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The five key solutions to rescue the landscaping sector in the United Arab Emirates (UAE)

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ABSTRACT

The United Arab Emirates (UAE) is a country located in the arid region of the world with limited fresh water resources. The main water resource that plays significant role in converting the UAE desert into a green paradise is the groundwater, which supplies 70% of the total water resources in the country. However, this resource is a non-renewable water resource and it has a limited life time expectancy between 16 to 36 years. Also, it suffers from several problems, including depletion, saline water intrusion and contamination. The main problem is, while the situation of groundwater resource is critical, around 82% of the watering requirements for landscaping purposes are covered by the groundwater. In addition, the total annual water withdrawal by the green sector in the country is estimated to be above 2198 million m3, from which around one-third is used to cover the irrigation requirements for landscaping purposes, while the two-thirds are used for crop production purposes. The sustainability of the landscaping sector is extremely difficult, especially with the sharp population growth and the absence of groundwater supply. Therefore, serious and quick actions have to take place, through landscaping management, which includes the application of five key solutions, capable to save the future of the green sector in the UAE.

Keywords— Landscaping sector, water shortage, groundwater depletion, non-conventional water resources, treated domestic wastewater, irrigation resources, sustainability, population growth, indigenous plants, irrigation management, landscaping management, strategic planning, United Arab Emirates (UAE).

1. INTRODUCTION

The UAE is a young established country, with total area about 82,880 km^2 and total population estimated to be 9,346 million in 2013 [1]. It is located in southern part of the Arabian Peninsula and opens into Gulf of Oman in the east and Arabian Gulf in the west [2].

Similar to any country located in the arid region of the world, the climate is characterized by very high summer temperatures reaching 46^{o}C in average, with high humidity rate reaching around 100% along the coastal lines [3]. Despite, the high evaporation rates, precipitation amounts are low and irregular, with average rainfall reaching in maximum 160 mm annually. This is additional to the high sun exposure rates, as well as, the high wind speed [4]. Since the precipitation rates are scarce, 100% of the watering requirements of the green sector in the UAE are depending on irrigation [1, 5].

In general, the soil texture is classified as sandy soil [6], and thus has high water permeability rate, low water holding capacity, low water moisture content, poor nutrients availability, and consequently low fertility rates [7].

Although, the UAE has harsh environmental conditions, as mentioned previously, however, over a short period, huge areas in the UAE have been converted from deserts into green lands. Enormous amounts of water has been used; in order to make the impossible dream a possible one [8].

The main objective of this work is to review the available irrigation resources in the UAE and to represent the watering requirements for the green sector, including the landscaping sector. Also, to highlight the expensive cost, in terms of water, that the country pays for the landscaping sector; in order to establish a green paradise in the heart of an arid desert. Besides, how this can lead to a serious problem related to the food security in the UAE. Finally, this work will offer five key solutions, which are potential for decision makers; in order to conserve and sustain the future of the landscaping sector in the UAE.

2. IRRIGATION RESOURCES IN THE UAE

In fact, there are three main fresh water resources in the UAE, groundwater (70%, 4,052 million m^3), desalinated water (24%, 950 million m^3) and treated wastewater (6%, 319 million m^3), as illustrated in Figure 1 [1, 9]. Comparing to the domestic and the industrial sector, the green sector consumes alone a major part of the total water demand in the country estimated to be around 83% [10, 11], which is much higher than the normal situation in most of the countries, that usually reaches around 70% in average.

Over time, the green sector showed huge expansion in water consumption; from 950 million m^3 in 1990 [11] reaching 3,320 million m^3 in 2010 [12], as illustrated in Table 1. The main reason was to cover the sharp population growth in the UAE, as represented in Figure 2 [13], which was extremely increased from 231,529 in 1970 to 9,346,129 in 2013 [1]. Meaning that, it increased by around 40 folds in just 4 decades. Besides, the concept of "desert greening" was a great motivator to greatly expand the agricultural sector and turn the arid desert into green land [14].

