipline of planning is not only a discipline that has to keep its finger on the pulse of the age, but also a science that thinks beyond the requirements of the age, that is, the world of tomorrow. While planning has shaped cities, social, environmental and economic developments in the world have shaped planning. It is known that planning has undergone a rapid change and transformation especially after the industrial revolution. Today's world is in a new transformation process. The digitalization process is shaping the discipline of urban planning and it is possible to say that urban planning and artificial intelligence will be used together more in the future.

The first studies on urban planning and artificial intelligence were conducted in the 1960s. During this period, AI was an area of expertise that was generally not embraced by planners. In the 1990s, with advances in computer technologies and the use of expert systems, AI started to be integrated into planning processes. In the following years, AI started to play an active role in urban planning processes by combining it with urban modeling studies and geographic information systems. In the 2000s, artificial intelligence supported planning software was developed. In the early stages of AI in planning, the focus was on data processing and analysis and applications were not fully developed. However, with improving technology and more effective algorithms, AI has become an important tool in urban planning processes.

With the rise of smart cities, artificial intelligence technologies have become more significant nowadays. In relation to urban challenges including transportation, climate change, environmental research, and participatory planning, these technologies offer a number of benefits. Smart cities make considerable use of artificial intelligence-based technologies including big data, machine learning, and the Internet of Things. For instance, GPS data can be used to assess traffic density in transportation planning, which helps urban planners make better informed decisions. Furthermore, AI can be used to gather local data, facilitate stakeholder interactions, and automate plan creation in participatory planning procedures. The quantity and variety of studies on urban planning have expanded along with the application of AI. These developments, meanwhile, still need to be dispersed more widely because they have mostly been made in industrialized nations.

The use of artificial intelligence in planning is increasing and accelerating. Today, much work is needed to develop the applications and put them on a scientific basis. The integration of disciplines that require different skills, such as design, with AI requires more time than sciences such as engineering. AI can provide data on the real-time functioning of cities, but it is difficult to predict how quickly these methods will be integrated into planning and design. Furthermore, a concerted effort is needed to identify how AI can be used in urban analysis, urban science, urban planning and design. Through various examples, it has been proven that AI has the potential to contribute to urban planning in many different areas. In order to train future planners with AI techniques, AI-oriented education should be added to the urban planning curriculum.

With the spread of artificial intelligence applications, ethical issues have come to the fore. Issues such as centralized control, data privacy, biased data and inequality are at the forefront of these issues. Data privacy concerns reveal the risks of big data collection processes. High-cost AI models carry the risk of bias and social inequality. It is also known that AI-enabled planning processes may favor special interests. In conclusion, various issues related to the integration of AI technology into planning processes need to be carefully addressed.

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CHAPTER IX

THE IMPORTANCE OF GEOGRAPHIC INFORMATION SYSTEMS AND REMOTE SENSING IN URBAN AND RURAL AGRICULTURAL PRODUCTION AND LAND PLANNING

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INTRODUCTION

Leaving a livable world to future generations is only possible by meeting the needs of the age with an environmentalist approach and implementing sustainable agricultural policies. With the rapid increase in the world population, resources such as water, soil and energy are needed more. Irregular urbanization makes it difficult to use natural resources in a sustainable way, and as a result, access to healthy food for human nutrition is becoming more and more difficult.

With the increase in urbanization trends as a result of globalization, the intensification of irregular migration to cities, inadequacies in social, economic, health, cultural, educational, etc. areas lead to the formation of segregated living spaces in cities, irregular construction trends and environmental destruction. Factors such as neglect of spatial planning and design, deficiencies in legislation, etc. have negatively affected rural settlements and threatened local identity values and lifestyle. At the same time, the fact that the zoning structure of the countryside is not given the necessary importance and even the development areas of villages and towns, that is, the development plans are ignored, causes an unplanned decrease in agricultural areas and negatively affects agricultural production. Villages and towns, which are the most important component of rural settlements, are places blended with unique lifestyles, land uses, socio-cultural structures, natural and cultural landscapes, historical phenomena, spatial organization and unique natural economic resources (Gül et al., 2020). It is vital that these structures, which have their own unique nature and ecosystems, can be sustainably preserved. In order to protect these ecosystems, concrete changes need to be monitored instantly and closely. For this purpose, remote sensing methods are used for continuous and large-scale monitoring of ecological developments, mapping of land cover or use, determination of river, sea, lake and water pollution, monitoring of changes in coastlines, industrial areas and their surroundings, and forest areas. These studies contribute to taking precautions before changes turn into environmental disasters. At the same time, many agricultural studies such as monitoring plant growth in agricultural areas, making crop yield estimates, determining soil type and soil moisture, and developing irrigation and fertilization programs accordingly can be successfully carried out with the help of images obtained with remote sensing, which is widely used in agricultural applications.

