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PRINCIPLES AND APPLICATIONS OF ECOLOGICAL LANDSCAPE DESIGN

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Abstract

With the industrial revolution and the increasing world population, human needs have started to be supplied uncontrollably by the biophysical environment/nature. In recent years, designers, planners, and practitioners have actively developed and discussed new ideas to reduce ecosystem destruction and create a sustainable environment. One of these applications is ecological landscape design. Ecological landscape design creates a double-sided sustainable system for people and the ecosystem. By focusing on the natural characteristics of a site and implementing sustainable practices, ecological landscape design aims to enhance biodiversity, ecosystem services, and the resilience of ecosystems, ultimately contributing to the well-being of communities and ensuring a sustainable environment for future generations. In this context, today, ecological design practices aim to minimise the ecosystem's damage and meet the user's needs. Within the scope of this study, the principles of ecological landscape design were determined and evaluated, and the aim was to reveal the application methods and tools of ecological landscape design.

Anahtar Kelimeler: *Ecological Landscape Design, Design Principles, Landscape Applications, Sustainability*

EKOLOJİK PEYZAJ TASARIM İLKELERİ VE UYGULAMALARI

Özet

Sanayi devrimi ve artan dünya nüfusu ile birlikte insan ihtiyaçları biyofiziksel çevre/doğa tarafından kontrolsüz bir şekilde karşılanmaya başlamıştır. Son yıllarda tasarımcılar, planlamacılar ve uygulayıcılar ekosistem tahribatını azaltmak ve sürdürülebilir bir çevre yaratmak için aktif olarak yeni fikirler geliştirmiş ve tartışmışlardır. Bu uygulamalardan biri de ekolojik peyzaj tasarımıdır. Ekolojik peyzaj tasarımı, insanlar ve ekosistem için çift taraflı sürdürülebilir bir sistem yaratır. Ekolojik peyzaj tasarımı, bir alanın doğal özelliklerine odaklanarak ve sürdürülebilir uygulamaları hayata geçirerek biyoçeşitliliği, ekosistem hizmetlerini ve ekosistemlerin direncini artırmayı, nihayetinde toplumların refahına katkıda bulunmayı ve gelecek nesiller için sürdürülebilir bir çevre sağlamayı hedeflemektedir. Bu bağlamda, günümüzde ekolojik tasarım uygulamaları, ekosistemin zarar görmesini en aza indirmeyi ve kullanıcının ihtiyaçlarını karşılamayı amaçlamaktadır. Bu çalışma kapsamında ekolojik peyzaj tasarımının ilkeleri belirlenerek değerlendirilmiş, ekolojik peyzaj tasarımının uygulama yöntem ve araçlarının ortaya konulması amaçlanmıştır.

Keywords: *Ekolojik Peyzaj Tasarımı, Tasarım Ilkeleri, Peyzaj Uygulamaları, Sürdürülebilirlik*

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1. INTRODUCTION

Due to the multifaceted problems of integrating ecology and design processes into contemporary, cultural, social, and political structures, ecological design is interdisciplinary. Therefore, professional groups such as architects, designers, engineers, planners, and biologists must cooperate to achieve a successful and sustainable implementation. Landscape architecture discipline carries out harmonious work in ecological design practices by keeping nature and people at the centre of design and planning. While supporting users' needs, landscape architects contribute to protecting and sustaining the ecological balance with natural and environmental processes In this context, ecological landscape design should integrate design and planning by considering the relationships between environmental processes and human needs. While designing from the perspective of material, water, energy renewability, sustainability, and ecosystem protection, it should not be ignored that landscapes are dynamic and physical, biological and social relations are constantly changing in the landscape. "Landscape architecture has ecological thinking at the care of its legacy" Mozingo (1997).

Design and planning are not only for people. Designers must also create diverse and healthy urban environments for the countless species that share these places. In this context, different designers have determined ecological design principles. Within the scope of this study, new ecological landscape design criteria were determined by evaluating the ecological design criteria in the literature. In addition, ecological design practices in landscape architecture have been introduced.

2. MATERIAL AND METHOD

Within the scope of the study, the method of collecting and interpreting data sources was used to analyse the research material. The research method consists of three stages. In the first stage, national and international literature on ecological design principles was reviewed, and all kinds of written and visual sources were used. In the second stage, ecological landscape design principles were evaluated, and new design principles were established in the literature. In the last stage of the study, ecological landscape design and implementation processes were evaluated using the information and findings obtained in the first and second stages, and examples were given in this context.

The methodology for this study on ecological landscape design involved a systematic review of existing literature, case studies, and design principles to identify and evaluate the core components and practices of ecological landscape design. The research process was structured into the following key phases:

Literature Review: A comprehensive review of academic articles, books, and reports on ecological landscape design was conducted. The primary focus was on seminal works by key authors such as McHarg (1995), Nassauer (1997), Tallamy (2007) and Ryn & Cowan (2013) who have contributed significantly to the field. The literature review aimed to extract and synthesize the principles and applications of ecological landscape design, including native plant species, water conservation techniques, soil health practices, and wildlife habitat creation.

Ecological Assessment: The study included an ecological assessment framework to evaluate the environmental impact of different landscape design approaches. This framework was based on established ecological metrics, such as biodiversity indices, water use efficiency, and soil health indicators. The assessment helped to understand how various design choices affect ecosystem services and sustainability.

