Review future concerns on irrigation requirements of date palm tree in United Arab Emirates (UAE):call for quick actions

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ABSTRACT

Date palm (*Phoenix dactylifera*) is a very essential traditional tree in a country located in the arid region, like the United Arab Emirates (UAE). This tree is considered as a significant source of food production and plays an crucial role in food security of the country. However, the limitations of natural water resources in conjunction with groundwater depletion and sharp growth in the UAE's population could create critical challenges in providing the irrigation requirements for such economical tree. The main purpose of this work is to investigate whether the future watering requirements of date palm tree could be met and sustained in 2030. This would be done through, reviewing the available irrigation resources and predicting the projected demand (from date palm production and watering requirements), which are required to reach food security in the country. The conclusion indicates that, in the absence of groundwater resources, that may take place in 2030, if all treated domestic wastewater in the UAE "about 578 million m3/year" would be used only to irrigate date palm trees "with irrigation requirements about 640 million m3/year", it would not be enough to cover the watering requirements for palm trees. Consequently, quick actions have to be done from decision makers through irrigation management and strategic planning.

Keywords: date palm, *Phoenix dactylifera*, water scarcity, groundwater depletion, non-conventional water resources, treated domestic wastewater, irrigation requirements, population growth, food security, 2030, United Arab Emirates (UAE).

INTRODUCTION

Throughout history, date palm (*Phoenix dactylifera* L.) has been one of the most essential trees in the arid regions of the world. Since ancient times (3000 BCE), date fruit was one of the most oldest cultivars of fruit crops, which was most probably originated from the olden Mosopotamia area (southern Iraq) or western India (Wrigley, 1995). This valuable fruit, with high nutritional value, played remarkable role in sustaining people's lives in the desert regions (Lambiote, 1982), which generally characterized by harsh environmental conditions and limited natural resources (Zaid and de Wet, 2002). Later on, date cultivation was spread out from its source of origin to the Arabian Peninsula, North Africa and the Middle East (Nixon, 1951). In the eighteenth century, date palm tree has been introduced to new production regions around the globe, including southern Africa, Mexico, Australia, South America and the United States (Chao and Krueger, 2007).

The date palm (*Phoenix dactylifera* L.) is a perennial dioecious monocot, belonging to the family Arecaceae (Al-Hooti, *et al.,* 1997). The name of this tree originated from its fruit; "phoenix" means purple or red "fruit" and "dactylifera" means finger-like appearance of the fruit bunch in the Greek (Sudhersan and Abo El-Nil, 1999). Fully ripe date contains around 67% simple sugars, 25% water

and 8% mainly from cellulose, pectin and vitamins (FAO, 1962). It provides high nutritional value and serves as rich natural energy resource, which makes this crop an ideal cultivar in arid regions, as well as, in any region suitable for their production (Lambiote, 1982). Nowadays, production and utilization of huge quantities of dates are sharply and continuously increasing at commercial global level (Ismail *et al.,* 2006). In reality, while the world population has doubled over the last 50 years, the world production of dates has increased around 3 times, and this trend is expected to continue in increasing (Al-shahib and Marshall, 2003; Chao and Krueger, 2007). Top producers' countries are Egypt, Iran, Saudi Arabia, Sudan and the United Arab Emirates (UAE), Pakistan, Algeria, Iraq and China (Ismail *et al.,* 2006).

In fact, palm trees flower and form fruit when the shade temperature exceeds 18 oC and 25 oC, respectively (Zaid and de Wet, 2002). Although date palm belonging to the xerophyte species, survive under long periods of drought and high temperatures, and adapting to harsh environmental conditions, however, large amounts of watering is required for vegetation growth and high quality production yield (Furr and Armstrong, 1956).

In the UAE, date palm is a very remarkable and precious tree, which has strong religious, traditional and nutritional significance to the local community. It is one of the most important crops in the country, with many great economical and environmental values. Over the last three decades, date production in the UAE has greatly increased; in order to cover the sharp population growth and to reach food security in the region (FAO, 2008). On the other hand, the groundwater reservoirs, which are the main irrigation resource for date palms, have significantly declined (EAD, 2009).

