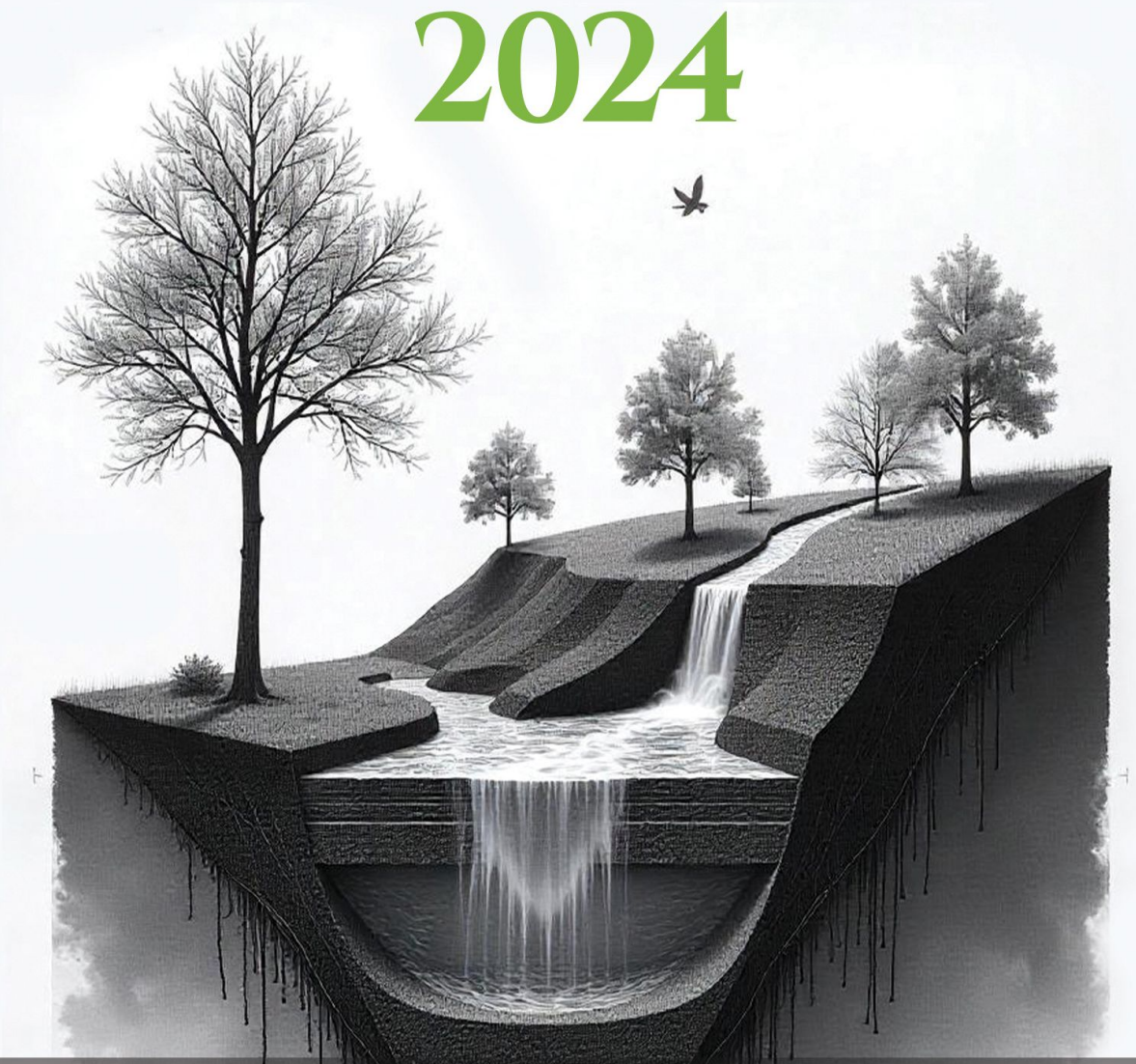
SCIENTIFIC APPROACHES IN LANDSCAPE ARCHITECTURE 2024



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Scientific Approaches in Landscape Architecture 2024

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PREFACE

This book addresses issues related to ecological planning and design approaches, sustainable economy perspective and combating climate change. Today, problems such as rapid urbanization, climate change and depletion of natural resources make the effects of human activities on nature even more evident. In this context, the necessity of an ecological approach to build a sustainable future has become more important than ever.

In different sections, planning strategies for coastal areas in the global climate change process are presented, and these areas are evaluated in the context of urban morphology, and recreational opportunities of coastal regions are also mentioned. Then, the place of the sustainable economy approach in landscape planning is discussed. The role of plants in creating a sustainable environment and the importance of xeriscaping applications against climate change are also emphasized.

The book also aims to provide people with more effective and sustainable movement in living spaces by presenting innovative approaches to vehicle and pedestrian integration in urban transportation. The biomorphic design approach, on the other hand, enriches the user experience with solutions in the entrance areas of spaces inspired by nature.

In addition, studio experiences for landscape architecture education aim to provide students with practical information. Finally, a comprehensive review is presented on how medicinal and aromatic plants can be used in landscape design. These plants have an important place in protecting local ecosystems and preserving cultural heritage.

This book aims to inspire professionals, academics, and students working in the field of ecological planning and design, and it aims to be an important resource in building a sustainable future. We hope that our content will provide readers with new perspectives and encourage them to deal with environmental problems.

We wish you a pleasant reading.

Assoc.Prof.Dr. Elvan ENDER ALTAY
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CHAPTER IX

THE IMPORTANCE OF XERISCAPE IN THE FACE OF CLIMATE CHANGE

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1. Introduction

Xeriscape is a landscaping concept that promotes water conservation through creative and imaginative design. It is a trademarked term developed by the Denver Water Department in 1981 to promote water conservation practices in the western United States. However, it is now used more broadly to refer to water-saving or drought-resistant gardening and landscaping. The basic principle behind xeriscape is simple: to create a visually attractive landscape that uses efficient irrigation technology and water-wise plants. There are seven fundamental principles of xeriscape, often used as a guide to creating and maintaining a water-saving landscape (Warner et al., 2020; Chesnutt, 2020; Bigurra-Alzati et al., 2020). These are:

1. Plan and design an efficient watered landscape.
2. Use water-wise plants.
3. Limit turf areas.
4. Use efficient irrigation methods.
5. Improve soil with water-retention compost.
6. Use mulch.
7. Maintain the landscape efficiently.

As long as these principles are followed, the appearance and aesthetics of a landscape will be protected by using less water. It should be remembered, however, that xeriscape is more than just drought tolerant or low water use plants.