Data Collection and Analysis: Data from the literature, case studies, and ecological assessments were systematically collected and analyzed using qualitative content analysis. This approach allowed for identifying recurring themes and patterns related to ecological design principles and their applications.

The methodology was designed to provide a comprehensive understanding of ecological landscape design and to develop practical guidelines that can be applied in various contexts to achieve sustainable and ecologically sound landscapes. Integrating theoretical knowledge with practical case studies and community involvement ensures that the findings are academically rigorous and practically relevant.

3. RESEARCH FINDINGS

3.1. Ecological Design

Rapid consumption and pollution of natural resources, increasing urbanisation and the resulting pressure on natural life, decrease in species diversity, global warming, climate changes and the ecological crisis resulting

from all these have led to contemporary ecological practices (Shivanna , 2022). In this context, ecology-priority and eco-design ideas have emerged. The concept of ecological design first emerged in the late 1960s in architecture, design and planning (Kallipoliti, 2018).

The new ideas that emerged in the 1960s consisted of small-scale architectural designs that aimed to alleviate the intensity of ecological footprints (Shu-Yang, Freedman, & Cote, 2004). However, most of these "new" ideas involve the re-emergence of methods and practices used in the past. Although ecological design emerged as a new idea, many societies in history have implemented ecological design in different ways. For instance, traditional Japanese architecture, such as the design of wooden houses with sliding doors and tatami mats, reflects ecological design principles (Çakır Kıasıf, 2018). These structures were crafted using locally sourced wood and bamboo, and they were designed to maximize natural ventilation and daylight, ensuring thermal comfort with minimal energy use (Zwerger, 2012). This illustrates that while ecological design is often viewed as a modern concept, it actually draws heavily from traditional practices, refined and enhanced through contemporary techniques (Shu-Yang, Freedman, & Cote, 2004). Ecological design thus strives to minimize environmental impact while addressing human needs efficiently.

Ecological design, as conceptualized by pioneers like Ryn and Cowan (2013), focuses on designing with nature to create systems that are sustainable, resilient, and capable of self-renewal. Ryn and Cowan (2013) define ecological design as "any form of design that minimizes environmentally destructive impacts by integrating itself with living processes." This approach emphasizes the need for design processes informed by ecological knowledge that aim to mimic natural processes.

Environmental issues are becoming more critical in political decision-making as the focus shifts to economic objectives (Grochová & Litzman, 2021). In this context, ecological practices are encouraged by international regulations.

In the 1969 US National Environmental Policy Act, sustainability is defined as "creating and sustaining" and " to create and maintain conditions, under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic, and other requirements of present and future generations" (NEPA, 1969). Sustainability is the process of examining the environmental, social, and economic impacts, benefits, relationships, and interactions and then implementing appropriate actions. The goal is to reach an equilibrium where the resources and systems can remain viable for future generations.

According to the Declaration on Environment and Development published at the United Nations meeting in Rio in (1992), sustainable development consists of social equality, economic feasibility and environmental protection. The principle of social equality covers issues such as education, health, personal security and leisure time. The main idea of this principle is to respect the economic resources of the environment and ecosystem while maintaining social cohesion. The principle of economic feasibility refers to meeting the needs of society by establishing a productive system without jeopardising natural resources and the needs of future generations. Therefore, the applicability of this principle is closely linked to the needs of society and environmental limits. The principle of environmental protection includes using natural resources without depleting them and recycling them for subsequent use, considering the population's needs and economic resources.

In 2015, the United Nations General Assembly accepted the Sustainable Development Goals. This goal and objectives are intended to be realised within 15 years. The 17-article Sustainable Development Goals aim to ensure the ecosystem's continuity, sustainability and ecological balance by providing the health, economic, equality and education needs of every member of society in the most humane and equal way. From an ecological point of view, humans are a part of nature and should be in harmony with each other, so resources should be protected.

Ecological design is an approach that aims to improve environmental health, integrating natural systems and the built environment, minimising damage to the ecosystem and combining sustainability and aesthetics (Terêncio et al., 2021). Improving ecological functionality, conserving and producing resources for human use, and developing a more flexible approach to designing and managing built environments will be possible with ecological design (Rottle & Yocom, 2011). Ecological design involves human and other living communities and systems and applies the best available scientific theory and evidence to create resilient, sustainable environmental quality (Rottle and Yocom 2011). Ecological design aims to create space for native

species and habitats, sustainable resource consumption in human activities, and effective integration of the legitimate needs of other species and natural ecosystems (Shu-Yang, Freedman, & Cote, 2004).

Due to the multifaceted problems of integrating ecology and design processes into contemporary, cultural, social and political structures, ecological design is inherently interdisciplinary. Therefore, different professional groups, architects, designers, engineers, planners and biologists, should cooperate for successful and sustainable practices. Landscape architects carry out harmonious and integrated work in ecological design applications due to their expertise in design and planning and the fact that nature and human beings are at the centre of this discipline. Landscape architecture has ecological thinking at its centre (Mozingo, 1997). Each design directly affects the environment, and designing with ecological priority will contribute to the harmony of the design with the environment and the protection of the environment.

