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Food security in the United Arab Emirates (UAE): The great competition between the agricultural and forestry sector on irrigation resources

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The United Arab Emirates (UAE) is a country that has scarcity in fresh water resources. Groundwater, which contributes to 70% of the total water resources in the country, is a non-renewable water resource. This resource plays significant role in converting the desert to a green paradise. It covers around 95% and 82% of the watering requirements of the agricultural and forestry sector, respectively. Besides the critical problems that this resource suffers from; including depletion, saline water intrusion and contamination. It has also a limited life time expectancy, estimated to be between 16 to 36 years. The total annual water withdrawal by the green sector in the country is estimated to be above 2198 million m^3, from which above 32% is used to cover the irrigation requirements for the forestry sector and landscaping, while the rest amount is used for crop production purposes. The great competition between the two sectors, lead to make the sustainability approach in maintaining both sectors extremely difficult, especially with the absence of groundwater supply and the sharp population growth. Therefore, serious and quick actions have to take place; in order to save the future of food security in the UAE.

Keywords: water scarcity, groundwater depletion, non-conventional water resources, treated domestic wastewater, agricultural sector, forestry sector, irrigation resources, sustainability, population growth, food security, United Arab Emirates (UAE).

I. Introduction

The UAE is a young country, with total area around 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 two coasts; Gulf of Oman in the east and Arabian Gulf in the west [2]. Similar to any country located in the arid region, the climate is characterized by very high summer temperatures reaching 46^{o}C in average with high humidity rate along the coastal areas reaching around 100% [3]. Despite, the high evaporation rates, precipitation rates are low and irregular, with average annual rainfall not exceeding 160 mm [4].

Based on above mentioned climatic facts, 100% of the watering requirements of the agriculture are depending on irrigation [1, 6]. Over short time, huge areas in the UAE have been converted from deserts into green lands. Enormous amounts of water has been used to accomplish this impossible dream.

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 forestry and the agricultural sector. Also, to highlight the huge competition between the two mentioned sectors on using the limited available water resources, and how this can lead to serious threaten to the crop production sector, and thus the food security in the UAE. Finally, this work will represent some important solutions and recommendations for decision makers, in order to save the future of food security in the UAE.

II. Irrigation Resources in the UAE

Currently, there are three main fresh water resources in the UAE, groundwater (4,052 million m^3, 70%), desalinated water (950 million m^3, 24%) and treated wastewater (319 million m^3, 6%), as illustrated in Figure 1 [1, 7]. According to the world bank [8], the agricultural sector alone consumes about 83% of the total water demand of the country comparing to the domestic and industrial sector [9].

Over time, the agricultural sector showed huge expansion in water consumption; from 950 million m^3 in 1990 [9] to 3,320 million m^3 in 2010 [10], as represented in Table 1. This was essential to cover the sharp population growth in the UAE, as illustrated in Figure 2 [11], which was extremely increased around 40 folds in just 4 decades, from 231,529 in 1970 to 9,346,129 in 2013 [1]. Besides, the concept of "desert greening" was a great motivator to enlarge the agricultural sector and turn the arid desert into green paradise [12].

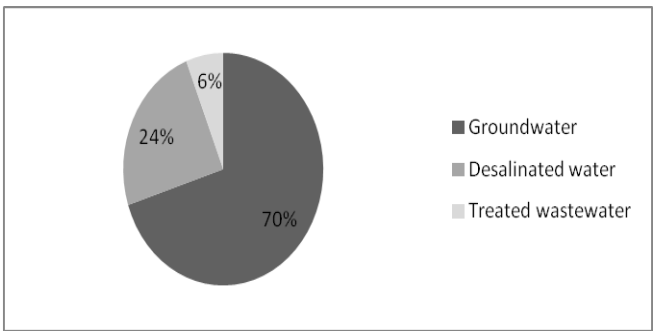

Fig. 1. Water resources in the UAE [8].

TABLE 1. Assessing water demands by agricultural sector in the UAE. [9; except a: 10].