The main objective of this work is to investigate and predict, based on reviewing the literature, whether watering requirements of date palms in the UAE could be met and sustained in 2030, if the current production trend continue in increasing. Besides, this paper will highlight potential recommendations which are crucially required to reach food security in the country, through irrigation management and strategic planning.

The significance of date palm

Truly, date fruit provides natural resource for simple sugar, from glucose and fructose, which is easily absorbed in the human body. Also, date is an extremely rich resource for potassium and contains very low amounts of sodium. Even date seed can be roasted and crushed into powder for different applications, like, date coffee (Aslam *et al.,* 2013). Besides, the trunk of this tree can be used in many applications, such as, as wood and fuel. Furthermore, the leaves can be used to make many products, like bags, baskets, fans, furniture and papers (Chao and Krueger, 2007).

In medicine, date fruit has many potential health benefits which are scientifically proven, related to its tonic effect and antioxidant activities to reduce the damages caused by the free radicals (Aslam *et al.,* 2013). Nowadays, date is greatly under investigation for its possible effectiveness on different illnesses, like diabetes and heart diseases (Ismail *et al.,* 2006).

In the UAE, date palm production is the main crop produced in the country (EAD, 2009), and thus provides great economical value to the farmers and land owners. The maximum date production of each tree is 70 kg, which is purchased by the government at varied prices based on the quality (FAO, 2008a). Different cultivars from date palms grow in UAE, such as, Khalas, Barhee, Fard "Fardh", Ruzeiz "Raziz" and Bumaan (Ismail *et al.,* 2006).

Palm plantation provides diverse significant values in the UAE. It has religious, traditional and social importance to the local society. In the old times, while the life in this region suffers from poor life conditions, date fruit was the rescuer and magical food resource with great nutritional benefits to the local community (Ahmed *et al.,* 1995; El-Behissy *et al.,* 2001). Also, date palms play an essential role in the desert ecological system and provide significant environmental benefits for the indigenous wildlife. Additionally, palms plantation are greatly effective in controlling the desertification and in land reclamation (Chao and Krueger, 2007). For all above mentioned reasons, this precious tree has attracted a great attention locally and globally.

Irrigation resources

The UAE is a young country, with total area around 82,880 km2 and total population estimated to be 9,206 million in 2012 (World Bank, 2012). It is located in the arid region of the world, southern part of the Arabian Peninsula. It opens into two coasts; Gulf of Oman in the east and Arabian Gulf in the west (UAE Yearbook, 2006). The climate is characterized by very high summer temperatures and high humidity rate along the coastal areas reaching 46oC in average and 100% respectively (FAO, 1997). Although, evaporation rates are high, precipitation rates are low and irregular, with average annual rainfall varies from 60 mm to 160 mm (MEW, 2005). Fresh water resources in the county are scarce and limited mainly to groundwater aquifers (Murad *et al.,* 2007).

Based on above mentioned climatic facts, 100% of the watering requirements of the agriculture are depending on irrigation. In the past, all agricultural lands were irrigated using traditional irrigation methods, such as, flood, furrow and aflaj systems (FAO, 2008a). Today, modern irrigation techniques, which were introduced in the mid of 1980s (EAD, 2009), are used (localized, surface and sprinkler irrigation),

which greatly contribute to save around 60% of the irrigation water comparing to the old methods (FAO, 2008a).

Today, there are three major water resources in the UAE, groundwater (4,052 million m3, 70%), desalinated water (950 million m3, 24%) and treated wastewater (319 million m3, 6%), as illustrated in Figure 1 (FAO, 2008a; FAO, 2008b). Comparing to the domestic and industrial sector, the agricultural sector alone consumes about 83% of the total water demand of the country (World Bank, 2013). Over time, the agricultural sector showed huge expansion; from 950 million m3 in 1990 (Murad *et al.,* 2007) to 3,320 million m3 in 2010 (FAO,2013), as represented in Table 1. This was essential to cover the sharp population growth in the UAE, which was extremely increased around 40 folds in just 4 decades, from 231,529 in 1970 to 8,441,537 in 2010 (World Bank, 2012). Besides, the concept of "desert greening" was a great motivator to enlarge the agricultural sector and turn the arid desert into green paradise (EAD, 2009).