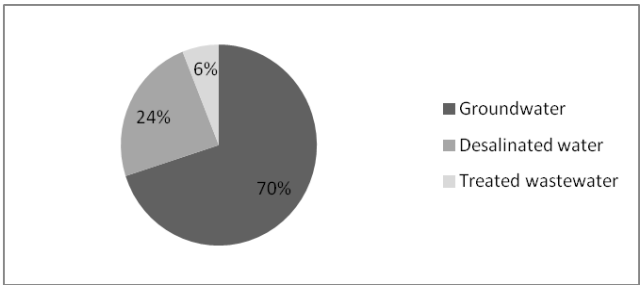

Figure 1 Main fresh water resources in the UAE [10].

Table 1 Water consumed by agricultural sector in the UAE [11; except a: 12].

Year	Water Consumed by Agriculture (million m^3/ year)
1990	950
1995	1,300
2000	1,400
2005	3,323[a]
2010	3,320[a]

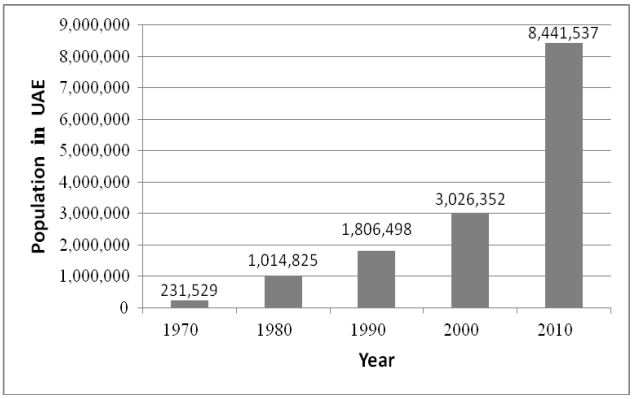

Figure 2 The sharp population growth in the UAE [13]

Groundwater is the main conventional water resource in the UAE [11], which is extremely used to cover two sectors; the forestry and the agricultural sector [5]. Unfortunately, the high dependency in this non-renewable water resource with the huge consumption rates comparing to the recharging ones lead to create severe problems, related to saline water intrusion [15], groundwater levels depletion, up to 60 meters, and contamination. Creating real concerns that groundwater aquifers would soon dry out and vanish [14]. Therefore, the non conventional water resources have attracted a great attention in the UAE; in order to cover the huge water demand. Non conventional resources include, seawater desalination and treated domestic wastewater [11].

However, desalinization plants are extremely expensive, in terms of construction and maintenance, which can cost above US$2 billion. In addition, they have many harmful environmental impacts, through emitting enormous amounts of carbon dioxides into the air, which contribute to air pollution and climate change and global warming. Besides, the desalinization plants, which constructed near the costal lines, cause serious threatening to the marine life and reduce the biodiversity [14].

On the other hand, treated domestic wastewater, which treated using high treatment standards, up to secondary and tertiary levels, could be reused and recycled safely at cost effective rates. Therefore, act as an attractive and sustainable solution to reuse and recycle the water already exists, and thus contributes to mitigate fresh water scarcity in the country [8, 16, 17].

3. OLD AND NEW IRRIGATION METHODS

In spite of, the harsh climatological and environmental conditions in the UAE, however, remarkable progress has been done in the green sector, particularly during the last decade. Since, the country has no permanent surface water resources and scarce rainfall amounts, therefore, all the agricultural lands are totally depending on the installed irrigation systems [5].

In the past, all agricultural lands were irrigated using traditional irrigation methods, including flood, furrow and aflaj systems. Today, modern irrigation techniques are used, such as, localized, surface and sprinkler irrigation systems [5, 8]. These new technologies were introduced in the mid of 1980s [14] and greatly contributed to save around 60% of the water comparing to the old applied methods [5].

In Abu Dhabi, the total irrigated area of the farms was around 199,414 ha in 2003. Irrigation practices include, drip (74.5%), bubbler (12%), sprinkler (10.8%) and other localized irrigation practices (2.7%), as represented in Figure 3 [18].

The cost of the modern irrigation systems is around US$10 000–13 000/ha for drip irrigation, excluding head stations. While the bubbler irrigation systems cost around US$8 500/ha [5].