It is a comprehensive and systematic approach to landscaping and gardening that can be applied to any landscape, not just the dry landscapes of the southwest. The principles of xeriscape will work within the framework of a complex system of soil particles, air, water, and organic matter that come together to form the root zone for plants. Such a system is referred to as soil structure, and it will determine the availability of air and water, the extent of filling the water withholding, and nutrient levels. As a result, good moisture-retaining soil will not necessarily have a high organic matter content. By building and maintaining healthy soils, plant roots will be encouraged to grow healthily and profoundly and have better access to available moisture and soil nutrients. This, in turn, means that less water and fertilizer will be required to maintain a vibrant and healthy garden, which has continuing benefits in terms of both the environment and the gardener's budget (Ender Altay and Pirselimoğlu Batman, 2019; Morera et al., 2020; Clem et al.2021; Warner, 2021; Warner et al., 2022; Ismaeil and Sobaih, 2022; Yue et al., 2022).

2. Impact of Climate Change on Water Resources

Historically, the concept of water conservation was considered largely irrelevant when water was abundant. However, the increasing demand for water, coupled with inadequate or unreliable supplies, has transformed water into a critical and finite resource. Conservation strategies now represent the most cost-effective and environmentally sustainable approach to reducing water demand. These strategies aim to optimize water use, safeguard this essential resource, and mitigate waste, thereby ensuring a sustainable supply for future generations. This issue, already significant for many communities, will become increasingly urgent. With global population growth accelerating, pressures on water resources are intensifying. Concurrently, climate change is altering weather patterns and increasing the frequency of extreme events, such as droughts, which exacerbate the challenges related to water availability, distribution, and quality. In this context, significant potential exists for reducing water consumption at the household level. For example, a sprinkler can consume as much as 1,000 liters of water per hour, illustrating the rapid escalation of water usage and the impact of conservation efforts. Installing a simple and cost-effective rainwater collection system, such as a water butt, can yield savings of up to 5,000 liters of water annually, which can be used for non-potable applications such as garden irrigation. The responsibility for water conservation extends to individuals, businesses, and communities, each of whom can contribute to reducing

water waste through both behavioral changes and technological innovations. Immediate solutions include implementing water recycling programs and adopting innovations that enhance water efficiency. Equally critical is the role of businesses and communities in advocating for sustainable water management practices. Incentivizing water conservation and promoting the development and adoption of water-efficient technologies are essential for ensuring long-term water sustainability (Zhang and Khachatryan, 2021; Kumawat et al., 2020; Maer et al., 2021; Zhong, 2021; Boutheina et al., 2022; Zahoor and Mushtaq, 2023).

The impacts of climate change are increasingly apparent, characterized by rising global temperatures and significant disruptions to weather patterns, including more severe and prolonged droughts, erratic rainfall, and widespread water shortages. Water scarcity has emerged as a critical global issue, exacerbated by growing demand for freshwater due to population growth, urbanization, the expansion of irrigated agriculture, and industrialization. Over the past five decades, global water usage has tripled, with demand now increasing at more than twice the rate of population growth. Agriculture remains the largest consumer of freshwater, placing immense pressure on global water resources, particularly as over 40% of the world's food supply relies on irrigated agriculture. Additionally, industrial water consumption is rising rapidly, often in direct competition with other sectors. Shifts in lifestyle, including increased consumption of water-intensive products such as meat, cotton, and paper, further intensify the challenge of meeting the growing demand for water. Climate change is poised to exacerbate global water scarcity, as rising temperatures accelerate evaporation rates and alter the timing and distribution of precipitation. This will result in diminished water availability during dry seasons, especially in vulnerable regions. Moreover, heavy rainfall events, which can cause flash floods, are increasingly destructive. Urbanization, through deforestation and the expansion of impervious surfaces such as concrete, further reduces the land's capacity to absorb rainwater, negatively impacting both water supply and quality. The contamination of water sources, due to increased runoff carrying pollutants, poses significant threats to both human health and ecosystems. Furthermore, the combined effects of climate variability and human activity on water resources are likely to fuel tensions and potential conflicts between different water users, both within and between nations. The health implications of water scarcity will be severe, particularly in regions where limited access to water compromises hygiene and domestic needs. Such challenges will be especially acute in less economically developed countries, which often lack the

financial and technological resources to implement efficient irrigation and water management systems necessary to adapt to climate change. These pressures will place additional burdens on governments, potentially exacerbating economic and political instability. In conclusion, addressing global water scarcity requires immediate and coordinated action. International collaboration is essential to raise awareness of the global dimensions of water issues and the interconnectedness of their impacts. Integrated measures must be implemented to improve agricultural water management, enhance water use efficiency, and promote the development of water-saving industrial processes and sustainable water and sanitation services. Moreover, increased research and data analysis are needed to deepen our understanding of the comprehensive effects of climate change on water resources and to support the innovation and adoption of new technologies in water management and conservation. Finally, public engagement is crucial; communities should be educated and encouraged to adopt daily water-saving practices (Zhou et al., 2020; Liu et al., 2020; Tamburino et al., 2020; Brás et al., 2021; Albert et al., 2021; Wang, 2022; Liu et al., 2022).

Water resources are fundamental to human survival, and their availability and quality are increasingly vulnerable to the impacts of climate change. Climate change is expected to significantly alter hydrological processes, which are crucial in determining the availability of freshwater. Additionally, the frequency of extreme weather events, such as droughts and floods, is projected to rise. Higher temperatures will accelerate evaporation from water bodies and soils, while simultaneously reducing the effectiveness of precipitation. Changes in the timing and volume of snow and glacier melt will further strain water resources in certain regions. Many areas are likely to experience more frequent and intense flooding due to increased heavy rainfall events. Scientific research indicates that the global water cycle is already being affected, and this trend is expected to continue. Water scarcity will also become a growing concern as the climate continues to change. Rising sea levels are projected to increase saltwater intrusion into estuaries and rivers, posing a significant threat to plant and animal species that are unable to adapt to these altered conditions (Frame et al., 2020; AghaKouchak et al., 2020; Mujumdar et al., 2020; Walsh et al., 2020; Alimonti et al., 2022).

Landscaping plays a crucial role in water conservation, yet a significant portion of water is wasted due to inefficient irrigation practices and inappropriate plant choices. One effective solution is xeriscaping, a landscaping method designed to minimize water use. Derived from the Greek word “xeros,”

meaning dry, and the English word "landscape," xeriscaping is a systematic approach to designing and maintaining landscapes that require minimal water. Contrary to misconceptions, xeriscaping does not imply the absence of water or maintenance, but rather the strategic and efficient use of water where it is most beneficial to plants (Thomson, 2020; Yılmaz and Zencirkıran, 2021).

