Water is Life..

Forward

As the fourth most water-impoverished country in the world, Jordan has stood face to face with water shortages for more than two decades. The annual amount of water availability per capita is less than one-third of the international water-poverty line. Global climate change may lead to greater strain on already limited resources. This ongoing water shortage has caused drastic over pumping of groundwater aquifers that has resulted in a major decrease of available water. On the other hand, Jordan's stability, tourism attraction, and the quality of its business and health services make it a prime regional hub for investment. This challenging situation provides a great opportunity for Jordan to efficiently use each drop of its water.

The government of Jordan began taking steps since the late 1980s to improve water management through policies, regulations, institutional reforms, and the use of new technologies. Water-use efficiency programs were launched afterwards to promote water conservation in the agricultural sector which uses more than 60 percent of the national water resources. In early 2000, the Kingdom embarked on a nationwide program to introduce urban water-use efficiency to the public and create a culture of water conservation for all parts of society. This was followed in 2007 by an institutional program that developed a water-demand management policy for the urban and agricultural sectors, and established the institutional model for urban water demand management at the Ministry of Water and Irrigation, the water utilities, and relevant public and private institutions. The program produced a set of water saving standards and a plumbing code for water-use efficiency. It also identified large consumer categories and conducted water audits and surveys to better help users understand their water use and pinpoint potential water-efficiency measures. A menu of best management practices was prepared for each water-use category to make efficient use of supplied water and benefit from water saving. The saved water will be accompanied by savings in energy and wastewater treatment and financial benefits, and will provide additional resources to reduce water shortage. The water-efficiency best management practices are presented in six guides covering the residential, health, and tourism sectors, high rises, office buildings, and landscaping, as well as a guide for communication.

The introduction of this Landscape Water Use Efficiency Guide to the municipal sector will help this sector benefit from the best practices and technologies for water-use efficiency in both existing and new park facilities.

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Introduction

This Landscape Water Use Effciency Guide[1] provides information about the efficient use of water in the design, installation, management, and maintenance in Jordan's urban landscapes, whether new or existing, public or private.

The primary focus of this Guide are recreational parks, street medians, and traffic circles. It also applies to large urban landscapes found at hotels, universities, hospitals, and some residences.

The users of this Guide include the Greater Amman Municipality (GAM), the Aqaba Special Economic Zone Authority (ASEZA), and other large municipalities that manage public landscapes. Water utilities, municipalities, NGOs and other organizations implementing water demand management programs may also benefit from this Guide. Landscape professionals - landscape architects and designers, landscape installers, maintenance staff, and irrigation professionals - will also find major sections of this Guide useful. For example, the Water-efficient Landscape Planning and Design Section, would be of great interest to landscape architects and designers.

[1] The information in this guide needs to be updated periodically

Understanding Landscape Water Use

PART 1

Why Save Water in Municipal Landscapes?

It Saves You Money

Saving water means reducing the cost of irrigating municipal landscaped areas. It can also reduce the energy and labor bill of pumping, transporting, and securing water for parks and open spaces.

It Helps You Gain National and International Recognition

Saving water can also put a municipality in a good position to compete for national awards such as the King Abdullah II Center for Excellence Award, where water efficiency is a key sub-criterion. It also prepares a municipality to be eligible for national and international green-building certifications.

Saving Water is a Noble National Cause

Water scarcity is a national concern in Jordan. Most irrigation water used in municipal landscapes comes from non-renewable sources such as groundwater. Water saving contributes to sustainable water use, a national responsibility of all public and private institutions and all citizens.

A Snapshot of Parks and Municipal Landscapes in Jordan

Public parks and green open spaces are becoming more important in Jordan's large urban centers as the population increases and cities become denser. The local governments of Amman and Aqaba have made the creation of public open spaces and street landscaping municipal priorities, and have developed new parks, plazas, and street and sidewalk plantings on a yearly basis. We are now seeing the development of public parks on larger scales and with complex programs. This increase in the number and scale of open spaces is inevitably increasing water consumption.

Although there are no specific studies on the amounts of water consumed by public parks, there are visible bad practices that result in considerable waste of this valuable resource. The use of unsuitable plants, tanker-hose watering, and visually appealing but water-consuming lawns are among the common bad practices.

The irrigation need of one square meter of lawn is 4.6 times more than that of a drought-tolerant groundcover for the same area. Water-consuming trees need three-times more water than drought-tolerant trees. The table below shows a comparison of water needs of drought-tolerant and water-consuming landscape plants and materials.

Trees & Shrubs	Water Requirements (L / Tree / 6-month dry season)
Non-drought-tolerant trees	1,200
Drought-tolerant trees	360
Native trees	0
Non-drought-tolerant shrubs	960
Drought-tolerant shrubs	540

Groundcovers	Water Requirements (L / m^2 / 6-month dry season)
Lawn or Dichondra	1,680
Non drought-tolerant groundcovers	1,080
Drought-tolerant groundcovers	360
Gravels and crushed ornamental stone	0
Artificial lawn	0

Figure 1: Water requirements of trees, shrubs, and groundcovers.

It is clear that that applying water-efficient best management practices can significantly reduce the water consumption of municipal parks and landscapes.

Best Management Practices

PART 2

Best Management Practices for New Landscapes: Designing, Installing, Managing and Maintaining Water-efficient Landscapes

Water-efficient landscape design, installation, management, and maintenance can effectively reduce water demand. In accordance with the practices outlined in this Guide, the municipality will develop and implement a water-efficient landscape program. The program will apply the principles of Xeriscape (derived from the Greek xeros, "dry," the term means literally "dry landscape") in the design of new landscapes, and also include the development of a maintenance and irrigation plan for each new landscape. In addition, the municipality will retrofit existing large landscapes that do not conform to the principles of Xeriscape as described in the following section.

While implementing this program, the municipality should also offer training for landscape design, maintenance, and irrigation management or co-sponsor training with qualified horticulture or park management programs. If training is not available in house, the municipality should send trainees to courses offered at institutions such as the Agricultural Engineering Association's Training Center in Amman, which offers an introductory course in water-efficient landscape design.

Water-efficient Landscape Planning and Design

Proper planning during the design phase of any landscape project can significantly reduce water use. A comprehensive site analysis should be conducted prior to the commencement of design:

- Start with a plan of the property that shows the location of surrounding buildings, roads, and existing features of the site.

- Identify the characteristics of the site such as orientation, desirable views, drainage patterns, topography, soil type, sun and shade patterns, and wind direction.

Water-efficient landscapes take advantage of existing micro-climates and create favorable ones to maximize the benefits of sun and shade exposures, topography, and wind protection. Creating the optimum environment for water conservation is based on a thorough site analysis. To begin, identify sunny and shady areas on the site. Locate areas that will be

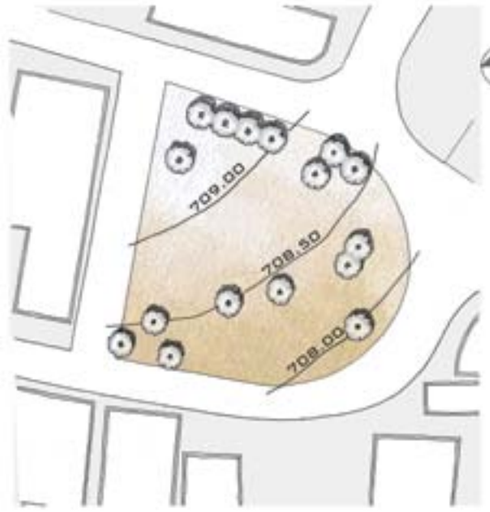


Figure 2: A site plan showing topography and existing features.

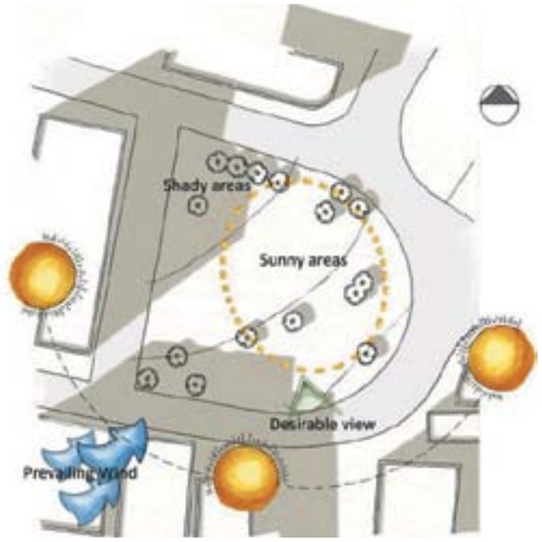


Figure 3: A site plan showing site characteristics (views, wind, sun and shade patterns, etc.).

affected by drying summer winds or cold winter winds. Windy exposures in summer will significantly dry out the soil and increase the need for irrigation. The need to create protection by adding a wall or windbreak will become apparent after conducting the analysis. Topography also plays a role in the amount of water a plant requires. Sloped areas may require as much as 50–75 percent more water than flat areas. Lawn areas for example, should not be located on slopes or on areas with a south exposure, where they will receive the most sun.

