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WATER SENSITIVE LANDSCAPE

CASE STUDY: PUBLIC OPEN GREEN SPACES IN NASER CITY, EGYPT

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ABSTRACT

The purpose of this paper is to reveal measures to lower water demand and consumption of public green spaces in arid environments such as Cairo city while maintaining a pleasant appearance. The Water Sensitive Urban Design approach is adopted to formulate a checklist in order to evaluate the extent to which public green spaces in "Naser City" district, participate in preserving water quality and quantity. After analyzing six case studies, the study concluded that the main problems are using high-quality water to irrigate green spaces, and the gardeners' reckless irrigation and maintenance techniques. Short term solutions were proposed, such as utilizing low flow irrigation system, minimizing the lawn areas, integrating water meters, using mulching and incorporating a competent maintenance schedule. Long term solutions mainly focused on replacing potable water with treated wastewater, which is estimated to cover irrigation needs for all green areas in the district.

Keywords: Water sensitive landscape, Water Sensitive Urban Design, Open Green Spaces in Cairo, Urban landscape

INTRODUCTION

One of the greatest challenges that architects and planners face today is controlling operating costs and creating more livable spaces in neighborhoods and cities through sustainable designs. One of the key elements of sustainable design is efficient water management, that simulates the natural hydrological cycle (Barraclough & Lucey, 2010). Since water is one of the most valuable resources on the planet and it is a finite one, it is essential to safeguard our supply. Therefore, Water-Sensitive Urban Design (WSUD) emerges as an approach to manage water in urban areas, first made popular in Australia as a response to water problems. Since then it has been adopted around the world and expanded to include not just stormwater management, but all aspects of the water cycle, including rainwater, snow melts, wastewater (including black water and gray water) and drinking water, in addition to natural freshwater systems (JSCWSC, 2009). In arid regions, such as in Egypt, water-scarcity became an important issue, especially in the last few years due to rapid urbanization and water conflicts. Such water concern forced local authorities to decreases open green spaces, arguing that to maintain a lush, beautiful appearance, green spaces would vastly contribute to the exploitation of scarce water resources. Accordingly, this research highlights the water sensitive landscape approach as one of the WSUD derivatives. An approach, not only considers the efficiency of water use but also stresses the need to preserve water quality. The water sensitive landscape approach seeks to achieve the optimum use of water resources through careful landscape design and planning, utilizing suitable plants, soil, irrigation and maintenance systems (Brown, 2007).

SCARCITY OF WATER IN EGYPT

The population of Egypt is increasing at an alarming rate. The annual rate of population growth was 1.9% between 1996-2006. The total population increased from 22 million in 1950 to around 85 million in 2010 (Ministry of Water Resources and Irrigation, 2014), future projections indicate that the current population of 90 million will elevate to 120-150 million by the year 2025 (Ministry of Water Resources and Irrigation, 2014). One undesirable result of such population augmentation is the stress on the country's water supply for domestic consumption, and increased irrigation water due to higher food demands (Dakkak Amir, 2014). Regarding the availability of water per capita, it has dropped significantly from 2189 m^3/capita/year in 1966 to 1035 m^3 in 1990 and below 1000 m^3 in 2011. It is expected to drop to 536 m^3/capita/year by 2025 signifying causing severe water scarcity (Abdel Wahaat & El-Din Omar, 2011; Abdin & Gaafar, 2009). As for water quality, the data available indicate that rapid deterioration is occurring in surface and groundwater quality. The main water sources in Egypt are confined into the following: (Ministry of Water Resources and Irrigation, 2014).

-The Nile River: It supplies 86.2% of needed water (El Nahrawy, 2011). Unfortunately, agricultural runoffs, industrial effluents, and municipal sewage are being recklessly dumped into the river. Discharges contain pollutants like pesticides, herbicides, and heavy metals (Dakkak, 2014). Moreover, countries along the Nile such as Burundi, and Ethiopia are gaining more control over the rights for the Nile, besides the increased temperatures, higher evaporation rates, and higher water demands. All previous factors are imposing limits on Egypt's national economic development, putting the country in a severe water scarcity situation.

-Rainfall: Its amount cannot be considered a reliable source of water due to high spatial and temporal variability, as it occurs only in winter in the form of scattered showers. The average annual amount of actually utilized rainfall water is estimated to be 1.3 BCM/year.

-Groundwater: The total groundwater volume has been estimated at about 40,000 BCM. However, current abstraction is estimated to be 2.0 BCM/year due to great depths reaching 1500 m in some areas.

-Desalination: Desalinating of sea water in Egypt has been given low priority as a water resource because the cost of treatment is high compared with other sources.