3. Benefits of Xeriscape

Xeriscaping can reduce water consumption by up to 50% compared to traditional lawns and gardens, following seven core principles: proper planning and design, practical turf areas, efficient irrigation, soil amendments, mulching, appropriate plant selection, and ongoing maintenance. These principles guide the evaluation and improvement of existing landscapes, focusing on sustainable and water-efficient gardening practices. Xeriscaping is not confined to water conservation efforts in the Western United States; it is a process grounded in time-tested gardening techniques, emphasizing plant choice, soil management, and water efficiency. Evidence suggests that residents in xeriscape-designed homes are more inclined to adopt water-saving behaviors and adhere to local water conservation regulations. Surveys indicate that 85% of individuals who moved into xeriscaped homes reported a positive shift in their attitudes toward water conservation. Moreover, water use in these communities has decreased by up to 14.8%, demonstrating the tangible impact of xeriscaping on sustainable water management (Null and Wurtsbaugh, 2020; Balogh and Watson, 2020; Clements, 2021; Blanchard; 2023; Longbottom and Gordon, 2023).

In traditional landscaping, a significant amount of water is lost through evaporation or runoff, primarily due to overwatering. In contrast, xeriscape gardens utilize plants specifically selected to thrive in the local climate, thereby reducing the need for excessive watering. A well-maintained xeriscape garden requires approximately two-thirds less water than a conventional lawn landscape, making it an ideal solution for both water conservation and cost efficiency. Many of the plants used in xeriscaping are species, and once established, they develop deep, extensive root systems that are highly effective at locating and storing water. This adaptability makes them exceptionally drought-resistant, allowing them to maintain their aesthetic appeal even during the hottest and driest summers. Beyond their visual appeal and the distinctive texture of gravel pathways, one of the most significant advantages of xeriscaping is its positive environmental impact. Water is a finite resource, and by reducing water consumption in gardens, we contribute to the preservation of this critical

resource for future generations. The financial benefits of xeriscaping extend beyond reduced water bills; the low-maintenance nature of this approach also saves time and labor. With less frequent watering and trimming required, homeowners can enjoy more leisure time in their gardens once established. This low-maintenance, water-efficient approach also holds particular appeal for commercial properties, such as business parks, where the costs associated with traditional landscaping can often escalate. Xeriscaping offers a sustainable, cost-effective alternative that supports environmental conservation while reducing long-term maintenance expenses (Ignatieva et al., 2020; Brelsford and Abbott, 2021; Clem et al.2021; Stacy et al.2021; Ismaeil and Sobaih, 2022; Meilinger and Monstadt, 2023; Visalakshi et al.2023; Aybey, 2024).

3.1 Reduced water usage

One of the primary advantages of xeriscaping is its significant reduction in water usage. According to the Colorado Geological Survey, xeriscaping can lower landscape water consumption by 60% or more. Traditional grass lawns, particularly in dry and hot summer months, have high water demands. For instance, a healthy bluegrass lawn requires nearly four times more water than most xeriscape plants. By replacing traditional lawns with water-efficient xeriscape designs, homeowners can drastically reduce their water usage. In addition to incorporating drought-tolerant plants and utilizing efficient irrigation systems, xeriscaping's core principle is water conservation. As emphasized by Denver Water's Plant Select program, the foundation of xeriscaping lies in using plants that need minimal water once established, along with strategically designed irrigation systems to maximize water efficiency and protect water quality while requiring low maintenance. A crucial concept in xeriscape design is the "irrigation audit," which involves careful planning of the landscape based on the water requirements of different areas and the implementation of an irrigation system tailored to these needs. This method ensures that each plant receives adequate water while preventing waste from overwatering, leading to both healthy plant growth and reduced water consumption. By cutting down on water demand, xeriscaping helps ensure a sustainable water supply for future generations (Ignatieva et al., 2020; Clem et al. 2021; Stacy et al. 2021).

The Colorado Water Wise Council reports that approximately 35% of water used in Colorado households is allocated to outdoor activities. Nationwide, it is estimated that more than 50% of the water used for landscaping is lost to evaporation or runoff due to overwatering. As climate change exacerbates water

scarcity, the adoption of xeriscaping at individual and community levels becomes increasingly crucial. According to the Center for ReSource Conservation, xeriscaping is critical for addressing Colorado's limited water resources and meeting the growing needs of high desert urban environments. From a broader perspective, xeriscaping helps reduce pressure on water supplies and serves as a key element in promoting sustainable development (Fausey, 2022; Green et al. 2024).

3.2 Drought Resistance

The benefits of xeriscaping have long been recognized, particularly in the context of water conservation. To illustrate the scale of these benefits, consider a homeowner with a substantial lawn. It is estimated that over fifty gallons of water can be saved annually for every square foot of lawn replaced with xeriscape plants. This considerable conservation of water could be allocated for other essential purposes. The advantages of xeriscaping, however, extend beyond water savings. By conserving water, homeowners can also mitigate the impact of water restrictions frequently imposed during summer months, which have become common in many U.S. cities due to seasonal water scarcity. With xeriscaping, the need for frequent watering is significantly reduced, alleviating concerns about such limitations. Additionally, xeriscaping contributes to increased property values. Research has shown that properties with landscapes that use less water tend to rise in value. As public awareness of the health and ecological benefits of green living environments grows, xeriscaping offers an environmentally responsible means of enhancing a property's appeal and value (Stacy et al.2021; Fuentes, 2021; Green et al. 2024).

Moreover, xeriscaping offers a tangible financial benefit through cost savings. Homeowners can expect to reduce both water bills and maintenance costs due to the lower demands of a xeriscaped garden compared to traditional lawns. The value of xeriscaping spreads quickly through word of mouth, as environmentally conscious individuals share their positive experiences with others. Educating people about xeriscaping can have long-lasting effects, as more people adopt this water-saving method. Given the increasing concerns about water resources, urban development pressures, and the effects of climate change, the case for xeriscaping is stronger than ever. The adoption of xeriscaping practices is poised to become more widespread, following historical trends in the acceptance of sustainable technologies and methods. As the movement for green spaces and environmentally conscious planning continues to grow, xeriscaping

presents a practical and realistic alternative to traditional landscaping. It holds the potential to become a mainstream solution for conserving the world's limited freshwater resources (Ignatieva et al., 2020; Stacy et al.2021; Ismaeil and Sobaih, 2022; Green et al.2024).

3.3 Preservations of Natural Resources

Preserving natural resources is essential for the well-being of our planet. Numerous human activities contribute to the depletion of these resources, jeopardizing the sustainability of life on Earth. Xeriscaping represents an effective strategy for conserving these vital resources. Contrary to the misconception that xeriscaping is limited to rocks and cacti, a well-designed xeriscape can incorporate a diverse array of plants that positively impact local ecosystems. For instance, by allowing stormwater to be absorbed into the ground, xeriscaping aids in replenishing groundwater supplies, thereby benefiting the water cycle and preserving natural water sources (Ignatieva et al., 2020; Sikorska et al., 2020).