3.2. Ecological Landscape Design

Ecological landscape design is a specialized application of ecological design principles to the planning and creation of landscapes. It aims to create outdoor spaces that are sustainable, environmentally friendly, and beneficial to both people and the ecosystem. This approach to landscape design is informed by the work of landscape architects like Ian McHarg, whose book Design with Nature (1969) laid the foundation for integrating ecological science with landscape architecture.

The applications of ecological landscape design range from urban parks and green roofs to residential gardens and large-scale ecological restoration projects. For example, the High Line in New York City is a well-known ecological landscape design project that transformed an abandoned railway into a vibrant green space supporting urban biodiversity and providing residents with recreational opportunities (Field Operations, 2024).

In conclusion, ecological design and ecological landscape design represent a paradigm shift in how we approach design and planning (Koh, 1982). By integrating ecological principles into the design process, these approaches create sustainable, resilient, and livable environments that benefit both people and the planet.

3.3. Principle of Ecological Landscape Design

Natural systems and user needs are at the centre of landscape design. Ecological design practices help both users and all components in the ecosystem to be healthy and sustainable (McHarg, 1995). While meeting users' needs, ecological landscape design aims to protect and maintain the ecological balance with natural and environmental processes. In this context, an integrated design and planning should be made in ecological landscape design by considering the relationships between environmental processes, other living things in the ecosystem, and user needs. While designing from the perspective of material, water, energy renewability, sustainability, and ecosystem protection, it should not be ignored that landscapes are dynamic and that physical, biological, and social relations are constantly changing within the landscape.

In ecological landscape design, ecological concerns should be integrated into the design and cultural formations and nature should be planned together (Corner, 1999). Renewable and sustainable use of natural resources should be ensured, and a system that connects these components with land use should be created. Each design directly affects the environment, and designing with ecological priorities will contribute to the harmony of the design with the environment and the protection of the environment.

Different groups and individuals interested in ecological and sustainable design have established some criteria and principles. In this context, researchers' ecological design and sustainability criteria were examined, and new ecological landscape design criteria were created by analyzing these criteria.

According to Harjanto and Hamka (2021), sustainable landscape design criteria:

• **Environmental**- Availability of green open spaces, maintaining water and air quality, flora and fauna, productive land use, determining land use functions, using environmentally friendly materials, saving energy.

• **Economic**- Agricultural and livestock cultivation, tourism development, entrepreneurship/ investment/ employment

• **Social cultural**- Education, health, scientific experience, cultural identity/ local wisdom, spaces for social interaction, group or individual collaboration

• **Architectural**- Provides a space and place experience of an attractive visual quality and a comfortable environment.

• **Institutional**- Policy, participation, and commitment of all parties.

Principles of sustainable landscape construction according to Thompson and Sorvig (2008):

• **Keep healthy sites healthy**- From the design phase to the application stage, the ecosystem should be protected as much as possible, and its health should be provided.

• **Heal injured soils and sites**- Drylands and agricultural areas should be restored, degraded soils should be renewed, and regionally appropriate vegetation should be recovered.

• **Favor living, flexible materials**- Natural vegetation should be used in the design.

• **Respect the waters of life**- Natural wetlands should be protected and restored. Rainwater harvesting should be carried out.

• **Pave less**- Ensuring using permeable pavements instead of impermeable surfaces. Ensuring that uncontrolled surface runoff is prevented.

• **Consider the origin and fate of materials**- Natural and recyclable materials should be used. Environmentally toxic and hazardous materials should not be used.

• **Know the energy costs over time**- Reducing energy costs through energy-efficient designs.

• **Celebrate light and respect darkness**- Ensuring efficient use of daylight. Ensuring the use of solar energy.

• **Quietly defend silence**- Use of noise barriers. Ensuring the use of noise-absorbing materials.

• **Maintain sustainability**- Natural and bio-based care products should be preferred without wasting resources. A total cost calculation should be made by evaluating all design, application and maintenance processes.

• **Demonstrate performance and learn from failure.**

Principles of sustainable design according to McLennan (2004):

• **Learning from natural systems (Biomimicry principle)**- Nature is the model for all design. For true sustainability, communities and the built environment must mimic natural systems.

• **Respect for energy and natural resources (Conservation principle)**- It is necessary to be aware of limited resources and ensure their sustainability. All natural resources are valuable and need to be protected.

• **Respect for people (Human vitality principle)**- The main goal is to create healthy living spaces for humans and other living things.

• **Respect for place (Ecosystem principle)**- Ecological design should consider the differences between regions, both at the macro level, such as climate characteristics, and at the micro level, such as topographical and biological characteristics.

• **Respect for the future (Seven generations principle)**- The environment must be safe at all times and for all people, and waste that is toxic to people and the environment must be eliminated wherever possible. There should be an appropriate match between the expected lifetime of a material and its use.

• **Systems thinking (Holistic principle)**- While it is possible to build a sustainable future by using design and implementation processes that reduce environmental impacts, it is fundamentally about improving the process to achieve mutual benefits.

Principles of ecological design according to Shu-Yang, Reedman, and Cote (2004):

• The need to meet the inherent needs of humans and their economy.

• The requirement to sustain the integrity of the structure and function of both natural and managed ecosystems.

• The appropriateness of emulating the inherent designs of nature in anthropogenic management systems.

• There is a need to progress toward a sustainable economy through greater reliance on renewable resources and more focus on recycling, reusing, and efficient use of materials and energy.