-Treated domestic sewage: It is being reused for irrigation with or without blending with fresh water. It is estimated that the total quantity of reused treated wastewater in Egypt is about 0.3 BCM in 2013.

In summary, the water resources in Egypt are limited, and the primary water source is exposed to pollution. Water management is not efficient, especially regarding irrigation, that mostly relies on excessive watering, increasing the water stress. Therefore, it is obvious that Egypt is in need to find more solutions to deal with water scarcity.

WATER SENSITIVE URBAN DESIGN APPROACH

Water Sensitive Urban Design (WSUD) is the interdisciplinary cooperation of water management, urban design, and landscape planning. It considers all parts of the urban water cycle and combines the functionality of water management with principles of urban design. WSUD develops integrative strategies for ecological, economic, social, and cultural sustainability (Hoyer *et al*., 2011). The motivation behind WSUD is to avoid, or at least minimize, the environmental impacts of urbanization through integrating urban design with natural ecological processes to protect and conserve water (Lloyd, 2001). WSUD embraces a range of measures, to protect natural waterways. It seeks to protect the water quality by using filtration and retention techniques, reduce potable water consumption, maximize water reuse, and reduce wastewater discharge. Moreover, it reduces stormwater runoff by using local detention and retention, minimizes stormwater pollution before it is released to the aquatic environment and maximizes groundwater protection (Hoyer, 2011; JSCWSC, 2009; City of Melbourne, 2011).

Water resources that WSUD manage are: (City of Melbourne, 2011)

- Rainwater
- Stormwater
- Potable drinking water
- Gray water (water from the bathroom sinks, shower, and laundry)
- Blackwater (toilet and kitchen)
- Water mining (sewer)

"Fit for purpose" in a significant principle in WSUD to ensure matching available water sources with the most appropriate uses, by this the demand for the highest quality potable mains water can be reduced. Finding alternative water sources for irrigation and toilet flushing, for example, should be a priority. Bedside targeting water conservation and quality, WSUD is able to benefit the environment in numerous perspectives. It can improve habitat and biodiversity through the establishment of wetlands and other ‘natural’ treatment replacements, and reduce greenhouse gas emissions by reducing water consumption and increasing rainwater harvesting. The urban setting also benefits when pipes are replaced with natural elements for drainage (wetlands), development cost decreases while improving sustainability and amenity of urban areas. Additionally, practicing WSUD would enhance the aesthetics through increased vegetation, aquatic elements, and landscaping by incorporating multiple use corridors that contribute to the visual and recreational amenity of urban areas (City of Melbourne, 2011; Howe *et al.*, 2011; Barraclough & Lucey, 2010).

WATER EFFICIENCY IN THE LANDSCAPE

How much water does it take to grow an attractive and healthy landscape? There really is no “right” answer to this question, as it depends on multitudes of factors. Many people envision that water-saving landscape inevitably looks like a desert, cacti and rocks without the lavish appearance that the customary landscape offers. Water saving landscape dispels that notion by adopting Landscape water conservation: Best Management Practices (BMPs). The primary objective of BMPs in water sensitive landscape would be considering the overall effects of design decisions on the water to reduce and improve water usage, without sacrificing the quality or the beauty of the design (Association and American Society of Irrigation Consultants, 2014). Additionally, the sensitive landscape seeks to preserve the water quality in the urban environment. Sensitive water Landscape integrates plant selection, plant adaptation, irrigation, cultural and management practices, to maintain water quality and minimize water consumption (WaterWise Consulting, 2010).

4.1 Landscape and Water quality

Reducing runoff by planting can significantly reduce water pollution and protect watersheds. Planting can collect and treat the urban runoff, which is generally caused by irrigation, while stormwater runoff is probably caused by natural precipitation (WaterWise Consulting, 2010). Landscape (rain garden) is able to filter storm water and urban runoff carrying pollutants as automotive fluids, emissions, commercial waste, trash, pesticides, and fertilizers before pouring into local watersheds. Mitigating the water enables groundwater to reach lakes or streams cleaner, minimizing health hazards (Van Buren Conservation District, 2014).