In traditional landscapes, as much as 70% of household water usage may be allocated to maintaining lawns. By reducing lawn areas and incorporating drought-resistant plants, xeriscaping effectively mitigates water overconsumption. Importantly, a water-efficient landscape does not necessitate sacrificing plant diversity or aesthetic appeal; rather, it focuses on meeting the specific water needs of plants suited to the local environment. Many xeriscape plants are native species that have adapted well to local conditions, contributing to a resilient landscape. Furthermore, xeriscaping minimizes the reliance on pesticides and fertilizers, thereby preventing chemical pollution of natural ecosystems. In conventional landscapes, excessive use of herbicides, fungicides, and insecticides can result in harmful runoff during storm events or snowmelt, contaminating surface waters and placing undue stress on local ecosystems. By eliminating chemical inputs and significantly reducing water consumption, xeriscaping fosters a cleaner and safer environment for both flora and fauna. Lastly, xeriscaping reduces the need for gasoline-powered lawn maintenance equipment, which are substantial contributors to air pollution. By decreasing air pollution and mitigating the greenhouse gas emissions associated with fossil fuel combustion, even modest changes in landscaping practices can have a significant positive impact on the preservation of the Earth for future generations (Brelsford and Abbott, 2021; Visalakshi et al.2023; Meilinger and Monstadt, 2023).

3.4 Cost Savings

Another significant advantage of xeriscaping is the potential for cost savings. This landscaping technique not only reduces water consumption but also provides direct financial benefits to homeowners. While the immediate impact on water bills may take time to manifest, the long-term economic advantages become apparent over time. Establishing a new xeriscape garden involves initial investments in drought-resistant plants and appropriate landscaping methods. However, research conducted by Colorado Springs Utilities in Colorado demonstrates that the cost of maintaining a traditional lawn area is approximately USD 1,875 per acre, whereas the cost of converting to a xeriscape area is only USD 320 per acre. This stark comparison illustrates that the long-term maintenance costs associated with traditional gardens far exceed those of xeriscaped gardens (Stacy et al., 2021; Visalakshi et al., 2023).

When applied to larger commercial landscapes, the cost savings from xeriscaping can be substantial. In addition to the direct reduction in annual maintenance costs—estimated at around 60%—the financial benefits accumulate over time as the xeriscaped garden matures. Furthermore, various government incentives and rebates are available to encourage the adoption of xeriscaping as an environmentally sustainable practice. For instance, in California, particularly in Southern California, which frequently experiences water shortages, the Metropolitan Water District offers USD 1 for every square foot of turf converted to xeriscape, provided the conversion encompasses a minimum of 250 square feet. Such incentives can significantly alleviate the financial burden on homeowners contemplating the transition to xeriscaping while simultaneously raising public awareness of this sustainable approach (Stacy et al. 2021; Clem et al. 2021).

The popularity of xeriscaping has already gained traction in regions such as California and Colorado, particularly in areas affected by prolonged drought conditions, due to its appealing cost savings. This trend promotes the economic and environmental advantages of xeriscaping, making it an attractive option for cost-conscious and environmentally aware citizens. By effectively demonstrating that "xeriscaping can lead to extra money in your pocket," the movement encourages more individuals to consider switching to this efficient gardening method. When planned and managed thoughtfully, xeriscaping can fundamentally transform the gardening experience, alleviating the traditional burdens associated with landscape maintenance (Brelsford and Abbott, 2021; Ismaeil and Sobaih, 2022; Visalakshi et al., 2023).

4. Designing a Xeriscape Garden

The first step is to consider hydrozones and select appropriate plants. Each plant will fall into one of four hydrozones: the oasis zone, xeric zone, transition zone, and wetland zone (Visalakshi et al. 2023; Reynaert et al. 2024).

- Oasis Zone: This zone acts as the focal point of the garden and is typically located closest to the house. It requires the most water, so plant selection here will be diverse, often including species that need regular watering, such as lawn grass or colorful flowering plants.
- Xeric Zone: This area has the lowest moisture levels and should be populated with plants that can survive on little to no irrigation once established. Native plants are highly recommended for this zone, as they are well-adapted to local conditions and can attract native wildlife.
- Transition Zone: This zone serves as a buffer between the xeric and wetland zones. It features a mix of plants that can tolerate varying levels of moisture, creating a seamless blend of both environments.
- Wetland Zone: If included in your design, this zone receives the most moisture, particularly if you collect rainwater. Plants chosen for this area should thrive in saturated conditions, such as certain types of reeds and sedges.

After selecting and placing your plants according to these zones, focus on efficient irrigation methods. A well-designed xeriscape will require less water over time, as mature drought-tolerant plants will adapt and survive on natural rainfall. Implementing "smart" irrigation technologies, such as drip irrigation systems and automatic weather-based controllers, can further minimize water waste (Drewry et al. 2022; Ma and Fan, 2023; Ferreira et al. 2023).

Appropriate mulching is crucial for a successful xeriscape garden. It serves multiple purposes: covering the surface of the planting bed, breaking the fall of raindrops (which reduces topsoil erosion), retaining moisture, slowing down evaporation, and inhibiting weed growth. Apply a layer of 3 to 4 inches of natural mulch across the entire planting bed, leaving clear spaces immediately around the crowns of plants. Good soil amendments enhance the water-holding capacity of sandy soils and improve drainage in clay soils. Organic materials like compost and well-rotted manure are excellent choices for soil enhancement. They not only improve soil structure but also promote healthy root growth and increase the penetration of water and nutrients to the roots (Besser et al., 2021; Drewry et al. 2022; Ma and Fan, 2023; Ferreira et al. 2023).