• Use of ecological economics (or full-cost accounting) to comprehensively consider resource depletion and environmental damage and thereby address issues of natural debt.

• There is a need to conserve natural ecosystems and indigenous biodiversity at viable levels.

•The desirability of increasing environmental literacy to build social support for sustainable development, resource conservation, and protection of the natural world.

Principles of ecological design according to Ryn and Cowan (2013):

• **Solutions grow from place**- The fact that the design space is the solution itself and that the unique cultural and physical characteristics inform the solution of the site is often overlooked in standard designs.

• **Ecological accounting informs design**- Environmental and social factors such as water, energy and indoor air quality should be considered alongside financial criteria in the design process.

• **Design with nature**- Biotic and abiotic factors such as wind, water and sun, which are components of nature, should be considered in the design.

• **Everyone is a designer**- Collaboration with all stakeholders should be central to design processes. For ecological design to succeed, all stakeholders must be involved in the process.

• **Make nature visible**- "Making natural cycles and processes visible brings the designed environment to life, and effective design helps to define the human place in nature" Ryn and Cowan (2013).

When different researchers analyzed ecological design and sustainability principles, it was found that the main ideas were similar. These are responding to the needs of users, water, energy, resource, and material efficiency, respecting the ecosystem and economic features. In this context, the basic principles of ecological landscape design were identified:

• Economy of design and processes,

•Sustainable designs,

• Participatory design,

• Protection of resources,

• Fulfilment of user needs,

• Ecosystem as a whole

• Habitat restoration and promotion of biodiversity, protection of landscape patterns.

3.1.1. Economy of design and processes

Applicators have always preferred economic designs. The fact that a design is economical increases its applicability. In landscape design, economic accounting should consider all stages, from the production stage of the material used, including transport, application, and then recycling or end of life. Although some ecological applications may be costly (such as photovoltaic panels), they will be economical in the long term due to the support of sustainability and the lack of energy consumption. During ecological design, all ecological costs should be calculated, from the consumption of resources to pollution and destruction of habitats (Van der Ryn and Cowan 2013). This principle advocates a holistic assessment of the environmental impacts of every product, material and application used in design during the entire use cycle.

Efficient Resource Use: Emphasizes the efficient use of natural and human resources to reduce waste and energy consumption during both the construction and maintenance phases. This includes using local materials to minimize transportation impacts and costs (McHarg, 1995) (Cowan & Ryn, 2013)

Lifecycle Cost Analysis: Incorporating a long-term view in design decisions, where the focus is on reducing costs over the lifespan of a project rather than just the initial investment.

3.1.2. Sustainable designs

If a design is not sustainable, it will cost more and have a shorter lifespan. Therefore, a design applies to the extent that it is sustainable. Sustainable designs are ecological applications that use renewable and natural

resources and local and recyclable materials. Renewable resources can potentially be utilised continuously for many generations. These resources should be used wisely.

On the other hand, non-renewable resources decline with use; although they can contribute to economic growth, they cannot be used as the primary basis for a sustainable economy (Shu-Yang, Freedman, & Cote, 2004). In ecological design, while maintaining the quality standards of goods and services, total resource consumption, waste generation and ecological damage should be reduced through reuse and recycling, and the use of renewable energy and material resources should be increased economy (Shu-Yang, Freedman, & Cote, 2004). It aims to be renewable and sustainable by establishing a balance within the design. Thus, it aims to make more economical applications using less energy and materials.

Integration with Local Ecosystems: Ensuring that designs work with existing ecological systems, preserving native species, and enhancing biodiversity (Ogunseitan, 2011).

Minimizing Environmental Impact: Designs should aim to reduce carbon footprints, water usage, and energy consumption. This includes employing green infrastructure like rain gardens, green roofs, and permeable pavements (United States Environmental Protection Agency, 2020).

3.1.3. Participatory design

In ecological landscape design, a participatory method should be followed in all design, application, and management stages. Thus, the design will be more effective and sustainable. The wishes and needs of local people should be determined and reflected in the design processes. Local users should be informed about the design and ecological sustainability, thus ensuring the sustainability of the design.

Community Involvement: Engaging local communities in the design process to ensure that the landscapes meet their needs and are maintained effectively. This principle recognizes that sustainable designs are more successful when they are supported by the community (Steiner, 2012).

Inclusive Design: Designs should accommodate diverse users, including people with different physical abilities and cultural backgrounds, ensuring accessibility and usability for all.

3.1.4. Protection of resources

All natural resources are valuable and need to be protected. In this context, sustainable material, water, and energy resources should be used in landscape design. It aims to ensure the least possible resource consumption by responsibly turning to renewable resources in the use of natural resources necessary for all industrial economies. Ecological landscape design creates a sustainable environment by making a material, energy and water-efficient design. Natural and inexhaustible energy sources such as solar, geothermal, and wind should be used in ecological landscape design. Sustainability will be ensured by selecting local, natural, and recyclable materials for use in landscape design.

Water Conservation: Implementing strategies like xeriscaping, rainwater harvesting, and efficient irrigation systems to conserve water resources (WaterSense, 2021).

Soil Health: Protecting and enhancing soil health through sustainable practices such as composting, mulching, and avoiding chemical pollutants.