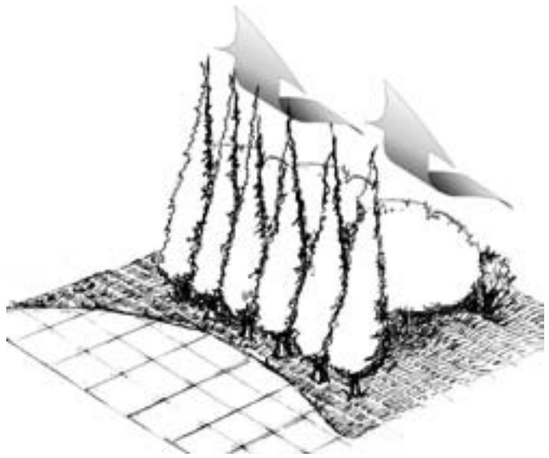


Figure 4: A windbreak creates a favorable microclimate

To begin the design process:

- Define the functions the park or landscaped area will accommodate.
- Indicate the areas of heavy, moderate, and low use, as well as service zones in the landscape.
- Consider the relationship between the different functions such as play fields, gathering areas, children's areas, seating areas, and boundary plantings.
- Establish water-use zones (hydrozones) in the landscape by positioning plants that use similar amounts of water together.
- Develop a master plan of the park, taking into consideration issues such as function, color, and the desired overall effect.
- Fit plants to the design, once you have achieved the overall effect you desire. For principles of plant selection, refer to the Appropriate Plant Section.

Proper zoning of functions according to water use is essential. A minimum amount of water should be allocated for areas with the least amount of use. Hydro-zoning of plants, which means grouping plants with similar water needs together, should also be used as an integral strategy for planting design and plant grouping. Below are tips for identifying and defining water-use zones:

- High water-use zones are small, highly visible, and highly maintained areas in your landscape, such as entrances, public areas, and areas around the main functions in the site. Plants in these zones should create the lushest part of your landscape and may require regular watering in the absence of rainfall.
- Moderate water-use zones blend lush areas with the drier parts of your landscape and require only occasional watering once plants are established. For this zone, use plants that take advantage of rain and any runoff water from structures and do not require constant watering. These can include low-water-use groundcovers and shrubs.
- Low water-use zones are the areas farthest away from the most active parts of your landscape and do not need irrigation once plants are established. Its plants are watered by rainfall. For this zone, use drought-tolerant native vegetation or imported plants from other regions with similar climates.

Figure 5: A site plan showing water-use zones.

Figure 6: A master plan of the garden design, showing plantings according to water-use zones.

Figure 7: In order to increase a garden's water-use efficiency, plants with differing water needs should not be grouped together. For example, it is not recommended to group English Ivy (*Hedera helix*), which requires regular irrigation, next to Agave (*Agave americana*), which requires no irrigation after establishment.

Designs should use appropriate mixes of hard and soft areas to minimize both water consumption and maintenance cost. Consider using hard surfaces or

Figure 8: Planting around a hardscape area.

artificial turf for playing fields and paving materials for gathering areas, pathways, and seating zones. Canopy trees, shading structures, and planted arbors can add variation to hard surfaces while also providing protection from the sun. To break the monotony of paved surfaces, surround them with groupings of shrubs and groundcovers. This will give a green appearance while minimizing the amount of vegetation and water use.

In areas with significant annual rainfall, parks, streetscapes, and other large landscapes should be planned to require a minimal amount of water or no irrigation after three years after its plants are established. Select appropriate drought- tolerant trees and deep- rooting shrubs. (For more information on plant selection and appropriate uses, refer to Appendices 1 and 2).

Following are guidelines for establishing trees:
Trees need supplemental irrigation to get established, especially if planted after the rainy season. During the first year, a tree needs to be irrigated with 25–30 liters of water two times a week. During its second year, it needs to be irrigated with 40 liters once a week. Beginning with the third year, when trees usually get established, some trees, such as pomegranates, require 50–60 liters of water once a month while others need no supplemental irrigation, such as Cypresses. Native trees such as the Carob usually do not need supplemental irrigation, once established. On the other hand, trees with flowers or crops need supplemental irrigation after their establishment to achieve optimal results.

Year	Amount and Frequency
Year One	25–30 liters of water twice per week
Year Two	40 liters of water once per week
Year Three	50-60 liters once per month

Figure 9: Amount of water and frequency of supplemental irrigation for establishing trees in Jordan.

Figure 10: Planting integrated within a hardscape area.

Soil Analysis and Improvement

Soil textures in Jordan range from clay loam mixtures to sandy soils. Proper soil analysis should be conducted and appropriate amendments added prior to planting any landscape. Alkaline soils that are poor in organic materials need to be amended. Also, high acidity in soil means there are fewer nutrients available for the plants. Adding organic matter to soils before planting increases their water- and nutrient-holding capacity and improves plant growth and water use. Soil can be amended by adding 2.5–5 centimeters of compost, peat moss, or sterilized manure and mixing it well into the top 15 centimeters of soil.

Soils differ greatly in their ability to store water. Soils that include a mixture of topsoil and organic fertilizers retain moisture well and also provide plants with their nutritional needs. Note that most agricultural soils in Jordan are clay loam and have a higher water-holding capacity than sandy soils. Adding organic materials to your soil mix will further increase its water-holding capacity.

Compacted soil reduces air and water circulation in the soil. In order for plants to increase their drought tolerance, their roots need to be able to move freely in

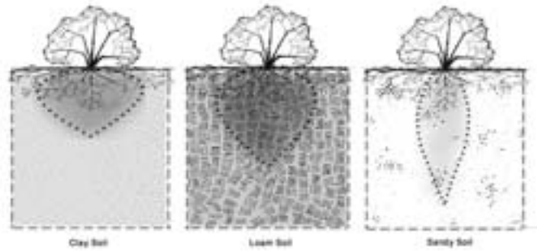


Figure 11: Soil composition determines the soil's ability to absorb and store water.

the soil in search of water. Compacted soil prevents them from doing this.

A soil test can shed light on necessary soil improvements. A typical soil analysis would include texture, infiltration, pH, total soluble salts, sodium, and the percentage of organic matter.

Appropriate Plant Selection

A wide selection of low-water-use plants is available in the market. Only drought-tolerant and native plants should be used, and trees and deep-rooting shrubs should constitute the majority of the plants selected. Less emphasis should be placed on small shrubs, perennials, and groundcovers as they often require irrigation after establishment. Water-consuming annuals should be reserved for special areas and should be excluded from street medians and traffic circles. Moreover, minimizing the amount of planting and including water-conserving groundcovers (such as gravels, stones, and other inert materials), should also be considered.

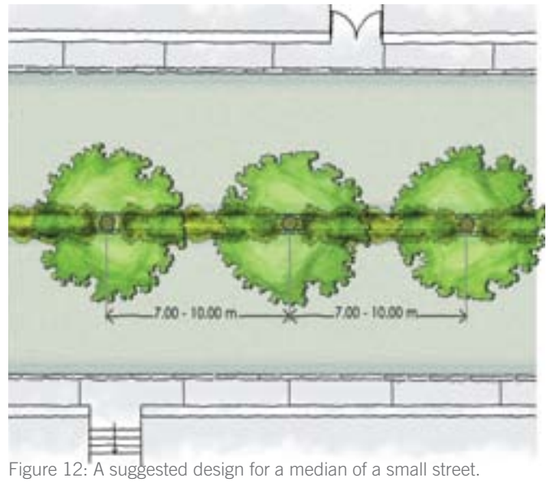


Figure 12: A suggested design for a median of a small street.