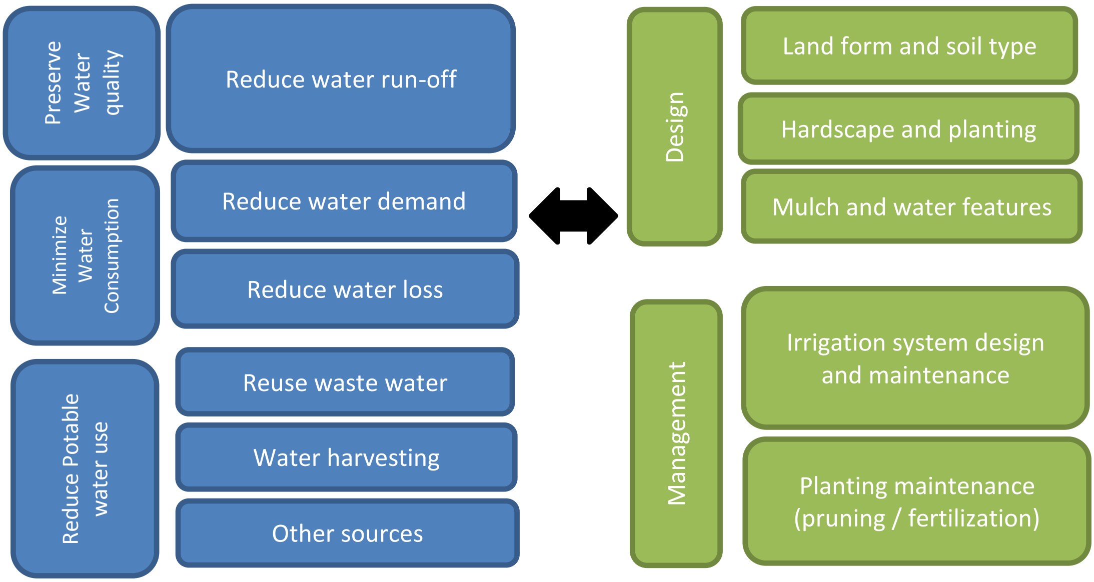
4.2 Landscape and water consumption

By instituting better water management practices in landscapes, the water amount used in irrigation can be greatly reduced. The main goal is reducing potable water and concentrating on the utilization of other water resources as alternatives in the irrigation process. Other additional water resources are: (East Bay Municipal Utility District, 2008; Deister, 2013)**.**

- Treated gray water
- Condensed water gained from air conditioning systems
- Rainwater and stormwater harvested from buildings and hardscape drainage water
- Swimming-pool-filter backwash water
- Cooling-tower blowdown water (if water quality will not harm plants and meets local code)
- Fountain drain water

The water management should strive to provide the right amount of water, in the right place, at the right time (Environmental Protection Agency, 2013). However, it is crucial to identify the differences between water demand and water consumption. Water demand is the specific need of the plant for water. While water consumption comprises water demand, losses due to soil evaporation, losses due to unsealed systems and wasteful irrigation (Deister, 2013)**.** Consequently, a general reduction of water consumption can be achieved, firstly, by reducing the demand, e.g. by using plants consuming less water. As studies have shown that water-conserving landscapes, known as xeriscapes, can save significant water up to 50 percent or more, and reduce maintenance costs up to 30 percent (East Bay Municipal Utility District, 2008). Secondly, lower water demand could be achieved by minimizing lost water, through preparing the soil to reserve water by using, for example, superabsorbent polymers (Zandi *et al*, 2012). Additionally, it is important to calculate the sufficient water amount needed, to avoid over-irrigating, taking into account climate factors, such as wind and ET rates, and using efficient irrigations systems. Furthermore, regular inspection of the irrigation system is crucial, to detect any leakage or broken parts, as to control water loss (Irrigation Association and American Society of Irrigation Consultants, 2014).

Fig. 1: Water sensitive practices diagram Source: Researcher



WATER SENSITIVE URBAN LANDSCAPE DESIGN CRITERIA

Though many researches defined the design principles of Water sensitive landscaping, very few analyzed the impact of each design principle on the smart water management process, in other words, this research targets illustrating the relationship between water sensitive landscape design/management criteria and the water conservation" Best Management Practices" (BMPs). The water sensitive landscaping approach tackles the following: (MWCOG, 2006)

- Grading and land form
- Soil analysis and amendments
- Appropriate plant selection and proper use of turf
- Efficient irrigation techniques considering the local climate
- Use of mulches
- Suitable fertilizers and pesticides
- Regular maintenance of planting and irrigation systems

Table (1) illustrating the relationship between water sensitive landscape design/ management criteria and the water conservation, Best Management Practices.

Table 1: Water Sensitive Landscape design criteria

Source: Researcher after: (Berle *et al.*, 2007; Van Buren Conservation District, 2014; WaterWise Consulting, 2010; MWCOG, 2006; Lloyd, 2001; JSCWSC, 2009; Hoyer *et al.*, 2011; Environmental Protection Agency, 2013; Brown, 2007; Brisbane city council, 2006; Berle *et al*., 2007; Barraclough and Lucey, 2010, Zandi *et al.*, 2012).