3.1.5. Fulfilment of user needs

People cannot sustain their lives without using natural resources such as food, materials, products and energy. The main purpose of traditional design is to fulfill user needs. In ecological landscape design, while fulfilling user needs, natural systems and other species living in these systems should also be considered (Spirn, 1985). Fulfilling user needs without harming the ecosystem is one of the main goals of ecological landscape design. For example, a green bridge application can be given to prevent the division of the habitats of living creatures in the region in an area that needs a vehicle road. Every non-ecological design has an ecological alternative. While fulfilling user needs from nature, it should be aimed to minimise damage to the ecosystem.

Functional and Aesthetic Balance: Creating spaces that are not only beautiful but also functional, meeting the practical needs of users while maintaining ecological integrity (Swaffield , 2002)

Health and Wellbeing: Designs should contribute to the physical and mental well-being of users by providing spaces for recreation, relaxation, and social interaction.

3.1.6. Habitat restoration and promotion of biodiversity

Habitat restoration efforts are important to promote biological flows and increase habitat availability (Wang, et al., 2021). Good design should aim for the mutual benefit of people and all living things. Ecological landscape design should support the health of ecosystems and habitat restoration. Within the scope of ecological design, designs should be made to help users be more aware of the regional ecosystem and to make connections. With the help of ecological landscape design, damaged or destroyed ecosystems should be restored to protect biodiversity.

Restoring Degraded Areas: Actively working to restore habitats that have been degraded by previous land use, with a focus on re-establishing native plant and animal communities (Clewell & Aronson , 2013)

Enhancing Biodiversity: Encouraging a variety of plant and animal species through diverse planting schemes and habitat creation, such as wildlife corridors and pollinator gardens.

3.1.7. Ecosystem as a whole

Design should be sustainable with the integration of living systems. It has been argued that design should consider humans and living systems as a whole. Designs should be made by considering each individual of the ecosystem and the principle of sustainability. In ecological landscape design, the entire ecosystem should be considered as a whole; human needs and nature's needs should be fulfilled simultaneously. All ecosystem components should be considered and included in the design processes in ecological landscape design. At the same time, all components and landscape patterns should be protected while designing.

The social, cultural, and spatial scales within the landscape should be considered as a whole in design, and the mutual interactions of these scales should be evaluated within the design processes. The landscape's biotic and abiotic factors are in constant change and development; it should be considered that the designs made in the process will change, transform and have different effects.

Maintaining Ecological Connectivity: Ensuring that landscapes are designed to support the movement of species and the flow of ecological processes, avoiding fragmentation of habitats (Forman & Godron, 1986)

Cultural Landscape Preservation: Integrating the conservation of historically and culturally significant landscapes into the design process to maintain a sense of place and identity.

3.2. Ecological Landscape Applications

Today, different applications are being made by considering ecological landscape design criteria. Ecological design applications in landscape architecture are;

• Energy efficient landscape design,

• Water efficient landscape design,

• Biomimicry, natural landscape design,

• Effective use of materials in landscape design,

• Permaculture

•Eco-village.

3.2.1. Energy efficient landscape design

Energy-efficient landscape design aims to save energy. Natural and sustainable resources such as solar, wind, water, and geothermal energy are used in energy-efficient landscape designs. It is also possible to make energy-efficient designs with the help of plants and materials used in landscape design. Renewable energy sources that can be used according to environmental factors should be determined in energy-efficient designs.

Energy efficient landscape design practices;

• Providing cooling and heating with the help of plant design,

• Using structural and plant materials for shading and lighting,

• Reducing heat loss by creating wind curtains with plant and structural elements,

• Contributing to cooling and heating with green wall and facade applications,

• Reducing the heat island effect by using permeable floors instead of reflective materials and minimizing hard floors,

• Using solar energy in lighting,

• Using alternative hand tools instead of gasoline-powered machines (such as lawnmowers, pruning machines, electric saws),

• Generating electricity using photovoltaic panels on hard floors, roads, roofs and bus stops,

• Reducing daily temperature differences on the earth by increasing wooded areas,

• It is evaluated as making plant and structural design suitable for the climate.

It is important for an energy-efficient design to consider both summer and winter season conditions in the planting arrangements to be applied around the building (DeKay & Brown , 2014). To reduce the heat effect of the sun in summer, the Gradual planting of trees and shrubs will reduce the energy used (Figure 1). In winter months, the heat effect of the sun is used by using large-crowned and deciduous plants to reduce the energy used for heating.