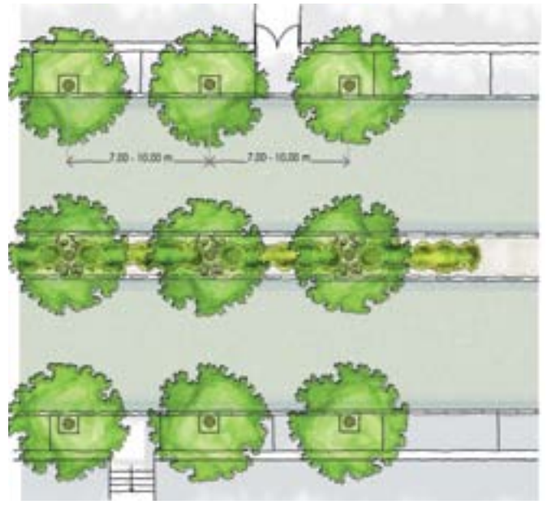


Figure 13: A suggested design for sidewalks and median of a large street.

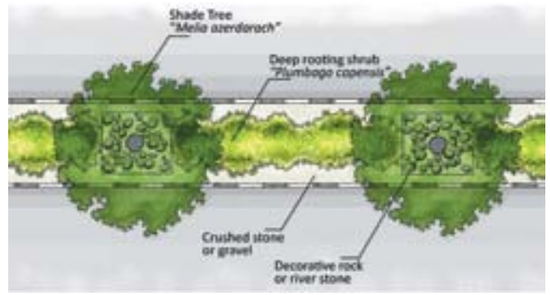


Figure 14: An example of a planting design for a large street median.

Figure 15: A section through a small street.

Figure 16: A section through a large street.

A number of issues need to be considered when selecting plants for water-conserving landscapes. In addition to choosing drought-tolerant plants, select plants compatible with the design of your landscape and well suited to your site and local environment. Choose plants that can tolerate the site's soil type and light levels. For example, although junipers are extremely drought tolerant, they cannot tolerate wet soils or heavy shade.

Figure 17: The combination of drought-tolerant plants such as *Rosmarinus officinalis*, *Gazania sp.*, and *Kalanchoe sp.*, is aesthetically pleasing and provides interesting textures and colors.

For information on the types of plants available in Jordan, see Appendix 2.

Limiting Grass Areas

Grass areas should only be used to provide functional benefits and should be limited in size. The use of grass to provide a green appearance should be prohibited when groundcovers or low shrubs offer an acceptable alternative. One square meter of grass needs approximately 300 liters of water per month during summer, while the same area planted with drought-tolerant groundcovers such as *Lantana montevidensis* requires 120 liters per month. If the same area is planted with cactus or succulents such as *Drosanthemum floribundum,* only 45 liters are required. Thus, there are significant water savings in reducing lawn areas.

Also, the use of drought-tolerant grasses such as Bermuda or Paspalum should be a standard practice in all parks that contain turf. These warm-season grasses need less water than the commonly planted turf mixes such as M5[2]. A Bermuda or Paspalum lawn needs to be irrigated 2-3 times per week while other mixes need to be irrigated daily. Note however, that these grasses are dormant in winter and may appear yellow or brown during the cold season. Nonetheless, parks are seldom used in winter and are subject to less visibility.

Artificial turf should be considered for large athletic fields, traffic circles, and street medians. Several high-quality types are available in the market.

Efficient Irrigation Systems and Rainwater Harvesting

Irrigation systems and rainwater harvesting are essential components of a water-efficient landscape. These components are often overlooked in the design of public parks and street medians. Including efficient irrigation systems and harvesting rainwater for irrigation purposes significantly reduces water consumption.

Efficient Irrigation

All parks and large landscapes should be irrigated using efficient drip irrigation systems. Drip irrigation is one method of providing water to plants in a low volume. Low-volume irrigation includes drip irrigation and other micro-spray systems.

Hose-watering and watering using the hose of transport tankers should be strictly prohibited. Moreover, sprinkler systems should only be used to irrigate turf areas. For large parks and when proper supervision by qualified staff can be guaranteed, automated systems should be considered if cost-effective.

[2] M5 is a commonly used plant mix in Jordan. It includes a combination of Rye Grass and Fescue.

Figure 18: Drip irrigation is the most efficient watering method.

General considerations for creating an effective irrigation system:

- Place plants with similar water requirements close together to irrigate them using the same irrigation line.

- Develop a schedule that trains plants to consume less water and thus increase their overall drought tolerance. This can be achieved by watering at widely spaced intervals, but with deep applications. This encourages root systems to extend deeper into the soil in search of water.

- While trees require generous amounts of water at widely spaced time intervals, plants with shallow root systems, such as groundcovers, should be irrigated with smaller amounts of water at more tightly spaced time intervals. When irrigating, water should reach a soil depth of 50–60 centimeters for trees, 35–40 centimeters for shrubs, and 15 centimeters for groundcovers.

- Irrigate in the early morning, when temperatures are lowest and evaporation is minimized.

- Modify the irrigation schedule as the seasons change and the plants grow. During the rainy season, for instance, irrigation can be decreased considerably, if not stopped altogether. Also, keep in mind that drought-tolerant plants need less water as they mature.

- Apply water slowly on slopes to allow better penetration. Do not apply water faster than the soil's ability to absorb it.

- Consider the use of moisture-retaining materials to minimize the need for irrigation. These can be placed either on top of the soil or mixed in it. One such material is pumice stone.

Conducting a landscape site inspection and a landscape water audit will provide useful information to the landscape manager. The following are a sample landscape site inspection checklist and a sample landscape water audit form.

Site Name: _____ Date: _____
Auditor: _____

Automated Sprinkler Irrigation System	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Irrigation heads						
Broken						
Clogged						
Tilted						
Sunken						
Mismatched						
Missing						
Obstructed						
Ponding						
Overspray						
Runoff						
Misting due to high pressure						
Reduced coverage due to low pressure						
Low head drainage						
Broken or leaking pipes, valves, seals or fittings						

Drip Irrigation System	1	2	3	4	5	6
Pinched or broken tubing						
Missing, clogged, or malfunctioning emitters						
Emitters too close to plant						
Pressure too high or too low						

Hose Watering	1	2	3	4	5	6
Leaks in hose						
Leak at hose bib						
No shut-off nozzle						

Figure 19: A Sample landscape site water inspection checklist.

Description: Trees and Shurbs	Number	Water Needs / Plant (Liter)	Watering Frequency / Month	Total Water Needs/Plant/ Month	Water Applied (Liter/Month)	Over/Under Irrigation (Liter/Month)
Newly planted trees (drought-tolerant and non-drought-tolerant (less than 3 years old))	20	30	8	4,800	5,000	200
Established trees (non-drought-tolerant (more than 3 years old))	40	50	4	8,000	7,000	(1,000)
Established drought-tolerant trees	60	60	1	3,600	5,000	1,400
Newly planted shrubs (drought-tolerant and non-drought-tolerant (less than 2 years old))	80	20	8	12,800	14,000	1,200
Established shrubs (non-drought-tolerant (more than 2 years old))	100	20	8	16,000	20,000	4,000
Established drought-tolerant shrubs (more than 2 years old)	120	30	3	10,800	9,000	(1,800)

Description: Lawns and Grondcovers	Area (m^2)	Water Needs (Liter/m^2)	Watering Frequency / Month	Total Water Needs/Plant/ Month	Water Applied (Liter/Month)	Over/Under Irrigation (Liter/Month)
Lawn or Dichondra	150	10	30	45,000	80,000	35,000
Non-drought-tolerant groundcover (established)	500	15	10	75,000	100,000	25,000
Drought-tolerant groundcover (established)	1,000	15	4	60,000	50,000	(10,000)
Drought-tolerant succulent groundcover (established)	500	15	3	22,500	40,000	17,500

	Total Water Needs/Plant/ Month	Water Applied (Liter/Month)	Over/Under Irrigation (Liter/Month)
Total	258,500	330,000	71,500

Figure 20: A sample water audit form : A comparison of landscape water needs to applied water.

Rainwater Harvesting

All landscapes more than 5,000 square meters, in areas where rainfall is above 250 millimeters, should be equipped with rain-water harvesting systems. All run-off water from roof surfaces, pathways, and plazas should be directed to the collection system.

Historically, rainwater harvesting was used in Jordan to provide water that is suitable for various domestic and irrigation uses. A number of distinctive historical examples that incorporate effective water harvesting systems survive in the country. These include the cut-stone reservoirs of the Nabatean city of Petra, as well as the underground cisterns found in the country's Umayyad desert palaces, Crusader period castles, and traditional village houses.