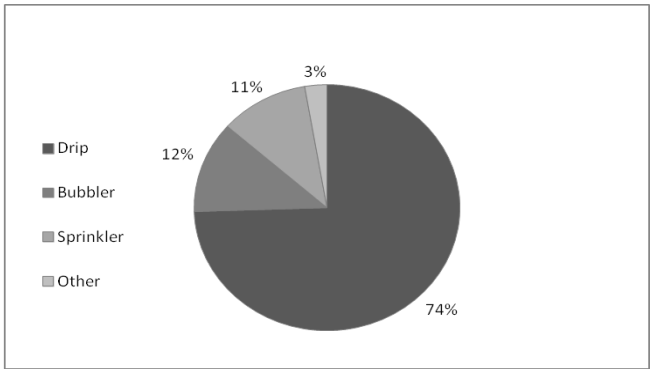

Figure 3 Irrigation practices in Abu Dhabi [18]

Although, the current applied irrigation methods are from the best water saving techniques globally, however, still there are many problems related to the irrigation efficiency and water use productivity. Additionally, while monitoring systems are absent, large quantities of water are wasted through over irrigation and leaking problems [5].

4. THE GREEN SECTOR AND THE SEVER COMPETITION ON THE IRRIGATION RESOURCES

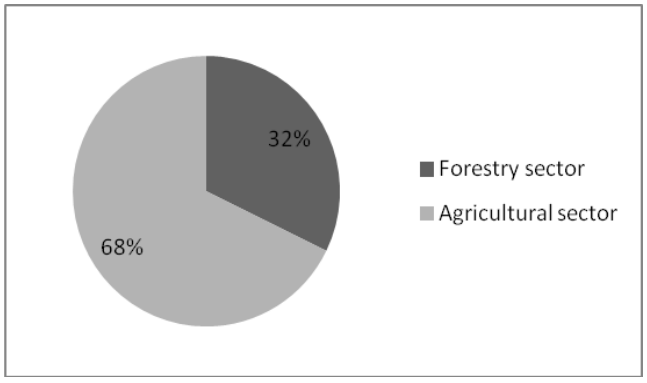

Figure 4 Water withdrawal by the green sector in the UAE

Based on the latest data mentioned in the water resources master plan, which was published by the Abu Dhabi Environmental Agency (2009) [14], the total annual amount of water withdrawal by the two sectors was estimated to be around 2,198 million m^3. Out of this amount, around 32.25%, was consumed by the forestry sector for landscaping purposes, and the rest 67.75%, was consumed by the agricultural sector for crop production purposes, as illustrated in Figure 4. This means that, although the fresh water resources are scarce in the UAE, one-third of the total water amount is used for landscaping purposes only, in order to create fantastic sightseeing for the residents and the visitors. This is very important to enhance the tourism sector, and make it more attractive for the tourists to visit the country.

Annually, the forestry sector consumes at least around 709 million m^3. This amount of water is used for irrigating the landscaping, such as, the street plantations and parks. This

sector is responsible for the beauty of the country and very attractive for the tourism sector. The main resources that cover the watering requirements for this sector are the groundwater and the treated domestic wastewater, which contribute to irrigate watering amounts estimated to be 579 million m^3 (81.7%) and 130 million m^3 (18.3%), respectively [14], as illustrated in Figure 5.

On the other hand, the agricultural sector consumes around 1,489 million m^3 per year. This amount of water is used to irrigate the agricultural crops, which contribute to the plants based food production, and thus food security in the country. The main resources that covers the watering requirements for this sector are the groundwater and the desalinated sea water, which contribute to irrigate watering amounts estimated to be 1,413 million m^3 (94.9%) and 76 million m^3 (5.1%), respectively [14], as illustrated in Figure 5.