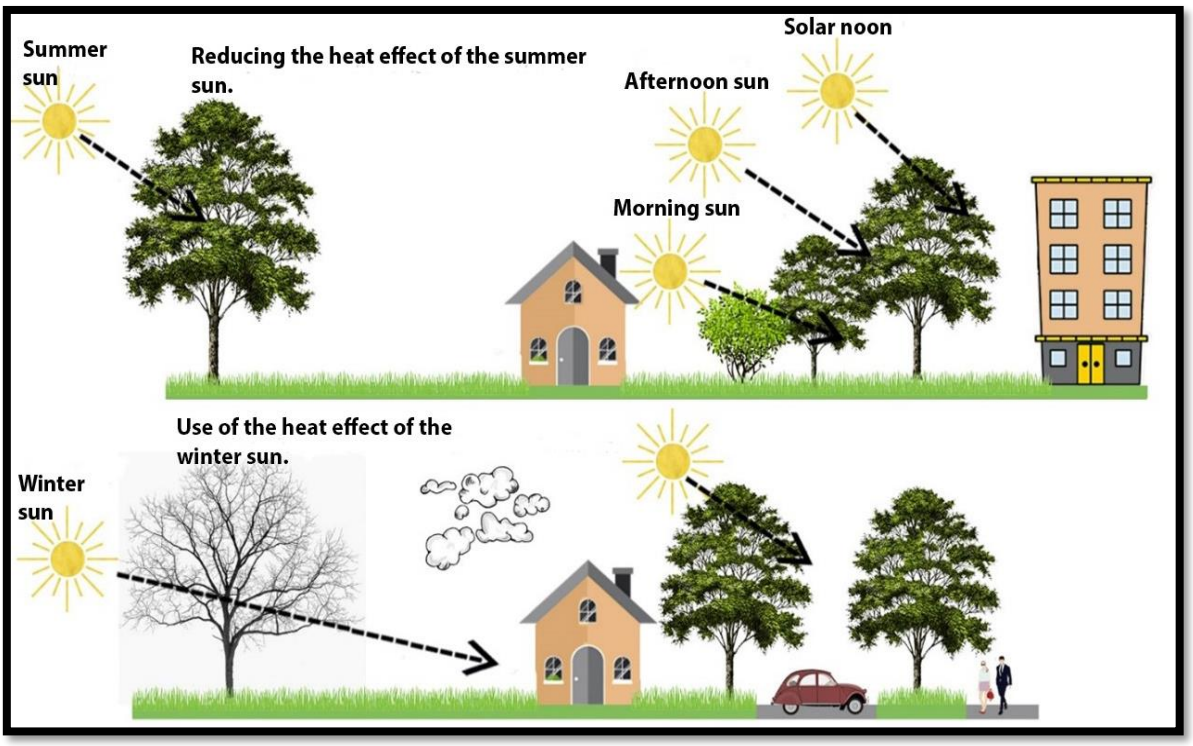

Figure 1. Winter-summer optimum solar energy use and gradual plant arrangement (Ak, 2021)

Heat losses can be prevented with plant arrangements in open green areas such as walking paths, squares, parking lots, children's playgrounds and recreation areas, and heating in winter and cooling in summer can be provided. With the help of trees, shade is provided for users in summer, and in winter, users are heated by letting the sun's rays through deciduous trees.

Solar energy is ecological because it does not create waste, has no damage or side effects, and is renewable and costless. So, it is used as a sustainable energy source in ecological landscape design applications. Current applications include solar-powered street lighting, seating units, bus stops, and floor coverings that generate electricity using solar energy (Figure 2. a-b).

Figure 2. a- Solar powered lighting (Original, 2023), **b-** Solar-powered bus shelter (Wee, 2019)

3.2.2. Water efficient landscape design

Water efficient landscape design is a design in which water waste is minimised, water recycling is ensured, and the least amount of water is used. The main objectives are water-efficient landscape design, groundwater protection, rainwater collection, and water saving. Examples of water-efficient landscape design;

• Rain gardens- Bioretention areas are an effective method of natural rainwater harvesting; they are gradually designed, permeable and planted depression areas. Rain gardens are rainwater harvesting methods that utilise the natural processes of the hydrological cycle (Figure 3.a).

• Bioswale ecological rainwater harvesting swales are designed to retain, treat, transport, and clean rainwater.

• Green roofs- are vegetated areas on the roofs of buildings designed to reduce and collect rainwater runoff and prevent heat losses in buildings.

• Permeable concrete, flooring and materials are permeable and porous materials that allow water to pass directly to the ground, forming a continuous, textured surface (Figure 3.b).

• Water cisterns and water tanks- Rainwater collected from the roofs of the buildings is transferred to the water tanks/ cistern with the help of pipes and can be used in the siphonic system, garden irrigation and as drinking water when filtered.

• Structured wetlands- are designed artificial shallow water basins with plants, usually on ground filled with soil, sand or gravel.

• Dry streams are sustainable practices of laying stones, rocks, and gravel on the ground to solve poor drainage problems in the area and channel and collect rainwater (Omondi & Navalia, 2020).

• Rain saucers- are systems designed in the form of an inverted umbrella, which is used to store rainwater directly without contact with foreign substances (Madgundi, Kumbha, Lele, Komble, & Maran, 2023).

• Xeriscaping- Dryland landscaping is a practice that reduces or eliminates the need for irrigation in open green areas and helps increase the use of natural and local plant materials (Smith & Hilaire, 1999).

When it rains, the water flow rate slows down in open green areas, and rainwater is filtered by plants and transmitted to the soil and then to the groundwater. When it rains in areas with impervious surfaces, rainwater cannot be transmitted to the soil; evaporation and uncontrolled surface water runoff occur. With this uncontrolled rainwater flow, pollutants such as fertilisers, pesticides, oils, and garbage cause pollution of groundwater and surface waters. Ecological rainwater harvesting methods aim to prevent the pollution of groundwater and surface water resources and save water.