Groundwater is the main conventional water resource in the UAE, which is extremely used to cover two sectors; the agricultural and forestry sector (FAO, 2008a). Unfortunately, the high dependency in this valuable resource and the huge consumption rates comparing to recharging ones lead to severe problems, related to saline water intrusion (Al-Zubari, 1998) and the significant depletion in the groundwater levels by 20 to 60 meters, creating real concerns that groundwater would soon dry out and vanish (EAD, 2009).

Consequently, the non conventional water resources have attracted great attention recently in the UAE; in order to cover the huge water demand, including seawater desalination and domestic wastewater treatment (Murad *et al.,* 2007). However, construction and maintenance of desalinization plants are extremely costly (more than US$2 billion). Besides, they have many negative environmental impacts, related to global warming and threat of the marine biodiversity (EAD, 2009). On the other hand, domestic wastewater treated to 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 (World Bank, 2011). Nevertheless, since the UAE is one of the most wealthy countries in the world, from oil revenue (UAE Yearbook, 2010), 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 (Murad *et al.,* 2007; ADSSC, 2007; ADSSC, 2010). Although, there are currently increasing interest to start using this valuable resource for crop production purposes (EAD, 2009).

According to many recent studies, wastewater can be used after adequate treatment in irrigating agricultural crops (Sheikh *et al.,* 1990; Asano and Levine, 1996; Van *et al.,* 2002; York *et al.,* 2008; Pedreroa *et al.,*2010), even it can be used safely for drinking (Tortajada, 2007). Thus, it can be used safely for watering agricultural crops in the country. According to FAO (2010), date palm is among agricultural crops suitable to be irrigated with treated wastewater, and since this tree is the most important economical tree in the UAE, thus it will have a greater priority to be irrigated with the domestic treated wastewater comparing to other agricultural crops.

Irrigation requirements, food security and future concerns

Over the years, date palm plantations and dates production have been dramatically increased in the UAE, from around 8,000 tons in 1970 to over 50,000 tons in 2003 (FAO, 2008b). In 2005, the total area of the cultivated date palm was estimated to be 172,000 ha (EAD, 2009). The main factor that direct this sharp increasing trend is the dramatic population growth in the country, as illustrated in Figure 2 (World Bank, 2012), which consequently requires a parallel growth in dates production as shown in Figure 3 (FAO, 2008b); in order to reach food security. Undoubtedly, dates production sector will continue in increasing the production rates to cover the local and regional market needs (Chao and Krueger, 2007).

Utilized traditional irrigation techniques for date palms in UAE are mainly aflaj and groundwater (FAO, 2008b). Aflaj are a traditional irrigation systems which have high cultural values and had greatly supported date palm oases, however, currently this valued system has almost dried out. Groundwater aquifers have been substantially exploited by private farms. Unfortunately, water withdrawal rates from this valuable resource doesn't have monitoring system and the farmers, who are mainly uneducated people, have severely impacted groundwater levels. Resulted in drying out of 10% of the total wells and causing very high salinity rates, ranges from 3,500 to 23,100 ppm, to 70% of the groundwater aquifers in the UAE (EAD, 2009).

Modern irrigation systems for palm plantations were introduced at research level between the period 1975 and 1984, which include sprinkler, drip and bubbler systems. Costs of these irrigation systems have 50% subsidized by the government; in order to encourage the farmers to replace old techniques by the new and more efficient irrigation methods. Bubbler irrigation is mostly used for palm trees 3 to 4 years old and even used after maturity with a discharge of 360L/hr. This system is highly efficient in using irrigation water with efficiency reaching 80%. Drip irrigation is a localized irrigation system, which releases water slowly and accurately, using drippers that discharge in a range vary from 4L/hr to 24L/hr. It has two systems; online and inline drip systems. This system is greatly used at around 80% in the western regions (FAO, 2008b).