It worth mentioning that, the main watering resource for the green sector in the UAE is the groundwater [8, 11, 17], which contributes to irrigate 81.7% and 94.9% of the forestry and the agricultural sector, respectively, as illustrated in Figure 5. However, the groundwater resource is a non-renewable water resource. Besides, it's expected to dry out and vanish within the next 16 to 36 years [14]. In addition, the consumption rates from the groundwater are expected to increase sharply in an accelerated rates; in order to cover the extensive watering needs of the green sector. The reasons are mainly to go in parallel with the sharp population growth, which is expected to reach above 12 million by 2030 [8, 18]. Taking in consideration that, the UAE is becoming a very attractive destination for many international occasions, such as, Dubai EXPO 2020. Consequently, sever pressure will be added soon on the limited irrigation resources, which sustain the green sector and the crop production sector in specific. Thus, the sustainability in this context is a controversial topic and a critical challenge.

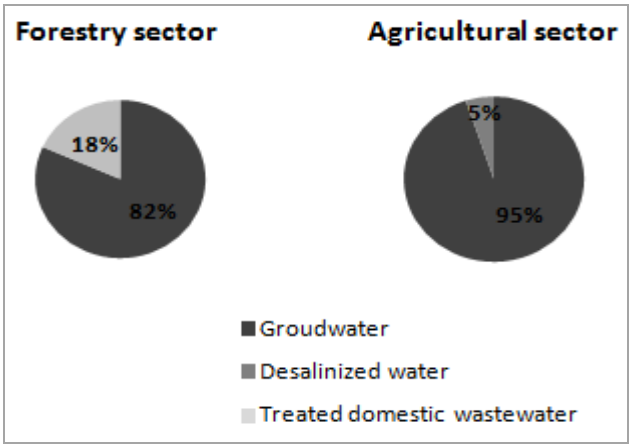

Figure 5 Main water resources consumed by the forestry and the agricultural sector in the UAE

5. THE GREEN SECTOR CHALLENGES

The main future concern related to the green sector in the UAE is when the watering requirements that supply the green sector, including the landscaping sector and crop production sector, greatly increased, while the groundwater supply will be vanished.

Although, the country landscaping beauty plays very significant role in the era of urbanization, however, this worth nothing comparing to a life fundamental requirement, which is the food production and security. The water consumed to supply the irrigation requirement needed by the landscaping sector, exceeding 579 million m3 annually, and the crop production sector, exceeding 1,413 million m^3 annually, will be left with big question mark. While, seeking for cost effective and environmentally friendly solution, to help in mitigating the sever situation, the landscaping sector will severely struggle to survive.

According to many recent studies, wastewater can be used after adequate treatment, up to tertiary levels, in irrigating agricultural crops [19, 20, 21, 22, 23], such as, irrigating the most important economical tree in the UAE, which is the date palm [24]. However, since the UAE is one of the most rich countries in the world, from oil revenue [2], and based on cultural and religious thoughts, treated domestic wastewater is not used in the country for crop production purposes, and used mainly by the forestry sector for landscaping purposes [11, 25, 26].

Putting aside the social aspect on the application of treated domestic wastewater, the total available treated domestic wastewater in the UAE, which was estimated by the Abu Dhabi Environmental Agency [14], was around 289 million m^3 in 2007. At the same time, the total irrigation requirements for the date palm plantations only was approximately 320 million m^3 in 2007 [12]. This means that, if all the treated domestic wastewater used to irrigate date palm trees only, it will not be enough. Although, this resource is a sustainable and cost effective resource, however, it can cover very small percentages from the total watering needs [8].

Although, the treated domestic wastewater is currently covering around 18% of the watering requirements of the forestry sector, however, there will be more interest in the near future to start using this valuable resource for crop production, instead of using it for landscaping purposes [14]. There will be severe competition to invest every drop from the treated domestic wastewater effluent in the country for food production purposes. While, the landscaping sector will be a weak competitor in this competition. Consequently, the landscaping sector will be in a real challenging situation, and the sustainability of this sector will be extremely difficult.

6. THE KEY SOLUTIONS

In the UAE, the heart of the solution, which can best rescue the

landscaping sector and today's amazing green lands could be achieved through landscaping management. This solution summarized and includes all the aspects that guarantee the sustainability of the landscaping sector and the green sector, generally, in the country. Managing the landscapes based on the best use of the available resources in a sustainable manner is the core meaning of this solution.