	Design and management criteria	**Preserving water quality**	**Less Water demand**	**Less water consumption**	**Reducing potable water**
Land form	Build bio-retention areas/ use vegetated swales/ Infiltration zones and trenches /build detention ponds to control runoff water	✓			
	Restructuring the landscape as a depressed or rain garden to collect rainwater to be used in irrigation				✓
Soil Composition	Use Loam soil as it allows the water to be absorbed in an efficient rate, delivering water to the root zone. Loam is a makeup of three particle components (sand, silt, clay)			✓	
	New landscapes should have at least six inches of soil for healthy plant growth, the deeper the soil profile, the greater the amount of water available to plants, to the depth that plant roots extend.			✓	
Planting Types	Use local native species		✓		
	Create Hydrozones			✓	
	Use plants with low water demands (thrifty water plants)		✓		
	Decrease the ratio of green area to hardscape or artificial greenery		✓		
	Use xeriscape planting		✓		
	Integrate treated wastewater polishing parks to the design to reuse water in irrigation				✓
	Use water-efficient turf species		✓		
	Balance the ratio between lawn and other plants (less lawn)		✓		
	Minimize the use of plant species that are highly susceptible to infection, to reduce pesticides.	✓			
Mulch	Use mulch to: prevent weeds by stopping photosynthesis	✓			
	Use mulch to reduce water demand by 40 to 70 percent as it reduces evaporation			✓	
	When using mulch, apply water with bubblers, soaker hoses, or drip lines beneath the mulch to the plant-root areas. Sprinklers are inefficient methods in mulched areas since mulch materials restrict water flow and absorb significant amounts of water before it can reach the soil			✓	
	Mulching keeps the soil, chemicals, fertilizers, and other pollutants from washing away into storm drains	✓			
	When mulch breaks down, it helps build up the composition of the soil allowing water to move through it with ease			✓	

Hardscape / Water features	Minimize the use of impervious land cover	✓			
	Use porous pavements (gravel pavers and interlocking concrete paver blocks, pervious asphalt, decomposed granite to maximize infiltration and remove pollutants	✓			
	Design water features, e.g., fountains, to store rain water or use recycled treated wastewater				✓
Irrigation System and Operation	Use Reused water from: condensate water from A/C / stormwater and rainwater harvesting / irrigation drainage water/ gray water/ swimming-pool-filter backwash water/ fountain drain water				✓
	Enhance irrigation behavior and knowledge of gardeners	✓		✓	
	Decentralize treatment of waste water to decrease losses during transportation and treatment process			✓	
	Use water budget or/and checklist approaches to control the amount of irrigation water	✓		✓	
	Apply ET irrigation system, determined by solar radiation, temperature, wind, humidity (daily weather data or historical data), plant and soil types	✓		✓	
	Employ drip or low-volume irrigation equipment when possible	✓		✓	
	Use effect irrigation system with “smart controllers, anti-drain check valves matching the precipitation rates with hydrozones in the site	✓		✓	
	Apply multiple short run times of water to steeper slopes and clay soils, while flat ground with sandy soils may allow longer irrigation applications	✓			
	Water at the appropriate time of day (early morning hours before sunrise) to minimize evaporation.			✓	
	Perform regular inspection and maintenance to check the efficiency of the irrigation system(fix broken or malfunctioning sprinklers or any leaky or broken irrigation lines)			✓	
Pesticides, Fertilization and Soil Amendments	Reduce pesticide and fertilizer use during times of rainfall, or during inefficient irrigation practices, as these materials can easily be washed away along with aquatic life and also transport pollutants	✓			
	Adding organic matter can improve the water-holding capacity. Compost, like (compost / wood chips/ peat moss) can improve soil porosity and water infiltration rates, especially in fine-textured or compacted soils			✓	
	Use hydro absorbents (super absorbent polymers,) that form a gel when water is added to retain moisture.			✓	
	Integrate proper implementation of an IPM program (Integrated Pest Management) to reduce the improper use of pesticides that may potentially reach surface or ground water	✓			
	Consider preemptive control measures such as sanitation and avoidance to protect plants from disease.	✓			
	Use natural organic fertilizers such as composts, to reduce the amount of chemicals in the landscape to help adjust to lower levels of fertilizers, plants will grow at a slower manageable rate, and use less water.	✓	✓		

Pruning Plants	Avoid hard pruning as it encourages the plant material to throw out sucker growth and to grow rapidly. The plant material may go through stress requiring more water and nutrients to recover		✓		
	Cut lawn higher to provide additional shade to the grass blades and reduces their water loss. Mow higher in the spring and summer (2 1/2" - 3") and shorter in the fall and winter (1 1/2" - 2")			✓	
	Use mulch mowers designed to cut up grass and leaves into small pieces or bits that can be left on top of the lawn to decompose			✓	