As declared by EAD (2009), the optimum watering requirements for date palm is 14,800 m3/ha. Most of the labor working in irrigating crops, including palm trees, are unskilled and uneducated people. Therefore, real irrigation rates exceeds the optimum rates and enormous amounts of water is discharged, evaporated and lost due to over irrigation practices given to the plantations in a short period of time (FAO, 2008b; EAD, 2009).

As declared by the EAD (2009), agriculture in the UAE is "living on borrowed time", including palm plantations. Groundwater, which is the main irrigation resource, would be vanished within the next 16 to 36 years. The year 2030, could be the first year with no more supply from groundwater aquifers. At the same time, the required supply from groundwater resources, that will be needed to cover palm plantations only, will reach at least 640 million m3 in 2030, as illustrated in Table 2 (estimates based on EAD, 2009). Therefore, if there will be no more supply from groundwater resources, what will be the destiny of the date palm trees in the country?! Which water resource can cope this shortage in watering resources?

At the same time, the population, based on all socio-economic indicators, is expected to at least doubled from 5.8 million in 2007 to be over 12 million in 2030 (World Bank, 2012). Consequently, the required dates production needed to reach food security, as well as, palm trees watering requirements will be at least doubled in 2030 comparing to 2007, as represented in Table 2, if the consumption rates stayed the same as it was in 2007 (estimates on date production based on EAD, 2009).

Similarly, available treated domestic wastewater in the country, which is the most feasible solution comparing to desalination sea water and currently used only for landscaping, will be doubled in 2030 if the life style of 2007 continued (related estimates represented in Table 2 based on FAO, 2013). It worth mentioning that, even if all treated domestic wastewater in 2030, estimated to be 578 million m3/year without any disposal into sea or desert, will be accepted from the public community to be used for irrigating date palm trees, it will not be enough to cover the required palm watering requirements, estimated to be 640 million m3 from groundwater resources, excluding leaching requirements.

Recommended solutions

All the indicators show that palm plantations in the UAE and dates production are expected to continue in a sharp increasing trend. Creating a very challenging situation related to the huge amounts of water needed for the irrigation, with further shortage in the available water resources in the country when the groundwater aquifers will be vanished.

Since, the groundwater aquifers, which is the main irrigation resource, have specific life time expectancy, this problem can't be solved totally, however, it could be best mitigated through different ways including in the first place irrigation management and strategic planning.

Irrigation management could be done 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. Irrigation scheduling for palm trees based on UAE climatic conditions is excellently illustrated in the FAO (2008b), and could be used as an ideal guidance by farmers. Besides, 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 (EAD, 2009; Schu¨tze *et al.,* 2011(.

The strategic planning and development option could be done through combination of four main strategic options; first, to take positive actions to reduce irrigation requirements (e.g. increase water use efficiency and water productivity). Second, to use the expensive desalinated water (costs $1.75/m3). Third option, is to irrigate with mixture from saline water and brackish water mixed up to acceptable limits. Fourth option, is to use treated domestic wastewater. Another essential strategic option is to develop the planning and development sector, through adoption and implementation of the best practices worldwide in water planning and development, such as, Australian's expertise (EAD, 2009)

CONCLUSION

The future of palm plantations in the UAE is very challenging, in terms of watering requirements. In 2030, the required supply from groundwater resources that will be needed to cover palm plantations will reach at least 640 million m3. At the same time, the groundwater aquifers, which is the main fresh water resource in the country, have 16 to 36 life time expectancy and will soon dry out. Leaving the enormous palm plantations, with irrigation requirements estimated to be 640 million m3, in very critical situation from watering requirements point of view.

Consequently, quick actions have to take place in order to save the future of this precious tree in this country. This can best be done through; first, irrigation management which include adoption of best agricultural practices, irrigation methods (deficit irrigation and irrigation scheduling) and optimization models. Second, strategic planning and development by reducing irrigation requirements, irrigate with mixture from saline water and brackish water and use treated domestic wastewater for irrigation.