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

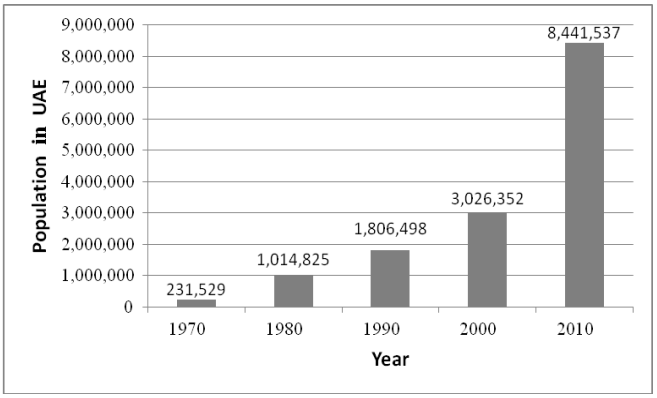

Fig. 2. Population growth in the UAE [11].

A. Conventional Irrigation Resources

Groundwater is the main conventional water resource in the UAE [9], 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 recharging ones lead to severe problems, related to saline water intrusion [13] and the significant depletion in the groundwater levels up to 60 meters, creating real concerns that groundwater would soon dry out and vanish [12].

B. Non Conventional Irrigation Resources

Recently, the non conventional water resources have attracted great attention in the UAE; in order to cover the huge water demand, including seawater desalination and domestic wastewater treatment [9]. However, desalinization plants are extremely expensive, in terms of construction and maintenance (more than US$2 billion). In addition, they have many negative environmental impacts, related to global warming and threatening the marine biodiversity [12]. On the other hand, domestic wastewater treated by high treatment standards, up to secondary and tertiary levels, could be reused and recycled safely at cost effective rates, thus act as an attractive sustainable solution to the fresh water scarcity [14, 6, 15].

III. Old and New Irrigation Methods

In fact, all the agricultural land in the UAE are 100% irrigated [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 [5,6]. These new technologies were introduced in the mid of 1980s [12] and greatly contributed to save around 60% of the water comparing to the old applied methods [5].

IV. The Green Sector and the Sever Competition on the Irrigation Resources

The green sector in the UAE is divided into two sectors; the forestry and the agricultural sector. The forestry sector is responsible for the landscaping purposes, and the agricultural sector is responsible for the crop production purposes [5].

Based on the latest data mentioned in the water resources master plan, which was published by the Abu Dhabi Environmental Agency (2009) [12], 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 and the rest amount, around 67.75%, was consumed by the agricultural sector for crop production purposes, as illustrated in Figure 3. 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.

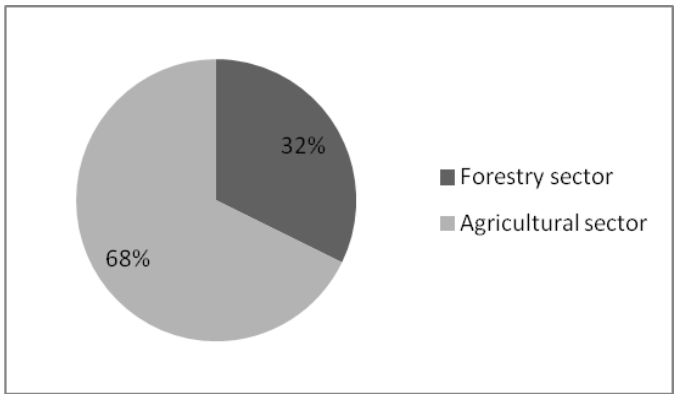

Fig. 3. Water withdrawal by the green sector in the UAE.

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 covers 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 [12], as illustrated in Figure 4.

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 [12] as illustrated in Figure 4.

It worth mentioning that, the main watering resource for the green sector in the UAE is the groundwater [9, 6, 15], which contributes to irrigate 81.7% and 94.9% of the forestry and the agricultural sector, respectively, as illustrated in Figure 4. 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 [12]. In addition, the consumption rates from the groundwater are expected to grow 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 [16, 6]. Taking in consideration that, the UAE is becoming a very attractive location 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.