CASE STUDY: OPEN GREEN SPACES IN NASER CITY

Naser City is the largest district in Cairo City, occupying nearly 250 km²;it is located to the east of the Cairo Governorate. The district was established in the 1960s as an extension to Heliopolis neighborhood, it is a crowded district, the population was estimated to be 675,859 in 2015 (Cairo Governorate, 2016). The original plans of the district offer many open green spaces, beginning with small parks distributed between the residential clusters, up to neighborhood parks and a city park. The total area of open spaces in the district is 1,488,605 m^2 (C.C.B.A, 2011). The typology of green spaces in the district can be divided into two main categories. The first group includes fenced parks under the Cairo Governorate authority, with entry fees. They comprise five parks representing 27.2% (405,000 m^2) of the total area of green spaces (out of research scope). The second type of the green spaces is more common; it falls under the authority of C.C.B.A. Those spaces are free to access and use, and they comprise, public parks, roundabouts, and vegetated islands. They represent 72.8% (1,083,605 m^2) of the open green space in the district (C.C.B.A, 2011) and they are the interest scope of the research.

Methods

A survey and semi structured interviews were carried by the researcher to investigate the water consumption pattern of the public spaces in Naser City district. By using satellite images and site visits, three green spaces types are found to fall in the research scope, they are: street islands, roundabouts and parks between residential clusters. Each classification was investigated upon the following criteria:

- Location
- Size
- Level of maintenance
- Planting diversity
- Accommodation of other landscape elements/ hardscape

-Level of maintenance is measured: by a scale 1 to 5 (1 is the least and 5 is the best) and it includes the condition of the turf and trees/ shrubs.

-Planting diversity: by scale 1 to 5 (1 is the least and 5 is the best) and it includes the number of different types of planting available.

-Accommodating other landscape elements: are recorded on the site, including site furniture, hardscape and water features.

It was found that there is a strong correlation between the street location (exposure) and level of maintenance, planting diversity, and accommodating other landscape elements, as main streets experience better maintenance, more diverse planing and different site furniture (Table 2). While in the case of parks the correlation is found between the size of the park and the level of maintenance, and the planting diversity, in other words, larger parks are subject to better maintenance, more diverse planting, at the same time insignificant differences are found in the site equipment/ hardscape availability between large and small parks (Table 3). As for the roundabouts, no substantial differences are noticed between them (all are similar regarding the five criteria mentioned above). Lastly, it could be concluded that the street location and the park size are the dominant variables, affecting the vegetation repertoire and the level of maintenance, consequently influencing the water consumption pattern. The second step was classifying the streets and parks in the area into “main / secondary” or “large / small” (Table 4), afterwards the case studies were selected: one large park, one small park, one roundabout, two islands in a main street (Nasr street) and one island in Abd El Rezak El Sanhouri street (secondary street), (Fig. 2/ Table 5). The restricted number of case studies is one of the research limitation due to limited time and effort.

Table 2: The correlation coefficient of the street rank and maintenance, planting diversity and site furniture (Source: Research)

Maintenance	*Diversity*	*Furniture*	
0.84016805	0.952579344	0.952579344	Street rank

Table 3: The correlation coefficient of the park size and maintenance, planting diversity and site furniture (Source: Researcher)

Maintenance	*Diversity*	*Furniture*	
0.84016805	0.952579344	0.40824829	Park size

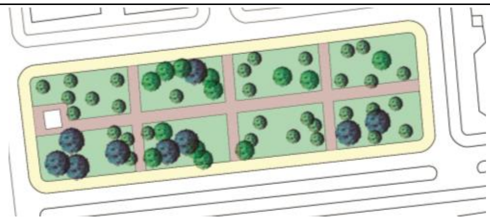
The survey was performed in June 2015 and April 2016, as for the semi- structured interviews, they were conducted to at least one member of the maintenance staff of each green space, on the site at 9 am. An Agricultural Engineer was consulted to identify plants, their habitat and water consumption. The semi-structured interviews comprised questions regarding the soil composition; the irrigation and operation process; pesticide application and pruning practices.

Table 4: Number of different open green spaces in the study area (Source: Researcher)

Large park	Small park	Main Street island	Secondary Street island	Roundabout
11	30	7	8	7

Fig. 2: Case studies' locations in Naser City (Source: Researcher)

Table5: Case studies' properties (Source: Researcher)

Park 1 :Between buildings	 Area: 4,645 m², Main path perpendicular on secondary paths.		
Park 2: Between buildings	 Area: 2,825 m² , Fenced park, with no paths, only plants		