Estimation of crop yields is extremely important for advanced planning and future national agricultural policies. In addition, with remote sensing technology, forest species can be mapped, deforestation and desertification can be monitored, timber production forecasts can be planned, and forest fires can be monitored.

Remote sensing plays an important role in protecting agricultural land in urban and rural development planning. Remote sensing is used to assess the impact of urbanization on agricultural land and to monitor agricultural land lost to unplanned land use. Remote sensing enables monitoring, data collection and analysis of agricultural land from a broad perspective, making valuable contributions to planning processes for the conservation and more effective use of agricultural land. This technology plays a critical role in the sustainability and conservation of farmland.

This situation, which has developed to the detriment of agricultural lands, is based on the rapid migration from rural areas to cities and their surroundings. According to the first census in 1927, the population of Turkey was 13,648,270. While 75.8% of the population lived in towns and villages (less than 10 thousand inhabitants) and 24.2% in provincial and district centers; after 1950, the population started to gather in urban areas. According to the results of Address Based Population Registration System 2021 announced by TurkStat, 93.2% of the population lives in provincial and district centers. Following this population erosion, many villages have become empty and agricultural activities, especially animal husbandry, have become impossible. Although there are many reasons for this, the most important reasons are the insufficiency of agricultural areas, inefficiency and inadequate use of modern agricultural techniques, and the low level of economic and social welfare in rural areas have led people to migrate to big cities in the hope of a better life (TUIK 2022).

Land cover and land use in our country are changing dynamically due to migration from rural areas to cities and rapid population growth, as well as the destruction of natural areas for various reasons and in various ways. Remote sensing and geographical information systems methods are frequently used to determine the changes occurring in the world and in our country with fast, reliable and low cost and to produce maps that will be available to local governments and to prepare long-term zoning plans of cities (Özşahin et al., 2020; Polat and Yalçın, 2020; Kaya et al., 2020; Demir, 2021; Gudmann and Musci, 2022; Nacar and Karademir, 2022).

CHANGES IN AGRICULTURAL AREAS AND POPULATION STRUCTURE IN TURKEY AND THE WORLD

According to TUIK data for 2020, the total agricultural area is 37,762,000 hectares (including meadow and pasture land). Of the total agricultural area, 52.2 % is cultivated land, 9.4 % is under perennial crops (perennial orchards) and 38.4 % is permanent meadow and pasture land.

In Turkey, the amount of agricultural land per capita has decreased as a result of the increase in population and the decrease in the total amount of agricultural land. In the 1990-2020 period, Turkey's population increased by approximately 50 %, while the agricultural land per capita decreased by approximately 40 % in the same period.

While there was 1.32 hectares of agricultural land per capita in Turkey in the 1960s, this ratio decreased to 0.70 hectares in the 1990s and to 0.45 hectares in 2020. When meadow areas are subtracted from the agricultural area per capita, this ratio decreases even further in terms of arable land only. As of 2020, the arable area per capita is 0.28 ha in Turkey, 0.18 ha in the world and 0.22 ha in the European Union (TUIK, 2022; FAOSTAT, 2020).

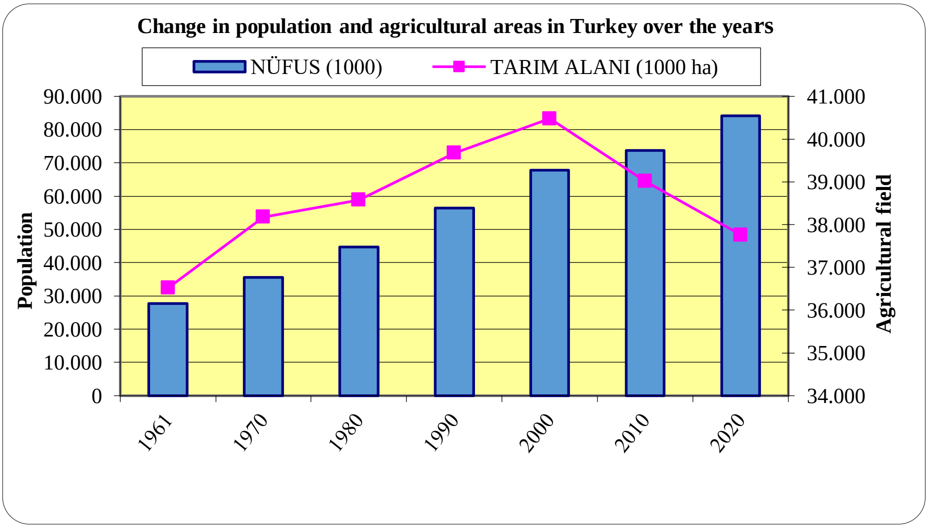

Figure 1. Changes in population and agricultural areas in Turkey by years
Source: TUIK, 2022; FAOSTAT, 2020