The general aspects which lead to landscaping management include the application of five core objectives; which are cultivating the indigenous plants, application of the hardscaping, irrigation management, raising community awareness and strategic planning and development. Each one of these aspects are discussed as follow:

A. Cultivating Indigenous and Naturalized Plants

First, cultivating indigenous and naturalized species to the UAE, from xerophytes and halophytes, which can successfully adapt and survive the harsh environmental conditions, such as, drought, soil salinity, poor availability of nutrients and low soil moisture content [27].

Over the time, such desert plants have developed different morphological modifications and physiological mechanisms; in order to adapt the limited availability of water resources, along the harsh environmental conditions [8]. Adaptation mechanisms include; seeds dormancy, short life cycle (ephemerals), short growth rate, long root system, small leave area, light green color, succulent leaves, existence of thorns, waxy surfaces and the hairy surface for shoots [28]. Also, the indigenous plants reflect the original identity of the place and preserve the heritage value of the country.

In fact, the UAE flora is rich with many plant species suitable for providing a multi-functional landscapes. For example, some plants have ornamental value, at the same time, provide therapeutic value, such as, *Ipomoea pes-caprae*, which is a salt tolerant species, has violet erect flowers and potential for the ornamental landscapes, as well as, seeds of this species were used in the traditional medicine as purgative. Besides, *Acacia Arabica* is a useful tree for landscaping and leaves of it were used in the folk medicine to soothe burns [29].

However, the national market lack suppliers of seeds and seedlings for such indigenous and naturalized species. Therefore, it's crucially required to establish a national germplasm bank; to conserve, propagate and sustain the availability of this valuable resource. This is crucially needed, not only for the sake of biodiversity conservation, but also to protect this natural resource from the concerns of declining in numbers and becoming threatening [29].

On the other hand, cultivating exotic plants, which consumes massive amounts of water and compete on the limited available nutrients, should be minimized and done only under restricted precautions. Even, the exotic plants from xerophytes and halophytes, should be minimized, since such plants have no relationship with the original identity of the country and its original biodiversity. Such plants require heavily labor works (e.g. maintenance and adding fertilizers), thus pose very expensive environmental and economical costs [14].

According to the Environmental Agency Abu Dhabi, quick actions have to take place in banning of growing Rhodes grass, *Chloris gayana*, and replace the same with salt and drought tolerant species, which would definitely reduce watering requirements by half [14].

B. Adoption of Hardscaping

It is required to adopt the hardscaping, while designing and constructing the UAE landscapes. For example, applying the rock garden or the dry landscape garden, such as the Japanese rock garden, would enhance the beauty of the landscape, with zero requirements of water [27].

C. Irrigation Management

Perform irrigation management, through adoption the best agricultural practices and irrigation methods, including deficit irrigation and irrigation scheduling, in order to reduce watering amounts, increase water use efficiency and increase water productivity.

Here, it worth mentioning that, more effort have to be done related to irrigation scheduling through optimization models; to reach the maximum yield with minimal drops. Taking in consideration, the climatologically factors and climate change [14, 30].

Moreover, monitoring systems have to be installed, in order to minimize the water use and to avoid the over irrigation practices. As well as, to control the water lost by leaking problems.

Additionally, more efforts have to be done in order to match between the quality of the treated sewage effluent and the application, which have to be based on priority use. This could be achieved through evaluating and analyzing the quality of treated domestic wastewater, then manage the possibilities of usage for specific purposes. For example, high quality water have to be used for food production purposes, while low quality ones could be used for landscaping [14].

D. Raising Community Awareness

The community plays crucial role to accomplish this task, through understanding the curiosity of the situation, valuing the water resources and the native plants, and following the recommendations of the municipalities and the water authorities; to save more water in their farms, homes and in all life aspects [14].

Therefore, educating and raising the awareness level for every individual, through campaigns and educational programs,

is fundamental ; in order to conserve and sustain this wonderful sector for the futures generations.