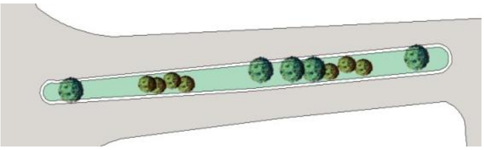
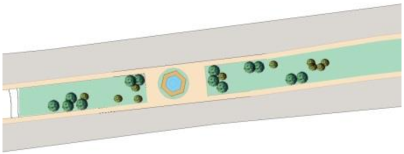
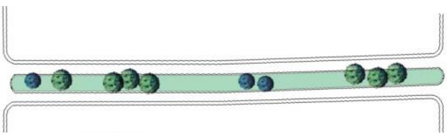
Island 1: Main street	 Area: 1067 m², Nasr street, plants and a sidewalk.		
Island 1A: Main street	 Area: 2947 m², plants, water fountain and a sidewalk		
Roundabout: secondary street	 Area: 45 m², water fountain with plants		
Island 2: Secondary street	 Area: 800m², plants with a sidewalk		

Table 6: Water sensitivity evaluation in case studies (Source: Researcher)

	Water quality and preservation design criteria
Landform	The surface is flat with no depressions to collect rain or runoff water
Soil Composition	The soil is 66% sand and 34% clay
	Soil depth is 30-90 cm
Planting Type	Plants used are not native plants, but well adapted to the local environment
	Plants are not placed based on hydrozones
	Plants found are classified based on their water demand to:

		Parks between buildings		Islands in main streets		Island / roundabout in secondary street
	1	35% low water demand 55% medium water demand 10% high water demand	1	30.7% low water demand 61.6% medium water demand 7.7% high water demand	2	30% low water demand 50% medium water demand 10% high water demand
		The percent of softscape is 79.4%, 20.6% is hardscape		The percent of softscape is 75.5%, 24.5% is hardscape		The percent of softscape is 87.2%, 12.8% is hardscape
	2	63% low water demand 37% medium water demand 0% high water demand	1 A	40% low water demand 55% medium water demand 5% high water demand	roundsbout	40% low water demand 60% medium water demand 0% high water demand
		The percent of softscape is 100%, 0% is hardscape		The percent of softscape is 68%, 32% is hardscape		The percent of softscape is 61%, 39% is hardscape
		Lawn suffers from weed infestation in all case studies, and in the parks from bugs (birds found eating from the lawn)				
		The park does not comprise xeriscape (except for few cactuses), nor treated wastewater polishing parks				
		Plants used are not highly susceptible to infections				
Mulch and hydro absorbents		No mulches or hydro absorbents are used in all the case studies				
Hardscape / Water features		Paths' materials are impervious asphalt or concrete and surrounded with pre cast concrete curbs				
		12-39% of the area is impervious				
		Water fountains in the island and the roundabout use potable water No water features are found in the parks				
Irrigation System and Operation		Potable water is used to irrigate the open green spaces and operating the fountains, no use of treated water				
		Gardeners did not receive any training regarding water saving				
		Water budget and checklist approaches are not used to control the water consumption				
		Hoses attached to taps are used to irrigate the park by gardeners				
		Water flows for 10-15 minutes in each irrigated area to submerge the plant				
		Irrigation is performed at 10 am every day in the summer and every two days in the winter				
		No inspection is performed to water taps, and hoses are replaced when damaged				
Pesticides, and Fertilization		Fertilizers are applied 2-3 times in the summer and none in the winter				
		Chemical fertilizers are used with compost				
		IPM program, sanitation and avoidance actions are not applied				
		Pesticides are used after the appearance of infections, but not applied to the lawn				
Pruning Plants		Harsh pruning is performed to Ficus trees				
		Natural weeds and lawn are not mowed				

RESULTS

The primary concern regarding water quality and consumption in the green spaces is the careless use of potable water, in operating fountains and irrigation, regardless of the plants' needs. Plants in the green spaces are not classified into hydrozones, therefore, gardeners wind up flooding the soil equality, besides the duration of the irrigation is often longer than necessary (10-15 minutes). These practices result in wasting high-quality water and could cause soil pests, root-destroying fungi, as well as the lack of oxygen for the plants (Moore, 1986). According to an agricultural engineer[1], the park is irrigated with 5 – 7 L/m^2 day and 60% of the water is lost due to the flooding irrigation technique. Another fundamental issue is the percent of the area designed as lawn, currently, it comprises some lawn and natural weeds. In the case of islands and roundabouts (areas not used for recreation), lawn is not needed, it could be replaced by gravel much or succulent ground covers. While in the parks, it is advisable to minimize the lawn area by adding permeable hardscape, sand, low water consuming ground covers or even pergola constructions in order to decrease the need for irrigation. Moreover, reused water is highly recommended to be utilized in the fountain operation.