Figure 21: A historical example of water harvesting at the Amman Citadel. Water collected from the roof is directed through channels toward water storage areas.

There are two types of water harvesting systems: passive and active. Passive water harvesting systems require no storage containers, and rainwater can be diverted from roof areas or paved surfaces in the garden directly to the soil (called "landscape holding" areas) in the site for direct use by the plants. Below are tips for optimizing passive water harvesting systems:

- Make sure that the soil in the landscape holding areas is not compacted, because this inhibits water from moving through the soil. After planting, apply a layer of mulch to reduce evaporation and to control erosion. If the soil is compacted, loosen it by tilling. If the soil is too sandy, add organic matter to increase the soil's moisture-holding potential.
- Be careful in the selection of plants for the low-lying landscape-holding areas. These areas can get saturated with water for extended periods of time, and some plants may not be able to survive such conditions.
- For new plantings, locate the plants at the upper edge of concave holding areas to encourage extensive rooting and to prevent soil erosion.
- To take advantage of water falling freely from roofs, plant large sturdy plants where the water falls. Also, use rocks or other hard material or hang a large "rain chain" from the downspout to the ground to disperse and slow down the water, and also to prevent erosion.

Active water harvesting systems require storage containers, either above or underground. While underground reservoirs are more aesthetically pleasing, they are more expensive than above-ground containers. A cost analysis should be conducted during the design phase, to determine the feasibility of building an underground reservoir. Below are tips for optimizing active water-harvesting systems:

- Place water storage containers as close as possible to collection points and usage areas and far away from contamination sources, such as septic tanks and sewage networks.
- When collecting water from a high-level catchment area such as a roof, place containers at an elevated level to take advantage of gravity flow. This will put less stress on pumps and will conserve electricity.
- Connect the water storage containers to the municipal water supply and make them accessible to water trucks to be able to replenish them if the amounts of harvested rainwater become scarce during the dry season.
- Seal the water container to keep out organic materials and sunlight. This will prevent evaporation and bacterial growth.
- Provide the inlet for the water tank with a filtering device (which could simply consist of a window screen) to keep leaves and debris out of the tank. The level of filtration depends on the irrigation system used. For example, drip irrigation requires finer filtering compared to irrigation with a hose.
- Divert the first part of the rainfall away from the storage area to wash away the dust and debris that collects on the catchment area during the dry period. This will prevent dust and debris from accumulating in the storage containers.
- In some cases, it is more useful to locate several smaller water containers where water is required. These might be easier to handle and to hide, but they will increase installation costs.

To calculate the amount of water that could be harvested, apply the formula below:

Quantity of harvested rainwater (cubic meters) = Rainfall (meters) x Catchment Area (square meters) x Runoff Coefficient[3]

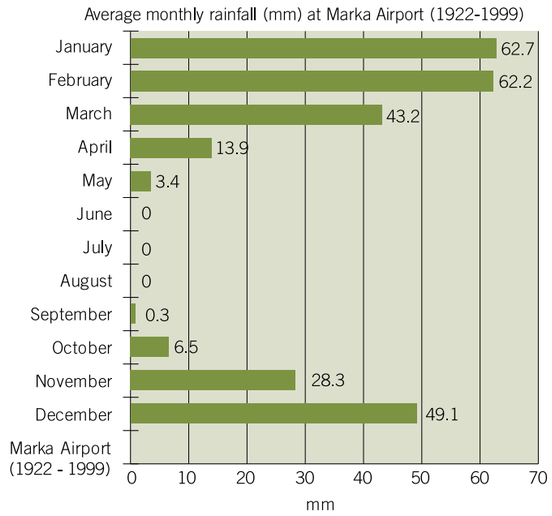


Figure 22: Monthly mean precipitation charts are available at the Jordan Meteorological Department, Amman.

Figure 23: An active rainwater harvesting system.

[3] The runoff coefficient is the percentage of the rainfall that can be harvested from a specific material. It varies from 0.95 - 0.90 for asphalt and smooth concrete to 0.10 - 0.05 for flat, sandy soil.

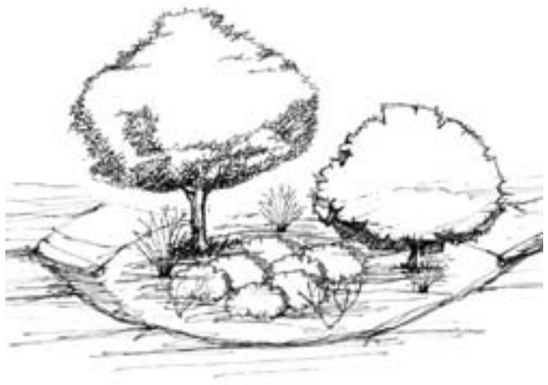


Figure 24: Landscape holding areas may be concave depressions that hold rainwater passing through the site, thus allowing plants to better benefit from that rainwater.

Figure 25: Paved areas directed to catch rainwater via a small collection channel.

Water Quality

Only low-quality, non-potable water should be used to irrigate landscapes. The use of reclaimed, reused, or recycled water for landscape irrigation offers excellent opportunities for conservation of potable water. When available, reclaimed water should be used to irrigate street medians, traffic circles, and other landscapes that are not in direct contact with users. Where high environmental quality standards can be applied, reclaimed water may be used to irrigate parks. Drip irrigation systems should be used when irrigating with reclaimed water.

Often, you may find sources of water from the interior of buildings on the site that can be reused outdoors. For example, water from a hospital's reject water from the reverse osmosis process may be available for landscape irrigation. Graywater, (rinse water from the washing machine) is another good source of water for sub-surface irrigation of trees and shrubs.

Use of Mulches

Mulches are organic or inorganic materials applied to a planting bed as a top-dressing to serve a number of purposes. In addition to serving as an aesthetic element in the landscape, mulches play several important roles in a water-wise garden. These include the following:

- Maintaining moisture levels in the soil
- Moderating soil temperatures
- Inhibiting weed growth, thus reducing competition for water among plants
- Reducing soil erosion, compaction, and water runoff
- Providing a barrier between the plant and the soil, thus successfully controlling soil-borne diseases that might cause plant stress.

Also keep in mind that aside from occasional weed control and top-dressing with additional mulch, unplanted mulched areas require no water and little routine maintenance.

Mulches should be applied at the base of all plants, but should not touch the plants' stems or trunks directly. Inorganic mulches—of stone, rock, and synthetic products—are recommended for public parks and street medians because they require less maintenance than organic mulches. Local materials such as pumice stone are very effective. Mulches should be regularly augmented or replaced for best results. Examples of inorganic mulches include the following:

- Gravel
- Marble chips
- Crushed stone
- Decomposed granite
- River-run rock
- Pumice stone: known locally as tuff stone. It retains moisture well because of its highly porous structure

Figure 26: Pumice stone mulch applied at the base of plants.

Figure 27: A combination of both organic and inorganic mulches.

Figure 28: Inorganic mulch consisting of river-run rock.

Figure 29: Pumice stone mulch is available in different sizes.

Efficient Installation, Management and Maintenance Practices

The installation, management, and maintenance of water-efficient landscapes is essential to achieving anticipated water savings.

Installing Water-efficient Landscapes

Often, a landscape is not installed exactly as the landscape plan depicts. The following are some things to look for as the landscape is installed.

- The soil is prepared and the site is graded as planned.
- The plants are the ones specified in the plan and are planted where and how designated.
- The irrigation equipment meets the listed specifications.
- The irrigation system, if one is specified, is installed as designated.
- The landscape receives an adequate layer of mulch.

Managing Irrigation in Water-efficient Landscapes

Irrigation scheduling is the main task in terms of management of water-efficient landscapes. Overall, irrigation schedules should insure that the water applied is the minimum amount of water required to maintain plant health. The length of time the irrigation system runs should not result in water run-off from the landscape. Cycling the irrigation event—which means applying a portion of the water needed, waiting an hour for the water to soak in, then applying the rest of the water—helps reduce run-off and water waste.

Maintaining Water-efficient Landscapes

Water-efficient landscapes can reduce the overall water use of a landscape and minimize maintenance efforts. A regular maintenance schedule would include routine inspection, adjustment and repair of the irrigation system and its components, aerating and dethatching turf areas, replenishing mulch, fertilizing, pruning, weeding, and removing obstructions to sprinkler heads.