Farmers and the whole community members have to be educated about the value of water and wastewater specifically. Farmers (mainly having very low educational level and came from rich water countries) are using groundwater for irrigation free of charge. The same situation is valid, while using treated domestic wastewater for irrigation purposes [17, 27].

Additionally, surveys clearly show that beneficiaries of wastewater sector in Abu Dhabi are unaware to the necessity of the wastewater treatment service provided by Abu Dhabi Sewerage Services Company (ADSSC). At the same time, the UAE is amongst the rich countries in the world, thus the price of luxury lifestyle costs the natural resources huge lost, and beneficiaries extremely misuse these resources. Global experience prove that, a 10% increase in tariffs decreases demand by 4 to 6%. Therefore, it is not surprising that, current demand is very high, while groundwater and treated domestic wastewater are opened resources for free. Reasonable tariffs and awareness could facilitate the way toward sustainability [14].

E. The Strategic Planning and Development

Application of the strategic planning and development could be done through following three strategic options; First, taking positive actions to reduce irrigation requirements (e.g. increase water use efficiency and water productivity). Second, irrigating with mixture from saline water and brackish water mixed up to acceptable limits. Third, adoption and implementation of the best practices worldwide in water planning and development, such as, Australian's expertise [14].

In fact, the country is working currently, to explore the possibilities of using the nuclear power as a sustainable energy resource. Additionally, the Masdar initiative is an excellent example which is designed to explore, plan develop future energy sources locally and globally. Solar power is the main motivated energy source for this research institution. Also, many significant research projects are taking place in this institute, seeking for implementation of sustainable energy resources, like solar power and wind power.

Certainly, the agricultural sector has to adopt the best agricultural practices and irrigation methods, including deficit irrigation and irrigation scheduling, which reduce watering volumes, increase water use efficiency and increase water productivity. Hardly works have to be done for optimization (optimization models) of the irrigation schedules; in order to apply the minimal watering volumes with maximal acceptable yields. Taking in consideration, the climatologically conditions and climate change [14, 30].

Undoubtedly, it is very important to imitate the natural and original environment of the country, through planting native plant species from the xerophytes and halopthytes. Besides, adoption of the hardscaping plays very essential role to reduce the heavy pressure on the limited available water resources. On the other hand, exotic plants have to be very restricted or even panned. Such plants, are extremely high consumers for irrigation water and require heavily labor works (e.g. maintenance and adding fertilizers), thus pose very expensive environmental and economical costs.

As mentioned previously, quick actions have to take place in banning of growing Rhodes grass, and replace the same with salt and drought tolerant species, which would definitely reduce watering requirements by half [14].

7. CONCLUSION

In the UAE, the future of the landscaping sector is very challenging, in terms of irrigation resources. There will be a severe competition between this sector and the agricultural sector, on the limited available irrigation resources.

Although, the watering resources are scarce, the landscaping sector consumes alone one-third of the total water supply of the green sector (above 709 million m^3 annually). In addition, this trend is highly expected to increase, especially with the urbanization and the sharp population growth in the country.

The main problem will appear in the next 16 to 36 years, when the groundwater aquifers, which supply 82% (579 million m^3) of the forestry sector, will be stopped and vanished. Leaving the greenery beauty of the country in a real challenging situation.

As a result, quick actions have to take place; in order to save the future of the green sector in the country. This could best be done through landscaping management, which includes the application of five key solutions; First, cultivating indigenous and naturalized species to the UAE, from xerophytes and halophytes. Second, adoption of the hardscapin. Third, applying irrigation management, through adoption the best agricultural practices and irrigation methods, including deficit irrigation and irrigation scheduling. Fourth, raise community awareness. Fifth, strategic planning and development, which could be done through, taking positive actions to reduce irrigation requirements.

It is very important to emphasize that, the public community have to be aware about the current situation, and have to work positively and jointly with the water authority, in order to save the future of the green sector in the UAE.

Finally, it's very clear from this work that, any further expansions in the green sector of the UAE, and in specific the landscaping sector, have to be done under absolute control and have to be cautiously evaluated and managed from decision makers; in order to best fulfil the sustainable approach for the future of agriculture in the country.

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