Figure 3. a- Rain garden application (Original, 2019), **b-** Permeable flooring application (Original, 2021)

3.2.3. Biophilic landscape design

Psychologist Erich Fromm introduced the term "biophilia" to describe the psychological orientation of being interested in everything alive and vital (Barbiero & Berto, 2021). The concept of biophilia expresses love for nature. Biophilic design, which emerged from this concept, is inspired by natural systems in built environment design. So, it is aimed to be inspired by the functioning of natural systems and their sustainability in landscape design and to bring people together with nature.

Imitating the patterns in nature, making designs inspired by them, and naturalising the built environment are the main goals of biophilic design. It also aims to ensure sustainability by reflecting the perfect order of nature in the design (Kellert, Heerwagen, & Mador , 2008). Green roof-wall-bridge applications and biological ponds can be examples of biophilic landscape design. (Figure 4). Green facades and roofs soften the structural elements from a design perspective by carrying green areas to the building structures by the natural structure. Green facade and wall applications have benefits such as noise pollution, air quality, heat and moisture insulation.

Figure 4. Green wall design (Cabanek, 2020)

3.2.4. Effective use of materials in landscape design

Within the scope of material-efficient design, local, recyclable, climate-friendly and economical materials should be selected. Using efficient materials will also contribute to efficient energy and water applications. According to Gezer (2011): "In ecological design, materials should be renewable, recyclable, low energy consuming, non-toxic, self-repairing, and prone to change".

In material effective landscape design;

• Waste-free,

• Considering human needs,

• Recyclable and sustainable,

• Renewable,

• Durable,

• Useable,

• Healthy,

• Suitable for the natural and cultural structure of the area,

• Local and natural,

• Contributing to water and energy conversion,

• Materials that do not destroy nature should be used.

Although ecological materials are generally preferred to be natural, with the development of technology, sustainable and artificial materials that do not harm nature are also used in ecological designs today. The use of eco materials in landscape design is increasing. In this context, examples of landscape design using effective materials;

• Permeable surface - concrete applications,

• Use of natural and local materials instead of impermeable surfaces,

• Use of mulch in vegetated areas,

• Composting and utilisation of organic wastes.

Material renewability, transformation and waste management are important issues in ecological landscape design. Reusing wastes such as leaves and branches and composting (organic fertiliser) can be examples of material transformation.

3.2.5. Permaculture

The concept of permaculture is an understanding brought to the agenda by Mollison and Holmgren with the emergence of the environmental crisis in the 1960s and 1970s. Permaculture is an ecologically based sustainable production and lifestyle that aims to obtain the highest yield with minimum energy and material use, considering the relationships and interactions of biotic and abiotic factors with each other and their environment. Permaculture is a design theory that is shaped according to the sustainable lifestyle of people while guiding designers to imitate the patterns and relationships found in natüre (Althouse, 2016).

Although the functioning of nature is imitated in permaculture, it is impossible to imitate it in its entirety (Althouse, 2016). Because nature is in a constantly changing structure that cannot be constant. According to Mollison (1991): "Permaculture is permanent agriculture". Holmgren (2002) explained it as "consciously designed landscapes that provide abundant food, fibre and energy to meet local needs while mimicking patterns and relationships found in nature". Permaculture is an ecologically based system, a lifestyle integrated into the natural system that adopts the systems in nature and supports traditional agriculture while using current and technological knowledge (Mollison, 1991).

Application stages of permaculture:

• Water harvesting,

• Mulch application,

• Compost,

• Soil improvement,

• Biodiversity,

• Ecological agriculture,

• Reduction of labour and costs,

• Self-watering systems,

• Animal production.

Permaculture is a landscape design and lifestyle that includes all the principles of ecological design.

3.2.6. Eco-village

Eco-villages are living spaces that can be given as examples of ecological practices today. Eco-villages aim to create sustainably designed rural living spaces by fulfilling the needs of people in a way that does not harm nature.

According to Gilman (1991), eco-villages are "full-featured settlements on a human scale where human activities are integrated harmlessly into the world in a way that supports healthy human development and can successfully continue into the uncertain future". An eco-village is a deliberate, intentional, traditional rural or urban community that is consciously designed to revitalise its social and natural environments through locally owned, participatory processes in the four dimensions of sustainability (social, cultural, ecological and economic) (Joubert, 2016). Eco-villages are communities that include ongoing processes created through sustainable ecological practices. In eco-villages, ecological concerns are at the forefront instead of economic concerns.

Eco-villages are formed by taking into account four main principles, and these are;

• The principle of ecologically based practices: The use of renewable and sustainable resources in the use of energy, water and materials is within the scope of this principle.

•The principle of protecting traditional architecture and cultural values: The preservation and transfer of traditional cultural values to future generations is supported. It is also encouraged to continue living in traditional dwellings.

• Sustainable economy and transport principle,

• It is the principle of being socially cohesive and collective.

Eco-villages are ecological living spaces that combine various aspects of permaculture, green buildings, green production, alternative energy sources and water sustainability.

4. CONCLUSION AND SUGGESTIONS

Ecological landscape design is a transformative approach that integrates environmental sustainability with landscape architecture, fostering spaces that both respect and enhance the natural environment. This approach prioritises native plant species, water conservation techniques, soil health preservation, and wildlife habitat creation, all supporting resilience and ecological balance. As environmental crises, including climate change and biodiversity loss, intensify globally, adopting ecological landscape design principles has become increasingly crucial. Such practices mitigate environmental degradation and contribute significantly to creating healthy, functional, and aesthetically pleasing spaces that enhance the quality of life for both humans and wildlife.