Maintaining hard surfaces:

Cleaning

Eliminate water-wasting practices such as hosing of hard surfaces for cleaning purposes (brooms or cleaning machines should be considered as an alternative). Using a pail and a hose with a shut-off nozzle is recommended for washing cars or other vehicles.

Park Facilities

Park facilities such as tennis courts, basketball courts, and park buildings should be swept for regular sanitary purposes and only cleaned with the amounts of water needed for human health and safety purposes. Showerheads, faucets, and toilets in park facilities should be equipped or retrofitted with efficient fixtures and devices.

Water Features

Decorative water features at parks including fountains and pools should use recirculation systems. During high temperature seasons, operating procedures should be reduced and covers used to reduce evaporation losses. Water features should be designed with minimal water volumes.

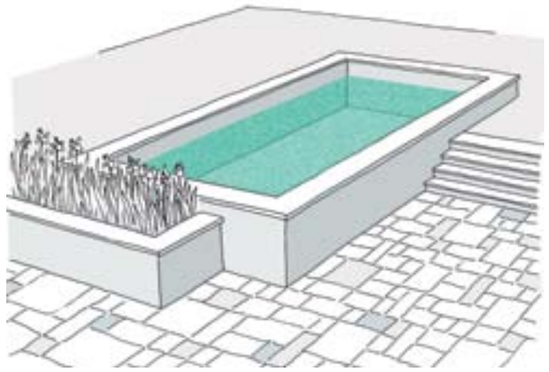


Figure 30: Large water surfaces as well as a lack of shade increase evaporation rates.

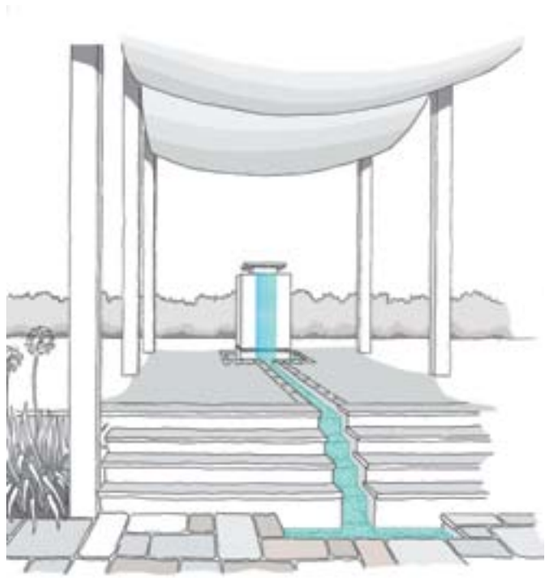


Figure 31: Water features should be designed with minimal water volumes to reduce evaporation. Shading structures further reduce evaporation.

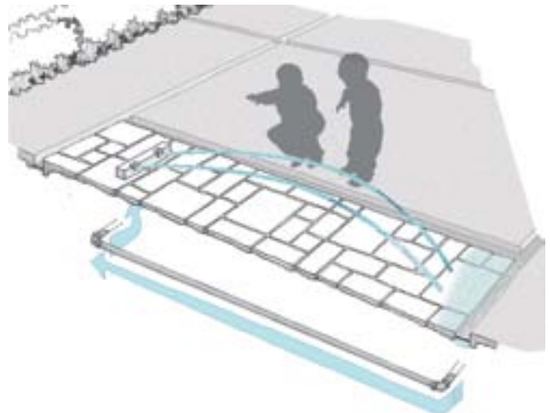


Figure 32: Fountains should use water recirculation systems.

Best Management Practices for Existing Landscapes

Retrofitting of existing landscapes may be more of a challenge. Not all Xeriscape principles may be implemented easily in retrofitting landscapes. Minimum retrofit plans should consider providing efficient irrigation systems for all parks that are irrigated regularly by hose, especially since many parks in Jordan are not equipped with any irrigation systems.

Begin by conducting a water audit to determine overall water consumption of the landscape requiring a retrofit (for more information refer to Appendix 3). If the consumption is high, develop a plan for the items requiring changes. Below are tips to follow when planning a retrofit:

- Identify which plants to keep and which to remove from the existing landscape (see list of recommended plants in Appendix 2).
- Develop a list of plants that may be added.
- Identify changes that need to be made to the existing irrigation system. This may include installing a drip system, providing the existing one with additional valves, replacing the irrigation controller, or replacing the whole system.
- Take advantage of the topographic characteristics of the site to direct rainwater to your plants.
- Considerable savings can be obtained by converting irrigated areas, especially lawn areas, into hardscapes.
- When planning the hardscape areas, make sure to provide an adequate slope to allow for proper drainage.

Note: Many parks in Jordan requiring a retrofit are in bad condition. These parks may not have adequate vegetation and thus may consume less water than they would after retrofitting. In such cases, conduct a water audit of the retrofitted design prior to installation to insure the maximum water savings.

Implementation of Water-efficient Landscape Programs

PART 3

Implementation

Under this Water Use Efficiency Guide, the municipality should develop water-efficient landscape design, installation, maintenance, and management policies and procedures. A water-efficient landscaping policy should be drafted by the municipality and approved by the elected municipal assembly.

A committee of all departments responsible for design, implementation, management, and maintenance of landscapes should be formed to draft the procedures.

The municipality should train personnel in the water-efficient design, maintenance, and management of landscapes. This could be achieved by establishing an in-house training program for employees or in association with a qualified institution.

To insure that all new designs comply with the adopted policy, an internal review committee should be formed to review all designs performed by external architecture and consulting firms.

The municipality should also require its maintenance and park management staff to develop and follow efficient irrigation and maintenance schedules and procedures. Water use should be closely monitored and corrected if over watering occurs, and irrigation equipment should be regularly maintained.

To track water consumption, the municipality should use meters to monitor water use in all landscaped facilities especially large parks. A database for the water consumption of all parks and large landscapes should be established and updated regularly. Water budgets can then be optimized by tracking consumption of new parks needing irrigation during the plant establishment period, and others needing less water once plants are established.

The municipality should perform water audits on existing parks, streetscapes, and other large landscape areas. A retrofitting program should be planned to reduce water consumption in high-water-consuming landscapes (for water audit sheets refer to Appendix 3).

Existing parks, streetscapes, and other large landscaped areas should be retrofitted, especially by installing irrigation systems and phasing out of hose and tanker watering.

Schedule

While time frames will differ for each municipality, to accomplish to the best practices outlined in this Guide, the municipality should do the following:

- Develop and approve policies and procedures within six months of adopting this Guide.
- Train personnel within 12 months of approval of policies and procedures.
- Perform water audits on existing landscapes, prioritizing large parks with high water consumption within 12 months of adopting this Guide.
- Retrofit 50 percent of eligible parks no later than three to five years after adopting the Guide.
- Retrofit up to 75 percent of eligible parks no later than six to nine years after the adoption of the Guide.

Scope

The municipatity should adopt the procedures and policies for all new landscapes specified in this section.

For retrofitting existing landscapes, the municipality may select items 1 or 2:

1. Retrofit 50 percent of all landscaped eligible areas.
2. Retrofit 75 percent of all landscaped eligible areas.

Documentation

To track the progress of implementation, the municipality should gather and have available the following documentation:

- Written policies and procedures for the water-efficient landscape program.
- Records of all new park design proposals including descriptive notes on adoption of Xeriscape principles and estimated water saving.
- The number of trained design, maintenance, and park management staff.
- Records of water consumption of all park or landscaped areas in a database.
- Water audit information on all existing parks.
- Retrofitting plan and schedule for intended retrofits.
- The number of parks retrofitted and estimated water savings.

Determination of Water Savings

Estimating total water savings may be difficult; however, water savings can be estimated from each water-wasting measure eliminated through the actions taken under this Guide. For the integration of efficient irrigation equipment, the water savings are the difference in water use between the new consumption of efficient systems and the inefficient hose-watering system.

For retrofitted parks, water consumption prior to the completion of the retrofit should be compared to water consumption post-retrofit.

Cost-Effectiveness Considerations

PART 4

Cost-Effictive Considerations

There will be a onetime administrative cost associated with developing policies and procedures and in training of staff. The ongoing administrative and staff cost may decrease as proper and efficient maintenance measures are adopted.

Material costs in building and retrofitting parks should be evaluated on a case-by-case basis. See below an example of cost-effectiveness when mulch is added.