Despite the fact that the temperature is high most of the year, irrigation is performed at 10 am daily in the summer and once every two days in the winter. Such timing increases the amount of evaporated water, especially without using mulch. It is noticed that trees and shrubs are excessively pruned, which results in stressing the plants and obstructs their ability to provide shade in summer days. Based on the interviewed gardeners, they did not receive any training regarding water conservation methods. Additionally, there is no regular checkup conducted for the plant's condition, as pesticides are applied when diseases or infestations are noticed. Furthermore, fertilizers are mixed with compost and added 2-3 times in the winter and not in the summer. Unfortunately, all the preceding practices escalate the water consumption.

Table 7: Water demand classification of plants in the case studies

Source: Researcher after (Deister, 2013; El Masry, 2014).

Type	Plant name	Water demand[2]		
		low	medium	high
Tree	*Ficus Microcarpa (Nitida)*		✓	
	Ficus Elastic			✓
	Ficus Benjamina		✓	
	Cassia Nodosa		✓	
	Jacaranda Ovalifolia		✓	
	Cupressus Arizonica		✓	
	Ficus Benjamina		✓	

[1] CCBA at Cairo Governate

[2] Definition of water demand (Deister, 2013)

High water demand: plants with high water demands (approx. 5.73 l/ m² day)

Medium water demand: plants with moderate water demands (approx. 3.58 l/ m² day)

Low water demand: plants with low water demands (approx. 1.42 l/ m² day)

	Morus Alba		✓	
	Aphanamixis Polystschya		✓	
	Cassia Fistula		✓	
Palm	*Washingtonia Robusta*	✓		
	Phoenix Dactylifera		✓	
	Syagrus Romanzoffiana		✓	
Shrubs	*Hibiscus Rosa-Sinensis*			✓
	Dodonaea Viscosa	✓		
	Nerium Oleander	✓		
	Duranta Repens		✓	
	Leucophyllum Frutescens	✓		
	Acualypha Wikesiana		✓	
	Lantana Camara		✓	
	Pulmeria Alba	✓		
	Pittosporum Tobira	✓		
	Lantana Camara		✓	
	Justicia Spicigera		✓	
Succulents	*Agave Angustifolia*	✓		
Ground cover	*Senecio Cineraria*	✓		
	Gazania Rigens		✓	
	Pelargonium Zonale		✓	
	Catharanthus Roseus		✓	
	Althea Rosea		✓	
	Lawn And Weed	✓		

On the other hand, some positive features are found in the case studies. Firstly the use of well-adapted plants to the Egyptian environment, and selecting the majority of plants with low to medium water demand (Fig. 3/ Table 4). Secondly, the soil composition and depth are fitting to capture irrigation water. Curbs are used to control runoff water which may be caused by irrigation and rarely by rain, due to the limited rainfall in the region; therefore there is no need to restructure the surface to collect rainwater.

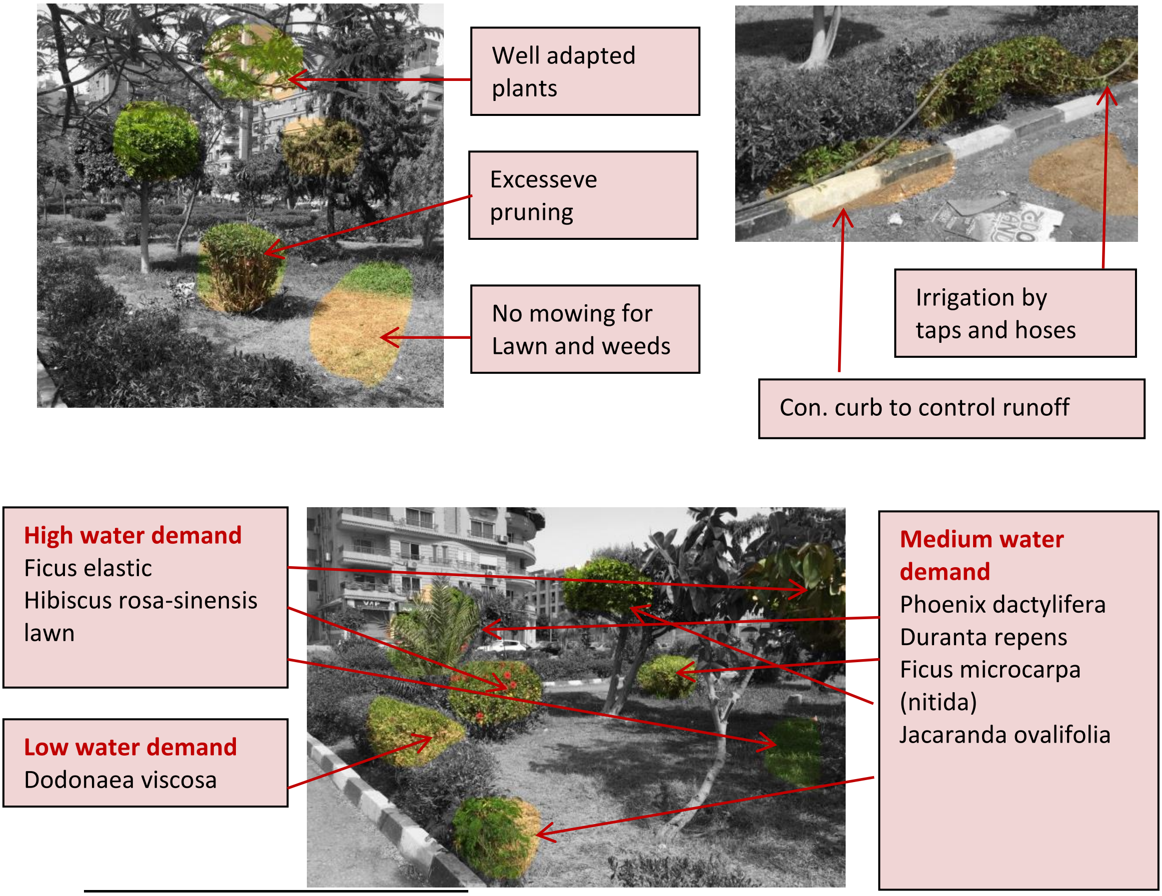
To sum up, it can be said that the green spaces, negative impact on the water consumption is way greater than their influence on the water quality (Table 3). Therefore, irrigation must depend on other water sources. One of these sources is gray water[3], which constitutes 60% of the total household wastewater (Ibrahim *et al.,* 2012). The average household water consumption in Egypt is estimated by 240 L/day (Rayan & Djebedjian, 2000). A rough