4.1 Choosing Native and Drought-Tolerant Plants

One of the fundamental principles in the design of a xeriscape garden is the selection of native plants and introduced species that have adapted to the local climate and require minimal water once established. Native plants, defined as those that originate in the region without human intervention, are generally better suited to the local soil, temperature, and water conditions. Most native plants are characterized by their drought tolerance, enabling them to endure prolonged periods of dryness without the need for irrigation. Additionally, native plants play a significant role in attracting local wildlife, such as birds and butterflies, thereby contributing to the preservation of local biodiversity. Furthermore, due to the natural defenses that native plants have evolved against pests and diseases within their ecosystem, they typically necessitate lower levels of maintenance, particularly concerning pesticides and fertilizers. Conversely, introduced species, also referred to as exotic or non-native plants, are those that have been brought into an area from different regions or countries. It is important to note that not all introduced species are invasive or detrimental to the local environment; however, those capable of out-competing native species and disrupting the natural ecosystem are classified as invasive (Zencirkıran, 2011; Irl et al., 2020; Calleja-Cabrera et al., 2020; Erickson and Halford, 2020)

Consequently, careful consideration must be given to the selection of introduced species, ensuring that non-invasive options are chosen to foster a healthy, balanced ecosystem. Beyond the selection of native and drought-tolerant plants, the establishment of an appropriate plant palette is essential for creating a visually appealing and environmentally sustainable xeriscape garden. A well-designed xeriscape garden should encompass a variety of plant forms, including low ground covers, shrubs, and trees, to provide diverse colors, textures, and heights throughout the year. Additionally, the strategic placement of plants based on their water needs and growth habits is crucial for the creation of water-saving microclimates and the minimization of maintenance requirements (Vicente et al., 2020; Dantas et al., 2020; Esperon-Rodriguez et al., 2020; Yener et al., 2020; Ender Altay and Zencirkıran, 2024).

4.2 Efficient Irrigation Systems

As the second principle of xeriscape, the establishment of an efficient irrigation system transcends merely providing the appropriate amount of water to plants; it emphasizes the critical importance of minimizing water waste in the

delivery process. The primary options available for efficient irrigation systems include drip irrigation, soaker hoses, and bubbler systems. These methods are designed to deliver water directly to the root zones of plants slowly over extended periods, significantly reducing water loss due to evaporation compared to conventional sprinklers. Moreover, these irrigation systems are relatively easy for homeowners to install and require minimal maintenance once operational. However, it is essential to ensure that nozzles and emitters remain unobstructed by soil, necessitating regular checks and cleaning (Juraev and Karimov, 2020; Kanda et al., 2020).

This maintenance consideration should be integrated into the planning and design of the irrigation system, particularly in relation to the types of plants included in the garden. For instance, in the presence of trees and shrubs, a tubing system may be preferable, allowing water to be directed around each plant or along the lines of multiple plants, with emitters strategically positioned at the base of each one. This configuration ensures that every plant receives the appropriate amount of water. Conversely, for groundcovers or expansive open areas, drip tubing with pre-inserted emitters at specific intervals or soaker hoses may be more suitable. Such an arrangement will enable the rapid and thorough wetting of the essential water-rich shallow soil, thereby reducing the frequency of watering and conserving both time and resources while ensuring adequate hydration for plant growth. Through the implementation of a well-designed xeriscape garden, alongside the appropriate combination of operational practices and materials, it is entirely feasible to maintain a visually appealing garden throughout the year that meets all requirements while promoting water conservation. A properly designed irrigation system provides the control and flexibility needed to cater to the varying water requirements of different plant types while effectively addressing the challenges posed by local climate conditions and weather patterns (Schuch, 2021; Jiang et al., 2022).

4.3 Mulching and Soil Improvement

Mulch constitutes a vital component in any xeriscape design, serving to prevent water evaporation from the soil while simultaneously inhibiting weed growth. Various natural materials, including wood chips, bark, shredded leaves, straw, grass clippings, and pine needles, may be utilized as mulch. It is recommended that mulch be evenly distributed over the soil surface to a depth of 2 to 4 inches, ensuring that a few inches of space are maintained around plant stems to prevent rot and associated diseases. The installation of a soaker hose

beneath the mulch can enhance watering efficiency and minimize water wastage (Rose, 2022; McKeown, 2023).

Over time, as mulch decomposes, it transforms into organic matter, enriching the soil with essential nutrients. Soil enhancements can be further achieved by incorporating compost and decomposed organic materials, which help to maintain soil structure, promote microbial activity, and sustain nutrient levels. Additionally, the introduction of inorganic amendments, such as vermiculite, perlite, and sand, can facilitate improved drainage and mitigate soil compaction. By enriching the soil with compost and other organic materials, the soil's capacity to retain water and nutrients is significantly increased, which is crucial for plant survival and the overall reduction of water consumption (Devitt and Morris, 2020; Rose, 2022; McKeown, 2023).

The methodologies associated with these soil enhancements and irrigation practices are well-established, having been in use for at least half a century. Their continued relevance is evident; however, there remains a necessity for broader adoption of these time-tested techniques. For instance, while professional gardeners and landscapers are educated on the benefits of mulch, its application is not yet universally implemented across all gardening practices. Consequently, enhancing education and awareness surrounding these sustainable gardening techniques is essential for their widespread adoption (Pathak et al., 2022; Rose, 2022; McKeown, 2023).

While mulching and soil improvements are indispensable to xeriscaping, the promotion of biodiversity warrants attention. A fundamental principle underlying xeriscape landscaping is the encouragement of rich and diverse ecosystems comprising both plant and animal life. In relation to mulch usage, the primary aim is to retain moisture in the soil and limit weed proliferation. However, by obstructing sunlight from reaching the soil surface, providing a cooling effect, and maintaining consistent soil moisture levels, mulch fosters a naturally diverse environment capable of supporting various insect life, such as ants and beetles, and enhancing soil health through improved microbiological activity (Torres Limache, 2020; Devitt and Morris, 2020; Pathak et al., 2022).

4.4 Incorporating Hardscapes and Rainwater Harvesting

Hardscapes refer to the non-living elements of a landscape, such as walkways, decks, patios, and gazebos. Within the context of xeriscape gardening, the incorporation of hardscaping is encouraged as a means to minimize the size of plant beds while promoting water conservation through efficient irrigation

practices. The installation of drip irrigation lines beneath hardscapes can create a partially subterranean wet area, which serves as both a practical watering source for adjacent plant beds and a small bio-retention area that aids in filtering excess water. Rainwater harvesting constitutes another essential component of xeriscape gardens. This process involves the collection of rainwater from roof gutters via downspouts, which can then be directed into storage containers, dry wells, or rain gardens. The harvested rainwater can subsequently be utilized for irrigating the garden, thereby reducing the need for additional water inputs over extended periods. A variety of rain barrel systems are now available, featuring barrels equipped with spigots and overflow outlets that can be connected directly to downspouts, effectively transforming a segment of the downspout into a rudimentary rainwater collection system. Additionally, rain barrels can be linked in series, and a first flush system can be integrated into the design to divert the initial, often contaminated, portion of rainwater away from the storage tank (Morera et al., 2020; Ruíz-Pérez et al., 2020; Loehrlein, 2020; Stacy et al., 2021; Yue et al., 2022; Ismaeil and Sobaih, 2022).