Cost Parameters	With Mulch	Without Mulch
Planted area	1,000 m^2	1,000 m^2
Depth of mulch	8 cm	0
Volume of mulch	80 m^3	0
Installation cost	500 JD	0
Cost of mulch@50JD/m3	4,000 JD	0
Total installation cost	4,500 JD	0
Lifetime of material	Inert mulch material will not decompose. May need to add 5% every year	0
Water & Energy Savings:		
Dry season water use in l/m^2/day. April to September	15 liters	15 liters
Total water use per month	450 m^3	450 m^3
Value of irrigation water at 1 JD/m^3. (Assuming 50% consumption due to mulch)	225 JD	450 JD
- Over a period of 6 months	1,350 JD	2,700 JD
- Over a period of 5 years (Assuming annual irrigation for 6 months in a year)	6,750 JD	13,500 JD
Annual maintenance cost	225 JD	0
- Over a period of 5 years	1,125 JD	0
Total running cost over a period of 5 years	7,875 JD	13,500 JD
Value of savings due to mulch over a 5 year period, after initial cost is recouped	5,625 JD	0

Figure 33: Cost effectiveness of using mulch in the landscape.

Enabling Tools

PART 5

Enabling Tools

There are many tools municipalities can use in developing and implementing water-efficient landscape practices. These include policy, institutional, management, and economic practices that assist municipalities in implementing water-saving measures and programs based on best management practices.

Policy, Codes, and Regulations

Jordan is the first country in the region to develop a comprehensive water demand management policy. This policy has paved the way for the adoption of a new water and sanitation plumbing code, the creation of a master-plumber certification and training program, and the promotion of research and development in water-use efficiency.

Various codes have been developed relevant to the development and maintenance of public parks and municipal landscapes:

- City Beautification Code by the Ministry of Public Works and Housing:
  This code was amended in 2004 to include specific water-efficient landscaping information such as appropriate plant selection, irrigation systems, and appropriate design for public parks and streetscapes.

- City of Amman Zoning By-Law 2009 (in draft form as of July 2010):
  This by-law contains a section on landscaping and screening provisions taking into account water conservation issues. It also contains a comprehensive plant list for Amman and the highland areas.

Institutional Support

Efficient water use has been instituted at the national level. Below are key entities and programs that can provide support:

- The Water Demand Management Unit (WDMU) at the Ministry of Water and Irrigation was established in 2002 as an entity that promotes water-use efficiency nationwide.

- The Jordan Green Building Council provides courses in green buildings, LEED certification workshops, and other training programs that include water efficiency. For more information visit http://www.jordangbc.org/

- The Center for the Study of the Built Environment (CSBE) provides information on water-efficient landscaping through print and web publications. For more information visit http://www.csbe.org/

References for Additional Information

PART 6

References

- Center for the Study of the Built Environment website. http://www.csbe.org
  Site contains information on drought-tolerant plants, Xeriscape principles, and other relevant publications developed by the Center for the Study of the Built Environment, a Jordanian research center.

- College of Agriculture and Life Science at the University of Arizona website. http://ag.arizona.edu/maricopa/garden/ Site contains information on gardening and landscaping in the Arizona Low Desert area.

- Florida Cooperative Extension Service of the Institute of Food and Agricultural Sciences at the University of Florida website. http://edis.ifas.ufl.edu/ Site contains publications on landscaping in drought conditions.

- Texas Horticulture Program at the Texas A&M University website. http://aggie-horticulture.tamu.edu/tamuhort.html Site contains information on horticulture, including papers on landscaping in arid climates.

- North Dakota State University Extension Service website. http://ndsuext.nodak.edu/extpubs/plantsci/landscap/h957w.htm Site contains an article on plant selections as well as ideas for Xeriscaping.

- American Society of Landscape Architects website. http://www.asla.org
  Site contains online sources on landscape architecture, including Landscape Architecture Magazine.

- College of Agricultural and Environmental Sciences at the University of Georgia website. http://pubs.caes.uga.edu/caespubs/pubcd/B1073.htm Site includes a 44-page downloadable guide (in PDF format) on developing water-efficient landscapes.

- Colorado Springs Utilities website. http://www.csu.org/environment/xeriscape/resources/index.html Site includes examples of Xeriscaped demonstration gardens.

- Las Vegas Valley Water District website. http://www.lvspgardens.org/ Site includes examples of desert demonstration gardens.

- Southern Nevada Water Authority website. http://www.snwa.com/ Site includes information on the principles and implementation of Xeriscaping.)

- Water Conservation section of the Southwest Florida Water Management District website. http://www.swfwmd.state.fl.us/ Site includes information on Xeriscaping and links to online reports, guides, and articles on water conservation. It also includes links to web sites on water conservation and low water use landscapes.

- Metropolitan Water District of Southern California's Be Water Wise website, provides water saving tips, a watering index and calculator, video tips, incentive programs for businesses, and links to other water conservation websites: www.bewaterwise.com.

- California Landscape Contractors Association provides a list of licensed landscape contractors, training and certification programs, and water management information. Includes resource links for installing and caring for California-friendly plants. www.clca.org.

- California Urban Water Conservation Council offers a wide array of information and services including a Virtual Home Tour of the Water Saver Home, product news, publications, and technical resources. www.cuwcc.org.

- Irrigation Association supports the irrigation industry in their efforts to pursue water conservation through efficient irrigation. They provide training and certification to irrigation professionals and foster a communication network among irrigation manufacturers, designers, distributors, contractors, educators, and technicians. www.irrigation.org.

- California Department of Water Resources' Office of Water Use Efficiency offers financial and technical assistance to agencies involved in water conservation. They host CIMIS, the California Irrigation Management Information System, a network of 120 automated weather stations to provide evapotranspiration information to help irrigation scheduling. Information about water recycling and desalination is also available through the office. http://www.water.ca.gov/wateruseefficiency/

- Alliance for Water Efficiency provides a weekly Water Efficiency Watch Newsletter, a resources library, a Water Conservation Tracking Tool, and information about pending federal laws and regulations: www.allianceforwaterefficiency.org

- "Landscape Plants for California Gardens" by Bob Perry, Land Design Publishing, 2010, covers evapotranspiration, plant factors, hydrozones, irrigation efficiency, water budgets and estimating landscape water use along with a compendium of 2,100 plants that thrive in California's Mediterranean, desert, and temperate climate zones. Everything except the plant list is available in a free downloadable format from this website. http://landdesignpublishing.com

- Water Conservation Alliance of Southern Arizona (Water CASA) website. http://www.watercasa.org An organization affiliated with the University of Arizona's Water Resources Research Center. Site includes on-line publications and tips relating to water conservation and Xeriscaping, as well as links to relevant web sites.

- Xeriscape Colorado!, Inc. website. http://www.xeriscape.org A non-profit membership group promoting creative approaches to water conserving landscapes. Site includes information on the fundamentals of Xeriscaping, a list of Xeriscape demonstration gardens, and a list of references on Xeriscaping.

Appendices

PART 7

Appendix 1: Plants for Sidewalks and Street Medians

Trees for Sidewalks and Street Medians

Botanical name
Albizia julibrissin
Brachychiton populneus
Cercis siliquastrum
Elaeagnus angustifolia
Grevillea robusta
Melia azerdarach
Parkensonia aculeate
Quercus ilex
Sophora japonica
Robinia psuedoacacia
Ulmus glabra

Shrubs for Sidewalks and Street Medians

Botanical name
Dodonea viscosa
Myrtus communis
Lantana camara
Plumbago capensis
Nerium oleander <Nana>
Rosmarinus officinalis

Appendix 2: Plant Selection Tables

Tree Selection Table

Botanical / Common name	Evergreen	Deciduous	Size (height x width) meters	Fastigate	Columnar	Spreading	Rounded	Pyramidal	Weeping	Picturesque	Palm-like	Edible fruit	Fragrant	Attracts birds	Purple/lilac	Pink	Red	Orange	Yellow	White	Insignificant	None	Flowering months	Slow	Moderate	Fast	Full sun	Partial shad	Shade	No watering once established	Some watering once established
	Group			Form								Special features												Growth rate			Sun exposure			Water usage	
Acacia cyanophylla / Mimosa	x		6x5			x													x				3-4			x	x				
Albizia julibrissin / Silk Tree		x	6x8			x										x							5-6			x	x			x	x
Brachychiton populneus / Bottle Tree	x		10-15x6	x																	x		4-6		x		x			x	
Callistemon viminalis / Bottle-brush	x		5x5						x								x						4-5				x			x	x
Casuarina casuariana / Australian Pine	x		12x7	x																		x	-		x		x			x	
Ceratonia siliqua / Carob	x		8x8				x														x		-		x		x			x	
Cersis siliquastrum / Redbud		x	5x4			x										x							3-4		x		x			x	
Chamaerops humilis / European Fan Palm	x		3x1.5								x										x		-	x			x				x
Cupressus glabra / Smooth Arizona Cypress	x		10x4	x																	x	x	-		x		x				x
Cupressus sempervirens / Italian Cypress	x		10x2		x																x	x	-				x				x
Cycas revoluta / Sago Palm	x		2x1.5								x												-	x			x				x