In this study, we have identified seven core design principles for ecological landscape design, drawing from comprehensive research in ecological and sustainable design literature. These principles, supported by examples of existing ecological landscape applications, aim to provide valuable insights into landscape design's theoretical framework and practical applications. We propose several vital recommendations to strengthen the applicability and impact of ecological landscape design in Turkey.

Legal Regulations and Policy Development: Integrating ecological landscape design into environmental policy is essential. Policymakers must expand legislation and regulations to incorporate sustainable landscape practices into urban planning codes, zoning regulations, and building standards. Environmental policy should mandate incorporating green infrastructure and ecological landscapes in new urban developments, with compliance monitored by relevant authorities. Such policies can ensure that ecological landscape design becomes a standard in urban and rural areas, aiding environmental sustainability at a national level.

Institutional Collaboration and Interdisciplinary Cooperation: Effective ecological landscape design requires collaboration among various stakeholders, including governmental agencies, local authorities, private developers, and environmental organisations. Coordination between institutions like the Ministry of Environment, Urbanization, and Climate Change, local governments, and academic institutions is critical. Joint efforts can facilitate sharing resources, knowledge, and expertise, allowing for the development of cohesive and impactful ecological landscape projects. Furthermore, interdisciplinary collaboration with environmental scientists, ecologists, urban planners, and designers can enhance the success of these projects by addressing complex ecological challenges from multiple perspectives.

Education and Public Awareness: Raising awareness about the importance and benefits of ecological landscape design is vital to its acceptance and successful implementation. Ecological principles should be incorporated into university curricula for landscape architecture, urban planning, and environmental studies, equipping future professionals with the skills and knowledge to create sustainable designs. Additionally, local governments and environmental NGOs could organise public awareness campaigns, workshops, and educational programs to inform communities about ecological landscape benefits and engage them in participatory design processes. Involving the community in the planning and developing ecological landscapes can foster a sense of ownership and promote sustainable land stewardship.

Incentives and Financial Support: Economic incentives can be instrumental in encouraging the adoption of ecological landscape design in the private sector. Government grants, subsidies, and tax incentives can make sustainable landscape practices more accessible for developers, businesses, and homeowners. Additionally, local governments can establish green building certification programs that recognise and reward sustainable landscape designs. By creating financial benefits for those who incorporate ecological principles into their projects, governments can accelerate the shift toward sustainable landscapes at all levels of development.

Research and Development in Ecological Landscape Methods: Research into locally appropriate ecological landscape practices can enhance the relevance and effectiveness of these designs in Turkey's unique ecological and climatic conditions. Universities and research centres should collaborate with the private sector and government agencies to develop innovative approaches to native plant selection, water conservation techniques, soil health management, and urban biodiversity enhancement. R&D initiatives can lead to context-specific solutions that address challenges such as arid climates, urban density, and limited natural resources, thereby improving the resilience and functionality of ecological landscape projects across various regions in Turkey.

Pilot Projects and Demonstration Sites: Establishing pilot projects in various urban and rural areas across Turkey can provide valuable examples of ecological landscape design. These projects can serve as demonstration sites that showcase ecological design's environmental, social, and economic benefits to the public, policymakers, and private developers. Successful pilot projects can also generate valuable data on best practices, inform future landscape design projects, and support the refinement of ecological principles. For example, urban parks, green roofs, and rain gardens in city centres can demonstrate how ecological design can enhance urban resilience, improve air and water quality, and create habitat corridors for urban wildlife.

Monitoring and Evaluation of Ecological Landscape Projects: Implementing an evaluation system to monitor the success of ecological landscape projects is essential to ensure long-term sustainability. Evaluation criteria should include ecological, social, and economic indicators such as biodiversity levels, water and soil quality, user satisfaction, and maintenance costs. Regular monitoring and evaluation allow for adaptive management, ensuring ecological landscapes meet sustainability goals and providing feedback for future improvements. Such data can also help policymakers and urban planners make informed decisions when designing and implementing new ecological landscape projects.

Integration with Climate Resilience and Adaptation Strategies: Ecological landscape design must align with broader climate resilience and adaptation goals. Incorporating ecological landscapes into urban planning can mitigate climate risks by improving stormwater management, reducing urban heat islands, and enhancing air quality. Integrating green infrastructure and ecological landscapes into climate action plans at municipal and national levels can strengthen Turkey's overall resilience to climate change, protecting communities and ecosystems from adverse environmental impacts.

In conclusion, ecological landscape design represents a powerful approach to conserving natural resources and creating resilient, sustainable, and livable spaces for current and future generations. Turkey can facilitate the widespread adoption of ecological landscape design by adopting a comprehensive framework that includes supportive legal measures, institutional cooperation, education, incentives, research, and practical demonstrations. This approach will ultimately contribute to developing sustainable cities, enhancing the quality of life, and promoting a fair and balanced use of natural resources. As the global community faces pressing environmental challenges, Turkey's commitment to ecological landscape design will serve as a valuable model for creating a sustainable and thriving future. Through these efforts, Turkey will demonstrate the benefits of ecological landscape design, inspiring and guiding other nations in pursuing sustainable environmental practices.

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