The stored rainwater can also be employed for various non-potable daily activities, such as washing clothes, flushing toilets, and cleaning vehicles. Although the implementation of rainwater harvesting may not be feasible or cost-effective in certain regions, the environmentally friendly benefits of this practice can provide compelling incentives for future adoption and broader implementation of such technologies. With the growing popularity of rainwater harvesting, governmental agencies and municipal authorities across the country are introducing various rebate programs, which may include financial incentives or coupon rewards for the installation of rain barrels and other water-saving devices in residential settings. Furthermore, many local water utilities offer free workshops that teach residents how to construct and maintain rain barrels, as well as how to effectively utilize harvested rainwater for irrigation purposes. Therefore, it is advisable for individuals interested in promoting water conservation through xeriscape gardening to inquire with local authorities or city hall for more information regarding available programs and workshops (Ruíz-Pérez et al., 2020; Loehrlein, 2020; Yue et al., 2022).

5. Conclusion

A prevalent challenge in advocating for xeriscaping lies in the concern that a water-efficient landscape may lack the aesthetic appeal of traditional landscapes. However, it is essential to recognize that beauty in landscaping is

subjective, and there exists no singular definition of an attractive landscape. A xeriscape can be designed to be as visually appealing and enjoyable as any traditional landscape. It can incorporate various styles, including formal, contemporary, cottage, or oriental designs, and it can integrate familiar landscape elements regardless of their uniqueness. This method provides an opportunity for creativity and experimentation with innovative landscape design, utilizing accent and structural plants, art, hardscape materials, turf, and ground covers.

By employing a diverse selection of trees, shrubs, flowers, and decorative grasses, xeriscaping can result in vibrant and varied environments. In recent years, increased educational efforts have highlighted the aesthetic and practical benefits of xeriscaping. Demonstration xeriscape gardens have been established across various regions in the United States, allowing the public to experience the beauty of xeriscaping firsthand and learn about its principles. These gardens, often maintained by Master Gardener volunteers, serve to dispel myths surrounding xeriscaping and showcase its appeal, helping the public to appreciate it as a legitimate form of art.

In tandem with aesthetic appreciation, public awareness of the importance of water conservation has grown, along with recognition of the benefits associated with xeriscaping, such as water savings, reduced maintenance time, and minimized chemical use. This growing understanding can foster public interest in xeriscaping and bolster the efforts of professionals advocating for its principles. Educational initiatives conducted by landscape professionals—through seminars, workshops, and classes—can further promote xeriscaping and encourage its adoption.

As individuals begin to comprehend that xeriscaping does not necessitate a choice between lush landscapes and barren rock formations, they are likely to recognize the water conservation benefits of xeriscaping while still achieving a tidy and attractive landscape. Sharing successful experiences in the installation and maintenance of xeriscapes, along with creating incentive programs at the local level to acknowledge the advantages of xeriscaping, can also contribute to its acceptance as an art form in everyday life. Moreover, continued encouragement of research and experimentation with new irrigation techniques and plant technologies should be integrated into these incentive programs, thereby enhancing xeriscaping as a sustainable landscaping approach. Collectively, the implementation of these strategies is anticipated to elevate the attractiveness and acceptance of xeriscaping, ultimately contributing to the reduction of excessive water usage in landscape practices.

References

AghaKouchak, A., Chiang, F., Huning, L.S., Love, C.A., Mallakpour, I., Mazdiyasni, O., Sadegh, M. (2020). Climate extremes and compound hazards in a warming world. *Annual Review of Earth and Planetary Sciences*, 48: 519-548.

Albert, J.S., Destouni, G., Duke-Sylvester, S.M., Magurran, A. E., Oberdorff, T., Reis, R. E., Ripple, W. J. (2021). Scientists' warning to humanity on the freshwater biodiversity crisis. *Ambio,* 50 (1): 85-94.

Alimonti, G., Mariani, L., Prodi, F., and Ricci, R. A. (2022). A critical assessment of extreme events trends in times of global warming. *The European Physical Journal Plus*, 137 (1): 1-20.

Aybey, R. (2024). Bursa İli Nilüfer İlçesinde Yer Alan Bazı Parkların Kurakçıl Peyzaj Tasarımı İlkeleri Bakımından Değerlendirilmesi. Bursa Uludağ Üniversitesi Fen Bilimleri Enstitüsü Peyzaj Mimarlığı Anabilim Dalı, Yüksek Lisans Tezi, Bursa, Türkiye.

Balogh, J. C., Watson, J. R. (2020). Role and conservation of water resources. In book: Golf Course Management and Construction. ISBN: 9781003070092. pp.55 – 66.

Besser, H., Dhaouadi, L., Hadji, R., Hamed, Y., Jemmali, H. (2021). Ecologic and economic perspectives for sustainable irrigated agriculture under arid climate conditions: An analysis based on environmental indicators for southern Tunisia. *Journal of African Earth Sciences*, 177: 104134.

Bigurra-Alzati, C. A., Ortiz-Gómez, R., Vázquez-Rodríguez, G. A., López-León, L.D., Lizárraga-Mendiola, L. (2020). Water conservation and green infrastructure adaptations to reduce water scarcity for residential areas with semi-arid climate: Mineral de la reforma, Mexico. *Water,* 13 (1): 45.

Blanchard, D. (2023). Application of the Simplified Landscape Irrigation Design Estimation (Slide) Rule for Outdoor Water Conservation for the Industrial, Commercial, and Institutional (Ici) Sector. doi: 10.20944/preprints202307.1721.v1.

Boutheina, D., Amel, M., Sami, K., Fatma, B.S., Bassem, M. (2022). Agricultural water management practices in mena region facing climatic challenges and water scarcity. *Water Conservation and Management (WCM),* 6 (1): 39-44.

Brás, T. A., Seixas, J., Carvalhais, N., Jägermeyr, J. (2021). Severity of drought and heatwave crop losses tripled over the last five decades in Europe. *Environmental Research Letters*, 16 (6): 065012.

Brelsford, C., Abbott, J.K. (2021). How smart are water smart landscapes? *Journal of Environmental Economics and Management,* 106: 102402.

Calleja-Cabrera, J., Boter, M., Oñate-Sánchez, L., Pernas, M. (2020). Root growth adaptation to climate change in crops. *Frontiers in Plant Science,* 11: 544.

Chesnutt, T.W. (2020). Statistical estimates of water savings from landscape transformation programs. *AWWA Water Science,* 2 (1): e1167.

Clem, T.B., Hansen, G.M., Dukes, M.AlbertAD., Momol, E., Kruse, J., Harchick, C., Bossart, J. (2021). Sustainable residential landscapes in Florida: Controlled comparison of traditional versus Florida-friendly landscaping. *Journal of Irrigation and Drainage Engineering,* 147 (7): 04021025.