Also, treated domestic wastewater application have to be based on priority use, and using the same to irrigate palm plantations; to reach food security, has higher priority comparing to landscaping. Furthermore, public community have to accept the treated domestic wastewater, with availability estimated to be 578 m3 in 2030, as a potential irrigation resource for date palm trees in the UAE. Finally, hard efforts have to be done at farms level; to make the farmers aware about the current facts, related to limited water resources, and to educate them with best irrigation methods and practices, in order to save the future of both the date palm trees and the agricultural sector generally in the UAE.

Finally, it's very clear from this review that, any further expansion in palm trees in the following years and in the agricultural sector generally, have to be 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.

References

ADSSC (Abu Dhabi Sewerage Services Company), (2007). ADSSC annual report 2007. Abu Dhabi, United Arab Emirates.

ADSSC (Abu Dhabi Sewerage Services Company), (2010). ADSSC annual report 2010. Abu Dhabi, United Arab Emirates.

Ahmed, I.A., Ahmed, A.W.K., Robinson, R.K., (1995). Food Chem. 54, 305–309.

Al-Hooti, S., Sidhu, J.S., Qabazard, H. (1997). Plant Foods Hum. Nutr. 50 (2), 101–113.

Al-shahib, W., and Marshall, R., (2003). The fruit of the date palm: its possible use as the best food for the future? International Journal of Food Sciences and Nutrition. 54, (4): 247-259.

Asano, T., Levine, A.D., (1996). Wastewater reclamation, recycling and reuse: past, present, and future. Water Science and Technology 33 (10–11), 1–14 (special issue).

Aslam, J., Khan, S., Khan, S., (2013). Quantification of water soluble vitamins in six date palm (*Phoenix dactylifera* L.) cultivar's fruits growing in Dubai, United Arab Emirates, through high performance liquid chromatography. Journal of Saudi Chemical Society. 17, 9-16.

Al-Zubari, W., (1998). Towards the establishment of a total water cycle management and re-use program in the GCC countries. Desalination. 120, 3-14.

Chao, C., and Krueger, R. (2007). The Date Palm (*Phoenix dactylifera* L.): Overview of Biology, Uses, and Cultivation. HortScience. 42, 5: 1077- 1082.

EAD (Environmental Agency of Abu Dhabi), (2009). Abu Dhabi water resources master plan. Abu Dhabi, United Arab Emirates.

El-Behissy, E.Y., King, R.D., Ahmen, M.M. & Youssef, A.M. (2001). Fate of postharvest-applied dichlorvos in stored and processed dates. Journal of Agriculture and Food Chemistry, 49, 1239–1245.

FAO (Food and Agriculture Organization of the United Nations), (1997). Irrigation in the near east region in figures. (water reports 9). Rome, Italy.

FAO (Food and Agriculture Organization of the United Nations), (1962). Dates. Pp. 391. Rome, Italy.

FAO (Food and Agriculture Organization of the United Nations), (2008a). Irrigation in the Middle East region in figures. (AQUASTAT Survey: United Arab Emirates). Rome, Italy.

FAO (Food and Agriculture Organization of the United Nations), (2008b). Proceedings of the Workshop on Irrigation of Date Palm and Associated Crops. Regional office for the Near East, Cairo, 27-30 May.

FAO (Food and Agriculture Organization of the United Nations), (2013). Aquastat: Data for United Arab Emirates. Rome, Italy.

Furr, J.R. and W.W. Armstrong. (1956). The seasonal use of water by Khadrawy date palms. Date Growers Inst. Rep. 33:5–7.

Ismail, B., Haffar, I., Baalbaki, R., mechref, Y., Henry, J., (2006). Physico chemical characteristics and total quality of five date varieties grown in the United Arab Emirates. International Journal of Food Science and Technology. 41, 919-926.

Lambiote, B. (1982). Some aspects of the role of dates in human nutrition. In: Proceedings of the First International Symposium on Date Palm. King Faisal University, Saudi Arabia, 23-25 March.

Murad, A.A., Al-Nuaimi, H., Al-Hammadi, M., (2007). Comprehensive Assessment of Water Resources in the United Arab Emirates (UAE). Water Resources Management. 21, 1449-1463.