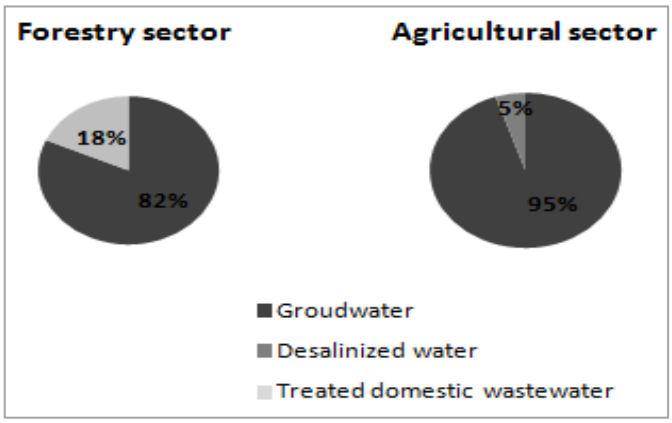

Fig. 4. Main water resources consumed by the forestry and the agricultural sector in the UAE.

V. Food Security Challenges & Recommendations

The main future concern related to food security in the UAE is when the watering requirements that supply the green sector, including the crop production sector, greatly increased, while the groundwater supply stopped. 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 resource to supply the irrigation requirement needed by the crop production sector, that exceeds 1,413 million m^3 yearly, 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 be a serious competitor.

According to many recent studies, wastewater can be used after adequate treatment, up to tertiary levels, in irrigating agricultural crops [17, 18, 19, 20, 21], such as, irrigating the most important economical tree in the UAE, which is the date palm [22]. Nevertheless, 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 and for landscaping purposes [9, 23, 24]. Although, there are currently increasing interest to start using this valuable resource for crop production purposes [12].

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 [12], 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 [10]. 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 percentage from the total watering needs [6].

The key solution that can best mitigate the expected sever water shortage from groundwater resources can be done through following three main aspects; First, application of the water has to be based on priority use. Thus, watering the crop production sector has more priority comparing to watering the landscaping sector. Second, 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 [12, 25]. Third, strategic planning and development, which could be done through, taking positive actions to reduce irrigation requirements (e.g. increase water use efficiency and water productivity), irrigating with mixture from saline water and brackish water mixed up to acceptable

limits, using the treated domestic wastewater and developing the planning and development sector, through adoption and implementation of the best practices worldwide in water planning and development, such as, Australian's expertise [12].

Finally, the community in the UAE has essential role to save more drops per crops. Thus, educating and raising the awareness level for them to be aware about the expected critical challenges and available solutions, that can rescue the food production sector, is very crucial, in order to reach food security in the country, as well as, to save and sustain this sector for the futures generations.

VI. CONCLUSION

In the UAE, the future of the agricultural sector is very challenging in terms of irrigation requirements. There is a severe competition between the forestry and the agricultural sector. Although, the watering resources are scarce, the landscaping sector consumes alone one-third of the total water supply for the green sector (above 709 million m^3 annually). In addition, this trend is highly expected to increase, especially with the sharp population growth in the country.

Besides, the main resource that supply the green sector is the groundwater, which contributes to supply the forestry and the agricultural sector with 82% (579 million m^3) and 95% (1,489 million m^3), respectively. However, groundwater is a non-renewable water resource. Also, it's expected to dry out and vanish within the next 16 to 36 years. Leaving the green sector, and the crop production sector specifically, in a critical challenging situation.

As a result, quick actions have to take place in order to save the future of the agricultural sector and food security in the country. This can best be done through applying three key solutions; First, application of the water has to be always based on priority use, and the agricultural sector has more priority comparing to the forestry sector. Second, irrigation management, through adoption the best agricultural practices and irrigation methods, including deficit irrigation and irrigation scheduling, Third, strategic planning and development, which could be done through, taking positive actions to reduce irrigation requirements. Additionally, the public community have to be aware about the current situation, and have to accept the treated domestic wastewater as a potential irrigation resource for crop production purposes in the UAE.

Finally, it's very clear from this work that, any further expansion 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 fulfill the sustainable approach for the future of agriculture in the country.

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