[3] Gray water is defined as the urban waste water that includes water from baths, showers, hand basins, washing machines, dishwashers and kitchen sinks, but excludes streams from toilets (Ibrahim, *et al.*,2012)

estimation of the produced gray water in Naser City would be around 97,323,696 L/day4. In Egypt a water saving landscape would need around 2 - 3 L/m^2 (Ladki *et al.*, 2004), then to irrigate all parks and green areas in the district, the amount of water needed daily is 4,465,815 L/day. So it could be concluded that the gray water volume generated from the district is sufficient to substitute the use of potable water for irrigation purposes.

Fig. 3: Plants in the case studies (Source: Researcher)

Fig. 4: Plant water demand in the case studies (Source: Researcher)



[4] Without considering losses

CONCLUSION

In Egypt, the accelerated demographic development, with rapid urbanization, added up the pressures on the country’s water resources. Depending mainly on a single source of water (Nile River), created an alarming situation of water scarcity. This paper casts light on the water use in urban landscapes in Cairo City. It represents an attempt to collect knowledge about water sensitive landscape characteristics, and its impact on preserving water quality and minimizing potable water consumption as a part of the Water Sensitive Urban Design approach. Plant types, soil management/ amendment, hardscape design, irrigation systems, and maintenance practices were investigated.

Six open green spaces were selected in Naser City as case studies representing the open green spaces in the district. It was found that potable water is used for irrigating plants and operating fountains, and the current water consumption exceeded the required amount for irrigation, resulting in wasting high-quality water. Two strategies are suggested to improve the water management efficiency in the city green spaces. **Firstly, short term** solutions aiming at minimizing the consumption and preserving water quality. The most significant action is preventing the flooding irrigation, and substitute it with a low-flow irrigation system. Other recommendations include: introducing xeriscape in street islands and roundabouts, restructuring parks to decrease lawn area, grouping plants with similar water demands in hydrozones, using mulch, super absorbent polymers, and more compost. Additionally, it is recommended to incorporate a competent maintenance regime which, for example, includes: adjusting irrigation timing either at early morning or after sunset and applying IPM to prevent infestations and diseases. Nevertheless, the most crucial intervention is educating gardeners maintaining the green spaces, in order to control over-irrigation (until involving low flow irrigation) and over- pruning. Water consumption can be monitored by installing water meters and connecting water use with incentive programs for the gardeners (penalties or rewards), as to evolve a sense of responsibility and an adequate behavior.

Secondly, long-term solutions, those regard new infrastructure and focus on abolishing the use of potable water, by substituting it with treated wastewater (TWW). The population of Naser City enables providing enough reclaimed water to be reused, however, the quality of TWW, must meet irrigation needs. Moreover, it is significant to ensure the efficiency of the water supply system by detecting leakage to reduce losses. In the end, water touches all aspects of our lives and thus should affect all aspects of our designs.

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