MEW (Ministry of Environment and Water). (2005). Agriculture Information Center, Dubai, United Arab Emirates. http://www.uae.gov.ae/uaeagricent

Nixon, R.W. (1951). The date palm: "Tree of Life" in the subtropical deserts. Econ. Bot. 5:274–301.

Pedreroa, F., Kalavrouziotisb, I., Alarcóna, J.J., Koukoulakisb, P., Asanoc, T., (2010). Use of treated municipal wastewater in irrigated agriculture: Review of some practices in Spain and Greece. Agricultural Water Management. 97, 1233-1241.

Schu¨tze, N., Kloss, S., Lennartz, F., Al Bakri, A., Schmitz, G., (2011). Optimal planning and operation of irrigation systems under water resource constraints in Oman considering climatic uncertainty. Environmental Earth Sciences. doi: 10.1007/s12665-011-1135-4

Sheikh, B., Cort, R.P., Kirkpatrick, W.R., Jaques, R.S., Asano, T., (1990). Monterrey wastewater reclamation study for agriculture. Research Journal of the Water Pollution and Control Federation.

Sudhersan, C. and M. Abo El-Nil. (1999). Occurrence of hermaphroditism in the male date palm. Palms 43:18–19, 48–50.

Tortajada, C., (2007). Water Management in Singapore. International Journal of Water Resources Development. 22 (2): 227-240.

UAE Yearbook, (2006). Ministry of Information and Culture, Abu Dhabi, United Arab Emirates.

UAE Yearbook, (2010). Ministry of Information and Culture, Abu Dhabi, United Arab Emirates.

Van der Hoek W, Ul-Hassan M, Ensink JHJ, Feenstra S, Raschid-Sally L, Munir S, Aslam MR., (2002). Urban wastewater: a valuable resource for agriculture. International Water Management Institute Research Report. 63, Colombo.

World Bank, (2011). Introduction to wastewater treatment processes. Washington.USA.

World Bank, (2012). World development indicators: Data for United Arab Emirates. Washington.USA.

World Bank, (2013). Annual freshwater withdrawals, total (billion cubic meters): Data for United Arab Emirates. Washington. USA.

Wrigley, G. (1995). Date palm, p. 399–403. In: J. Smartt and N.W. Simmonds (eds.). Evolution of crop plants. 2nd ed. Longman Group, Essex, UK.

York, D.W., Holden, R., Sheikh, B., Parsons, L., (2008). Safety and suitability of recycled water for irrigation of edible crops. In: Proceedings of the 23rd Annual Water Reuse Symposium,Water Reuse Association, Dallas.

Zaid, A. and P.F. de Wet. (2002). Climatic requirements of date palm, p. 57–72. In: A. Zaid (ed.). Date palm cultivation. Food and Agriculture Organization Plant Production and Protection Paper no. 156. Food and Agriculture Organization of the United Nations, Rome, Italy.

Tables

Table 1: Assessing water demands by agricultural sector (million m3/year) in the UAE.

Year	Agriculture
1990	950
1995	1,300
2000	1,400
2005	3,323[a]
2010	3,320[a]

Source: Murad *et al.,* 2007; except a: FAO, 2013.

Table 2: Summary of important figures in 2007 and estimations for 2030 in the UAE.

Factors	2007	2030
Population (million)	5.8	> 12
Dates Production (tons)	595,000[a]	> 1,190,000
Watering requirements for date palms from groundwater resources (million m3/year)	320[b]	640[b]
Groundwater supply for date palms irrigation (million m3/year)	320[b]	0.0[b]
Total available domestic wastewater (million m3/year)	289	578