Clements, J. (2021). Conserving Water Through Modular Planting Design: Water-Wise Templates for Ogden's Residential Front Yard Landscapes. Graduate Studies in Utah State University. Website: https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=2577andcontext=gradreports. Accessed: 15.10.2024.

Dantas, B. F., Moura, M. S., Pelacani, C. R., Angelotti, F., Taura, T. A., Oliveira, G. M., Seal, C. E. (2020). Rainfall, not soil temperature, will limit the seed germination of dry forest species with climate change. *Oecologia,* 192 (2): 529-541.

Devitt, D. A., Morris, R. L. (2020). Selecting and Maintaining Trees for Urban Desert Landscapes: A Mojave Desert Water Conservation Perspective. iUniverse Press, ISBN: 978-1-5320-8917-6.

Drewry, J.J., Hedley, C., Sharp, J., Thomas, S., Wallace, D., El-Naggar, A., Roudier, P., Ekanayake, J., Clothier, (2022). Improving irrigation efficiency using soil water management and proximal soil sensing. In: Adaptive Strategies for Future Farming. (Eds. C.L. Christensen, D.J. Horne and R. Singh). http://flrc.massey.ac.nz/publications.html. Occasional Report No. 34. Farmed Landscapes Research Centre, Massey University, Palmerston North, New Zealand. 9 pages

Ender Altay, E., Pirselimoğlu Batman, Z. (2019). Açık ve Yeşil Alanların Çok Ölçütlü Algı Değerlendirmesi. *Bartın Orman Fakültesi Dergisi*, 21 (3): 655 – 664.

Ender Altay, E., Zencirkıran, M. (2024). Contributions of native plants to the urban ecosystem: Bursa (Turkey) sample. *TeMA - Journal of Land Use, Mobility and Environment,* (1): 191-204. https://doi.org/10.6093/1970-9870/10267.

Erickson, V.J., Halford, A. (2020). Seed planning, sourcing, and procurement. *Restoration Ecology,* 28 (S3): 219 – 227.

Esperon-Rodriguez, M., Rymer, P. D., Power, S. A., Challis, A., Marchin, R. M., Tjoelker, M. G. (2020). Functional adaptations and trait plasticity of urban trees along a climatic gradient. *Urban Forestry and Urban Greening,* 54: 126771.

Fausey, K. (2022). Community Ecosystem Services Values Support Conservation and Sustainable Landscape Development: Perspectives from Four University of California Campuses. Master Thesis in Virginia Polytechnic Institute and State University, Department of Civil Engineering. Virginia, US.

Ferreira, C. S., Kašanin-Grubin, M., Solomun, M. K., Sushkova, S., Minkina, T., Zhao, W., Kalantari, Z. (2023). Wetlands as nature-based solutions for water management in different environments. *Current Opinion in Environmental Science and Health,* 33: 100476.

Frame, D. J., Rosier, S. M., Noy, I., Harrington, L. J., Carey-Smith, T., Sparrow, S. N., Dean, S. M. (2020). Climate change attribution and the economic costs of extreme weather events: a study on damages from extreme rainfall and drought. *Climatic Change,* 162: 781-797.

Fuentes, T.L. (2021). Homeowner preferences drive lawn care practices and species diversity patterns in new lawn floras. *Journal of Urban Ecology,* 7 (1): 1 – 13.

Green, J. C., Solins, J. P., Brissette, L. E., Benning, T. L., Gould, K., Bell, E. M., Cadenasso, M. L. (2024). Patterns of water-wise residential landscaping in a drought-prone city. *Journal of Urban Ecology*, 10 (1): 1 – 11.

Ignatieva, M., Haase, D., Dushkova, D., Haase, A. (2020). Lawns in cities: from a globalised urban green space phenomenon to sustainable nature-based solutions. *Land*, 9, 73: 1 – 27.

Irl, S.D., Obermeier, A., Beierkuhnlein, C., Steinbauer, M. J. (2020). Climate controls plant life-form patterns on a high-elevation oceanic island. *Journal of Biogeography*, 47 (10): 2261-2273.

Ismaeil, E. M.H., Sobaih, A.E.E. (2022). Assessing xeriscaping as a retrofit sustainable water consumption approach for a desert university campus. *Water*, 14 (11): 1681.

Jiang, R., Li, T., Jia, Z., Dong, Y. (2022). Determining Soil Available Water Capacity and Reasonable Irrigation Volume in Dryland Pasture. *Water,* 14: 2760.

Juraev, F., Karimov, G. (2020). Water saving technique and technology of subsurface irrigation. In IOP Conference Series: *Materials Science and Engineering,* 883 (1): 012095.

Kanda, E.K., Niu, W., Mabhaudhi, T., Senzanje, A. (2020). Moistube irrigation technology: a review. *Agricultural Research,* 9: 139 – 147.

Kumawat, A., Yadav, D., Samadharmam, K., Rashmi, I. (2021). Soil and Water Conservation Measures for Agricultural Sustainability. *IntechOpen*. doi: 10.5772/intechopen.92895

Liu, L., Xu, W., Lu, X., Zhong, B., Guo, Y., Lu, X., Vitousek, P. (2022). Exploring global changes in agricultural ammonia emissions and their contribution to nitrogen deposition since 1980. *Proceedings of the National Academy of Sciences,* 119 (14): e2121998119.

Liu, Y., Chen, B., Wei, W., Shao, L., Li, Z., Jiang, W., Chen, G. (2020). Global water use associated with energy supply, demand and international trade of China. *Applied Energy,* 257: 113992.

Loehrlein, M. (2020). Sustainable landscaping: principles and practices. CRC Press, ISBN: 9780429285974.

Longbottom, B., Gordon, A. (2023). Beyond All Drought: Improving Urban Water Conservation in the West through Integrative Water and Land Use Policy. *Natural Resources Journal,* 63 (1): 88 – 123.

Ma, B., Fan, Q. (2023). Analysis on the importance of water resource recycling effect on urban landscape–waterscape. *Applied Nanoscience.* 13: 3405 – 3414.

Maer, E.D., Pop, A.A., Popa, D. C., Gros, I. C. (2021). Hybrid water collecting and management system using Smart Home Technologies. In 2021 28th International Workshop on Electric Drives: Improving Reliability of Electric Drives (IWED), pp. 1-6.

McKeown, T. M. (2023). Evaluating Form and Function of Groundcovers and their Environmental Impacts in Louisiana Landscapes. Master Thesis in Louisiana State University and Agricultural and Mechanical College, Department of School of Plant, Environmental, and Soil Science. Louisiana, US.

Meilinger, V., Monstadt, J. (2023). Infrastructuring Gardens: The Material Politics of Outdoor Water Conservation in Los Angeles. *Annals of the American Association of Geographers,* 113 (1): 206-224.