Botanical / Common name	Group		Size (height x width) meters	Form								Special features			Color of bloom								Flowering months	Growth rate			Sun exposure			Water usage	
	Evergreen	Deciduous		Fastigate	Columnar	Spreading	Rounded	Pyramidal	Weeping	Picturesque	Palm-like	Edible fruit	Fragrant	Attracts birds	Purple/lilac	Pink	Red	Orange	Yellow	White	Insignificant	None		Slow	Moderate	Fast	Full sun	Partial shad	Shade	No watering once established	Some watering once established
Elaeagnus angustifolia / Russian Olive		x	7x6			x							x								x		6-7	x			x	x			x
Ficus carica / Edible Fig		x	6x8							x		x		x							x				x		x			x	
Ficus nitida / Laurel Fig	x		5-10x 5-8				x														x			x			x	x			x
Grevillea robusta / Silk Oak	x		20x6	x														x	x				5-6			x	x	x			x
Lagerstroemia indica / Crape Myrtle		x	5x4			x									x	x							6-8		x		x	x			x
Ligustrum lucidum / Glossy Privet	x		6x4				x												x				6-7			x	x			x	
Melia azedarach / China-Berry		x	10x8			x										x							4-5		x		x			x	
Olea europaea / Olive	x		6x6				x					x								x			3-5		x		x			x	
Parkinsonia aculeata / Jerusalem Thorn		x	6x6			x													x				3-5			x	x			x	
Phoenix dactylifera / Date Palm	x		15x5								x	x									x			x			x	x		x	
Pinus halepensis / Aleppo Pine	x		18x10	x																		x	-		x		x			x	
Pistacia palaestina / Wild Pistachio		x	4-15x 4-10				x														x				x		x			x	
Punica granatum / Pomegranate		x	5x5				x					x					x						5-6		x		x				x

Botanical / Common name	Group		Size (height x width) meters	Form								Special features			Color of bloom								Flowering months	Growth rate			Sun exposure			Water usage	
	Evergreen	Deciduous		Fastigate	Columnar	Spreading	Rounded	Pyramidal	Weeping	Picturesque	Palm-like	Edible fruit	Fragrant	Attracts birds	Purple/lilac	Pink	Red	Orange	Yellow	White	Insignificant	None		Slow	Moderate	Fast	Full sun	Partial shad	Shade	No watering once established	Some watering once established
Quercus calliprinos / Common Oak	x		10x8				x														x			x			x			x	
Schinus molle / Pepper Tree	x		8x8						x										x				6-7			x	x			x	
Sophora japonica / Japanese Pagoda Tree		x	5x5			x														x			6-7		x		x	x		x	
Tamarix aphylla / Tamarisk	x		4x6	x												x							4-6		x		x				x
Ulmus glabra / Scotch Elm		x	15x8			x															x					x	x	x		x	
Washingtonia filifera / Washingtonia	x		15x3								x										x			x			x			x	

Ornamental Plant Selection Table

(Ornamental plants are plants grown for their aesthetic value, and can include shrubs, vines, perennials, and succulents.)

Botanical / Common name	Group		Size (height x width) meters	Texture			Type							Special features			Color of bloom									Flowering months	Growth rate			Sun exposure			Water usage			
	Evergreen	Deciduous		Fine	Medium	Coarse	Tree	Shrub	Vine	Succulent	Ornamental grass	Annual	Perennial	Edible fruit	Fragrant	Attracts butterflies	Blue	Violet/lilac	Pink	Red	Orange	Yellow	White	Insignificant	None		Slow	Moderate	Fast	Full sun	Partial shade	Shade	No watering	Once a month	Twice a month	Once a week
Aeonium arboreum / Schwarzkopf	x		0.6x0.4			x				x												x				11-1		x		x	x			x		
Agapanthus orientalis / Lily of the Nile	x		0.5x0.4		x								x				x						x			6-8			x	x	x					x
Agave palmeri / Foxtail Agave	x		1.5x1			x				x												x				6-7	x			x	x		x			
Alcea rosea / Hollyhock		x	1-2x 4			x							x						x							5-9			x	x						x
Aloe nobilis / Golden-tooth Aloe	x		0.3x0.4			x				x											x					4-5		x		x	x		x			
Argyranthemum frutescens/ Marguerite			1x1	x				x															x			5-10			x	x						x
Artemisia arborescens / Faith Raven	x		1x 0.5	x				x														x				5-6			x	x				x		
Berberis thunbergii / Japanese Barberry		x	1x1		x			x														x		x		4-5		x		x	x			x		
B*ougainvillea sp.* / Bougainvillea	x		6x 2-3		x				x									x	x		x	x	x			5-10		x		x						x
Buddleia davidii / Butterfly Bush		x	1-2x1.5		x			x								x		x	x				x			5-10			x	x						x
Campsis radicans / Trumpet Vine		x	10x2		x			x	x												x					6-8			x	x						x
Canna indica / Indian-shot	x		1.5x0.4			x							x							x	x	x				5-10			x	x						x
Carissa macrocarpa / Natal Plum	x		1x1		x			x															x			3-11			x	x	x			x		
Coreopsis auriculata / Coreopsis	x		0.3x0.3	x									x									X				4-10			x	x						x
Drosanthemum floribundum Rosea Ice Plant	x		0.1x0.4	x						x									x							3-4			x	x	x			x		

Botanical / Common name	Group		Size (height x width) meters	Texture			Type							Special features			Color of bloom									Flowering months	Growth rate			Sun exposure			Water usage			
	Evergreen	Deciduous		Fine	Medium	Coarse	Tree	Shrub	Vine	Succulent	Ornamental grass	Annual	Perennial	Edible fruit	Fragrant	Attracts butterfly	Blue	Violet/lilac	Pink	Red	Orange	Yellow	White	Insignificant	None		Slow	Moderate	Fast	Full sun	Partial shade	Shade	No watering	Once a month	Twice a month	Once a week
Echeveria imbricata / Hen and Chickens	x		0.15x 0.25			x				x									x							5-6		x		x	x			x		
Iris sp. / Bearded Iris	x		0.4x0.2			x							x					x								4			x	x	x				x	
Juniperus horizontalis / Juniper	x		1x1.5	x				x																	x	-	x			x					x	
Kalanchoe sp.	x		0.4x0.4			x				x																11-12		x			x	x		x		
Kniphofia uvaria / Torch Lily	x		0.7x0.5			x							x								x	x				4-5			x	x				x		
Lantana camara / Lantana	x		1.5x1.5		x			x								x			x		x	x				5-10			x	x					x	
Lavandula angustifolia / Lavender	x		0.8x0.80	x				x							x			x								5-6		x		x						x
Leonotis leonurus / Lion's Ear		x	0.7x0.7	x				x													x					5-10			x	x	x					x
Myrtus communis / Myrtle	x		2.5x1.5	x				x															x			6-8		x		x	x					x
Nerium oleander 'Nana' / Oleander	x		0.7x0.7		x			x											x				x			6-10		x		x					x	
Pelargonium domesticum / Regal Geranium	x		0.8-0.5			x		x					x						x							5-9			x	x	x				x	
Pennisetum setaceum / Fountain Grass	x		1x 0.7	x																				x		-			x	x	x				x	
Phormium tenax / New Zealand Flax	x		1.5x1			x							x							X						6-7		x		x					x	
Plumbago capensis / Cape Plumbago	x		3x 1.5		x			x	x																				x	x					x	
Rosmarinus officinalis / Rosemary	x		1x 0.7	x				x							x			x								3-5			x	x					x	