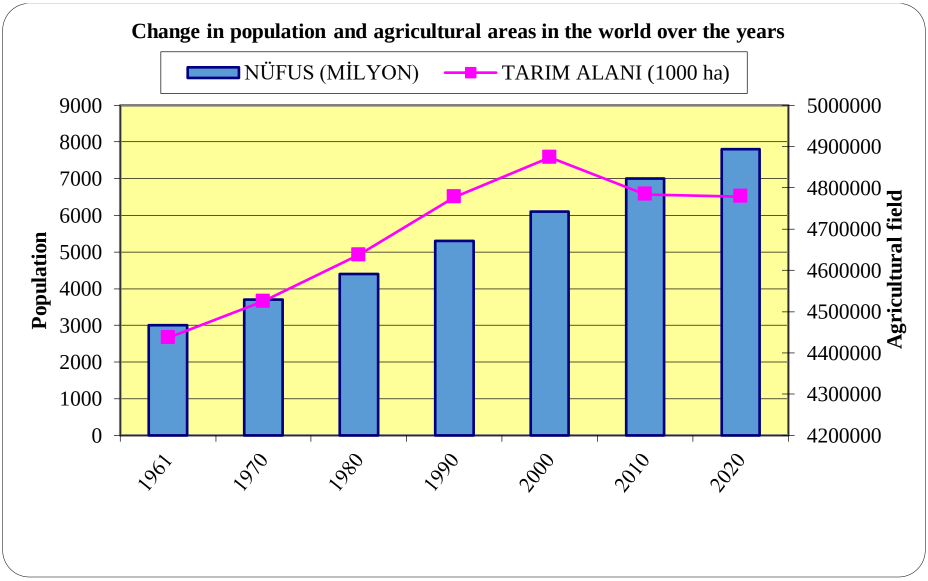

Figure 2. Changes in population and agricultural areas in the world by years
Source: TUIK, 2022; FAOSTAT, 2020

When the graphs are analyzed, it is seen that agricultural areas in Turkey are in a decreasing trend, while the population continues to increase. Considering that agricultural production is needed more than ever due to the ever-increasing population and that agricultural areas will be insufficient for access to food, Remote Sensing and Geographical Information Systems are important in urban and rural development planning and in protecting agricultural lands. Thanks to geographic information systems (GIS), agricultural lands can be protected in urban and rural planning through satellite maps, and thanks to these technologies, it is possible to recognize many problems early and provide solutions while monitoring agricultural lands from satellite.

Remote sensing is used to assess the impact of urbanization on agricultural land and to monitor agricultural land lost due to unplanned land use. Remote sensing enables monitoring, data collection and analysis of agricultural land from a wide range of perspectives, making valuable contributions to planning processes for the conservation and more effective use of agricultural land. This technology plays a critical role in the sustainability and conservation of farmland.

These systems help the Ministry of Environment and Urbanization and Climate Change, the Ministry of Agriculture, municipalities and all decision-makers, planners, researchers and those working with geographic data in general to build relationships between data, perform analysis and make informed decisions.

Along with the use of these systems in the world, they have also started to be used in Turkey. The Ministry of Environment, Urbanization and Climate Change has taken an important step by establishing the "General Directorate of Geographic Information Systems". The General Directorate of GIS has undertaken the mission to carry out and have carried out the works and operations related to the establishment, use and development of the National Geographical Information System, to determine the standards of urban information systems related to the activities of local governments regarding planning, mapping, infrastructure and superstructure and to encourage their widespread use and to operate the National Geographical Information Portal.

The geographic information systems (GIS) unit established within the General Directorate of Agricultural Research and Policies of the Ministry of Agriculture and Forestry aims to determine the quality of agricultural lands by using remote sensing geographic information systems in agriculture, to monitor agricultural areas, to take measures to prevent disease, pest invasion and possible frost damage thanks to early warning systems, and to make product and production planning in a healthy way in line with the needs of the country.

By using these systems, decision-making ministries can ensure the production and widespread sharing of accurate, standardized and high quality geographical information, contributing to more accurate, faster and higher quality planning, investment and audit activities and public services.

CONCLUSION AND RECOMMENDATIONS

GIS and remote sensing technologies can play an important role in protecting agricultural land in urban planning, but for this to happen, technology must be used effectively and the right strategies must be developed.

By improving living standards in villages and rural areas, and ensuring the spatial and economic development of administrative, commercial, social and agricultural life, it will be possible to keep the population in rural areas. In this way, it will be possible to prevent the misuse of agricultural land by reducing urban agglomeration.

Urban and rural planners can use GIS and remote sensing data to ensure that farmland is protected and sustainable. These technologies help to formulate policies for the protection of farmland. For example, it is possible to analyze the impacts of factors such as land use changes, urban expansion or environmental impacts on farmland.

GIS and remote sensing can be used to monitor changes in farmland and create early warning systems. In this way, possible threats can be identified and intervened in advance.

However, the correct interpretation and applicability of these data in planning is as important as the use of technology. Policy makers, in collaboration with local communities and stakeholders, should develop strategies to ensure the protection of agricultural land using the information obtained.

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