Morera, M.C., Monaghan, P.F., Dukes, M.D. (2020). Determinants of landscape irrigation water use in Florida-friendly yards. *Environmental Management*, 65: 19 – 31.

Mujumdar, M., Bhaskar, P., Ramarao, M. V. S., Uppara, U., Goswami, M., Borgaonkar, H., Niyogi, D. (2020). Droughts and floods. Assessment of climate change over the Indian region: a report of the Ministry of Earth Sciences (MoES), Government of India, 117-141.

Null, S. E., Wurtsbaugh, W.A. (2020). Water development, consumptive water uses, and Great Salt Lake. Great Salt Lake biology: A terminal Lake in a

time of change, 1-21. Website: https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=2138andcontext=wats_facpub. Accessed: 14.10.2024.

Pathak, A., Glick, P., Hansen, L. J., Hilberg, L. E., Ritter, J., Stein, B. A. (2022). Incorporating Nature-based Solutions into Community Climate Adaptation Planning. Washington, DC: National Wildlife Federation and EcoAdapt.

Reynaert, E., Nagappa, D., Sigrist, J. A., Morgenroth, E. (2024). Ensuring Microbial Water Quality for On-site Water Reuse: Importance of Online Sensors for Reliable Operation. *Water Research X,* 22: 100215.

Rose, S. (2022). The Regenerative Garden: 80 Practical Projects for Creating a Self-sustaining Garden Ecosystem. Quatro Publishing Group, ISBN: 978-0-7603-7168-8.

Ruíz-Pérez, M. R., Alba-Rodríguez, M. D., Marrero, M. (2020). The water footprint of city naturalisation. Evaluation of the water balance of city gardens. *Ecological Modelling,* 424: 109031.

Schuch, U.K. (2021). Drought and Extreme Heat: Plant Responses and Landscape Maintenance Practices. Website: https://repository.arizona.edu/bitstream/handle/10150/669984/AZ1876-2021.pdf?sequence=1. Accessed: 14.10.2024.

Sikorska, D., Macegoniuk, S., Łaszkiewicz, E., Sikorski, P. (2020). Energy crops in urban parks as a promising alternative to traditional lawns–Perceptions and a cost-benefit analysis. *Urban Forestry and Urban Greening,* 49: 126579.

Stacy, J., Ryan, R.L., Roy, A.H., Milman, A. (2021). Homeowners' willingness to adopt environmentally beneficial landscape practices in an urbanizing watershed. *Cities and the Environment (CATE),* 14 (1): 2.

Tamburino, L., Bravo, G., Clough, Y., Nicholas, K. A. (2020). From population to production: 50 years of scientific literature on how to feed the world. *Global Food Security*, 24: 100346.

Thomson, J.I.H. (2020). Evaluation of Best Practices for Urban Water Conservation and Water-Smart Growth Implementation in Utah. Website: https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=9052andcontext=etd. Accessed: 11.10.2024.

Torres Limache, C. (2020). The Green Area Ratio as a planning tool for sustainable green infrastructure in a highly dense and arid urban environment.: case study Lima, Peru. Master Thesis in Glasgow Caledonian University, Department of Urban Climate and Sustainability.

Vicente, M. J., Martínez-Díaz, E., Martínez-Sánchez, J. J., Franco, J. A., Bañón, S., Conesa, E. (2020). Effect of light, temperature, and salinity and drought stresses on seed germination of Hypericum ericoides, a wild plant with ornamental potential. *Scientia Horticulturae,* 270: 109433.

Visalakshi, M., Muthulakshmi, R., Ganga, M., Ganesh, S. (2023). Xeriscaping–A Doorway To Sustainable Gardening. Emerging *Trends in Agriculture and Allied Sciences*, 2: 101.

Walsh, J. E., Ballinger, T. J., Euskirchen, E. S., Hanna, E., Mård, J., Overland, J. E., Vihma, T. (2020). Extreme weather and climate events in northern areas: A review. *Earth-Science Reviews*, 209: 103324.

Wang, X. (2022). Managing land carrying capacity: Key to achieving sustainable production systems for food security. *Land*, 11 (4): 484.

Warner, L. A. (2021). Who conserves and who approves? Predicting water conservation intentions in urban landscapes with referent groups beyond the traditional 'important others'. *Urban Forestry and Urban Greening*, 60: 127070.

Warner, L. A., Diaz, J. M., Dukes, M. D. (2022). Selecting high-impact landscape irrigation conservation behaviors: Formative research to inform behavior-change efforts. *Social Marketing Quarterly*, 28 (1): 28 – 43.

Warner, L. A., Lamm, A. J., Silvert, C. (2020). Diffusion of water-saving irrigation innovations in Florida's urban residential landscapes. *Urban Forestry and Urban Greening,* 47: 126540.

Yener, D., Seyidoğlu Akdeniz, N., Zencirkıran, M. (2020). Ecological Tolerance and Woody Landscape Plants. In book: Trends in Landscape, Agriculture, Forest and Natural Science. Cambridge Scholars Publishing. ISBN (13): 978-1-5275-4300-3. pp.1 – 21.

Yılmaz, R., Zencirkıran, M. (2021). Kurakçıl Peyzaj Tasarımı ve Parklar İçin Önemi. 11. Uluslararası Bilimsel Araştırmalar Kongresi, Fen ve Mühendislik Bilimleri, 20 – 21 Ağustos 2021, Ankara, Türkiye.

Yue, C., Cui, M., Kong, X., Watkins, E., Barnes, M. (2022). Landscape irrigation and water conservation in urban areas: An analysis of information-based strategies. *HortTechnology,* 32 (2): 213 – 225.

Zahoor, I., Mushtaq, A. (2023). Water pollution from agricultural activities: A critical global review. *International Journal of Chemical and Biochemical Sciences*, 23 (1): 164 – 176.

Zencirkıran, M. (2011). Determination of native woody landscape plants in Bursa and Uludag. *African Journal of Biotechnology* Vol. 8 (21), pp. 5737-5746.

Zhang, X., Khachatryan, H. (2021). Interactive effects of homeowners' environmental concerns and rebate incentives on preferences for low-input residential landscapes. *Urban Forestry and Urban Greening*, 65: 127322.

Zhong, Z.W. (2021). Processes for environmentally friendly and/or cost-effective manufacturing. *Materials and Manufacturing Processes*, 36 (9): 987 – 1009.

Zhou, F., Bo, Y., Ciais, P., Dumas, P., Tang, Q., Wang, X., Wada, Y. (2020). Deceleration of China's human water use and its key drivers. *Proceedings of the national academy of sciences,* 117 (14): 7702-7711.