Botanical / Common name		Evergreen	Deciduous	Size (height x width) meters	Fine	Medium	Coarse	Tree	Shrub	Vine	Succulent	Ornamental grass	Annual	Perennial	Edible fruit	Fragrant	Attracts butterfly	Blue	Violet/lilac	Pink	Red	Orange	Yellow	White	Insignificant	None	Flowering months	Slow	Moderate	Fast	Full sun	Partial shade	Shade	No watering	Once a month	Twice a month	Once a week
Salvia microphylla / Sage		x		1x 0.7	x				x							x						x					6-9			x	x					x
Santolina chamaecyparissus / Lavender Cotton		x		0.3x0.4	x				x														x				5-6			x	x				x	
Senecio cineraria / Dusty Miller		x		0.7x0.5		x			x					x									x				5-6			x	x					
Tecomaria capensis / Cape Honeysuckle		x		8x 2-3		x			x	x											x						6-9		x		x					
Teucrium fruticans / Bush Germander		x		1x 0.7	x				x										x								5-6		x	x	x					
Yucca Aloifolia / Spanish Bayonet		x		4x 1.5			x		x																		5-6			x	x					

List of Plants that Require Relatively High Amounts of Water

Botanical name	Common name	Type
Abies sp.	Fir	Trees
Abutilon sp.	Flowering Maple	Shrubs
Acer sp.	Maple	Trees
Alnus sp.	Alder	Trees
Araucaria sp.	-	Trees
Bauhinia variegate *	Orchid Tree	Tree
Begonia sp.	Begonia	Perennials
Betula sp.	Birch	Trees
Buxus sp.	Boxwood	Shrubs
Camellia sp.	Camellia	Shrubs
Catalpa sp.	Catalpa	Trees
Chamaecyparis sp.	False Cypress	Trees
Cornus sp.	Dogwood	Shrubs or trees
Cupressocyparis leylandii	Leyland Cypress	Trees
Dahlia sp.	Dahlia	Perennials
Dianthus sp.	Pink	Perennials, biennials, and annuals
Dichondra micrantha	Ponyfoot Dichondra	Ground cover
Digitalis sp.	Foxglove	Perennials or biennials
Fuchsia sp.	-	Shrubs
Gardenia sp.	Gardenia	Shrub
Hebe sp. *	Hebe (Veronica)	Shrubs
Hedera helix	English Ivy	Vine
Helianthus sp.	Sunflower	Annuals and perennials
Hibiscus rosa-sinensis *	Chinese Hibiscus	Shrub
Hydrangea sp.	Hydrangea	Shrubs or vines
Ilex sp.	Holly	Shrubs or trees
Lilium sp.	Lily	Bulbs
Magnolia sp.	Magnolia	Shrubs or trees
Musa sp.	Banana	Perennial (some tree-like in size)
Paeonia sp.	Peony	Perennials or shrubs
Petunia hybrida	Common Garden Petunia	Annual
Populus sp.	Poplar	Trees
Rhododendron sp.	Rhododendron	Shrubs
Rosa sp.	Roses	Shrubs
Salix sp.	Willow	Trees or shrubs
Syringa sp.	Lilac	Shrubs
Thuja orientalis	Oriental Arborvitae	Shrub
Viburnum sp.	Viburnum	Shrubs and small trees
Vinca sp.	Periwinkle	Perennial
Viola sp.	Pansy	Annuals and perennials
Zantedeschia sp.	Calla	Perennial

* These plants will survive on low amounts of water, but require considerable watering to achieve optimal results

Appendix 3: Water Audit Forms

Assessing a Landscape's Water Needs - Checklist

A	**Planting Areas and Numbers:**	
1	What is the total ground cover area?	
2	How many trees?	
3	How many shrubs?	
B	**Average Age of Plantings:**	
1	When were the trees planted?	
2	When were the shrubs planted?	
3	When were the ground covers planted?	
C	**Water Sources and Quantities:**	
1	What is the water storage capacity?	
2	Municipal water availability	
3	Water harvesting	
4	Other water sources (wells, water tankers, etc.)	
D	**Is there an irrigation network, or is it manually irrigated?**	
E	**Types of Plants:**	
1	Drought-tolerant plants	
2	High water-use plants	

Calculating Water Needs of Ground Covers

Description	Area (m^2)	Water needs (liter/m^2)	Watering frequency/ week	Water needs /week	If in the shade (75%)*	If on a slope (125%)*	If in sandy soil (150%)*	Adjusted total water needs (liter/ week)
Lawn or dichondra		10	7					
Non-drought-tolerant groundcover ** (established)		15	3					
Drought-tolerant groundcover*** (established)		15	1					
Drought-tolerant succulent groundcover (established)		15	0.7 (every ten days)					

* If a ground cover is planted in the shade water amounts are reduced by 25%. If planted on a slope, water amounts should be increased by 25%, and if planted in sandy soil, water amounts should be increased by 50%, to compensate for water that is lost to the plants.

** Plants such as *Osteospermum sp.*, *Petunia sp.*, and other annuals

*** Plants such as *Gazania sp.*, *Verbina sp.*, *Lantana montevidensis*, *Santolina chamaecyparissus*

Calculating Water Needs of Trees and Shrubs

Description	Number	Water needs per tree (liter)	Watering frequency /month	Total water needs per tree / month	In the shade (75%)*	On a slope (125%)*	In sandy soil (150%)*	Adjusted total water needs per tree (liter/ month)
Newly planted trees (drought-tolerant and non-drought-tolerant (less than 3 years old))		30	8					
Established trees (non-drought-tolerant (more than 3 years old))		50	4					
Established native trees		-	0					
Established drought-tolerant trees **		60	1					
Newly planted shrubs (drought-tolerant and non-drought-tolerant (less than 2 years old))		20	8					
Established shrubs (non-drought-tolerant (more than 2 years old))		20	8					
Established drought-tolerant shrubs (more than 2 years old) ***		20	3					

* If a tree or shrub is planted in the shade, water amounts are reduced by 25%. If planted on a slope, water amounts should be increased by 25%, and if planted in sandy soil, water amounts should be increased by 50%, to compensate for water that is lost to the plants.

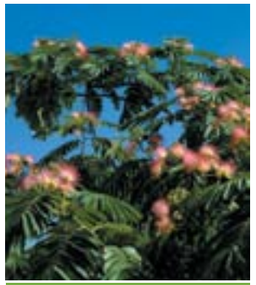
** Some drought-tolerant trees may not need any supplemental irrigation after 3-4 years of establishment (examples: *Melia azerderach*, *Sophora japonica*, *Robinia pseudoacacia*, *Acacia cyanophylla*, *Parkensonia acuelata*, *Zizyphus spina-christi*, *Platanus orientalis*, *Prosopis sp.*, *Brachychiton populneus*, *Casuarina equistifolia*, etc.)

*** Some drought-tolerant shrubs and certain cacti might not need supplemental irrigation after 2 years of establishment (examples: *Nerium oleander*, *Agave americana*, *Lantana camara*, *Dodonea viscose*, *Myoporum laetum*, etc.)

Appendix 4: Illustrated list of Trees and Ornamental Plants

Trees

Acacia cyanophylla



Albizia julibrissin

Brachychiton populneus

Callistemon viminalis

Casuarina equisetifolia

Ceratonia siliqua

Cercis siliquastrum

Chamaerops humilis

Cupressus arizonica

Cupresus sempervirens

Cycas revoluta

Elaeagus angustifolia

Ficus carica

Ficus nitida

Grevillea robusta

Lagestroemia indica

Ligustrum lucidum

Melia azerdarch

Olea europea

Parkinsonia aaaculeata

Phoenix dactylifera

Pinus halepensis

Pistacia palaestina

Punica granatum

Quercus calliprinos

Schinus molle

Sophora japonica

Tamarix aphylla

Ulmus glabra

Washingtonia filifera

Ornamental Plants


Aeonium arboreum


Agapanthus orientalis


Agave americana


Alcea rosea


Aloe nobilis


Argyranthemum frutescens


Artemisia arborescens


Berberis thunbergii


Bougainvillea


Buddleja davidii


Campsis radicans


Canna indica


Carissa macrocarpa


Coreopsis auriculata


Drosanthemum floribundum


Echeveria imbricata


Iris sp.


Juniperus horizontalis


Kalanchoe sp.


Kniphofia uvaria


Lantana camara


Lavandula angustifolia


Leonotis leonurus


Myrtus communis


Nerium oleander 'Nana'


Pelargonium domesticum


Pennisetum setaceum


Phormium tenax


Plumbago capensis


Rosmarinus officilanis


Salvia microphylla


Santolina chamaecyparissus


Senecio cineraria


Tecomaria capensis


Tuecrium fruticans


Yucca aloifolia