a: estimated value for 2005. b: leaching requirements are excluded

Figures

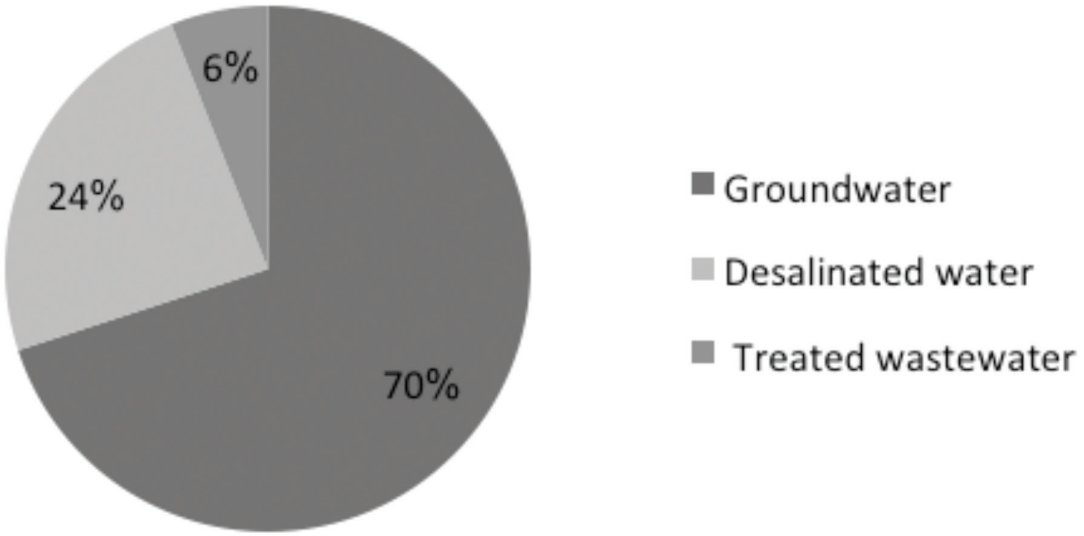

Figure 1: Water resources in UAE (Source: FAO, 2008a).

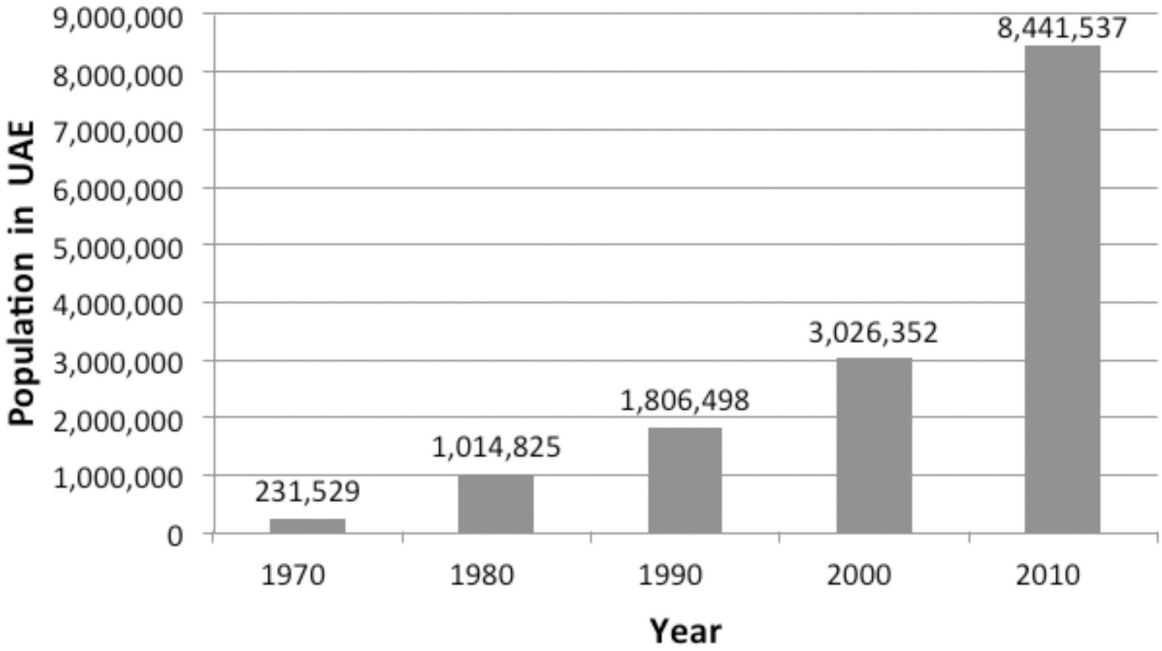

Figure 2: Population growth in UAE (Source: World Bank, 2012).

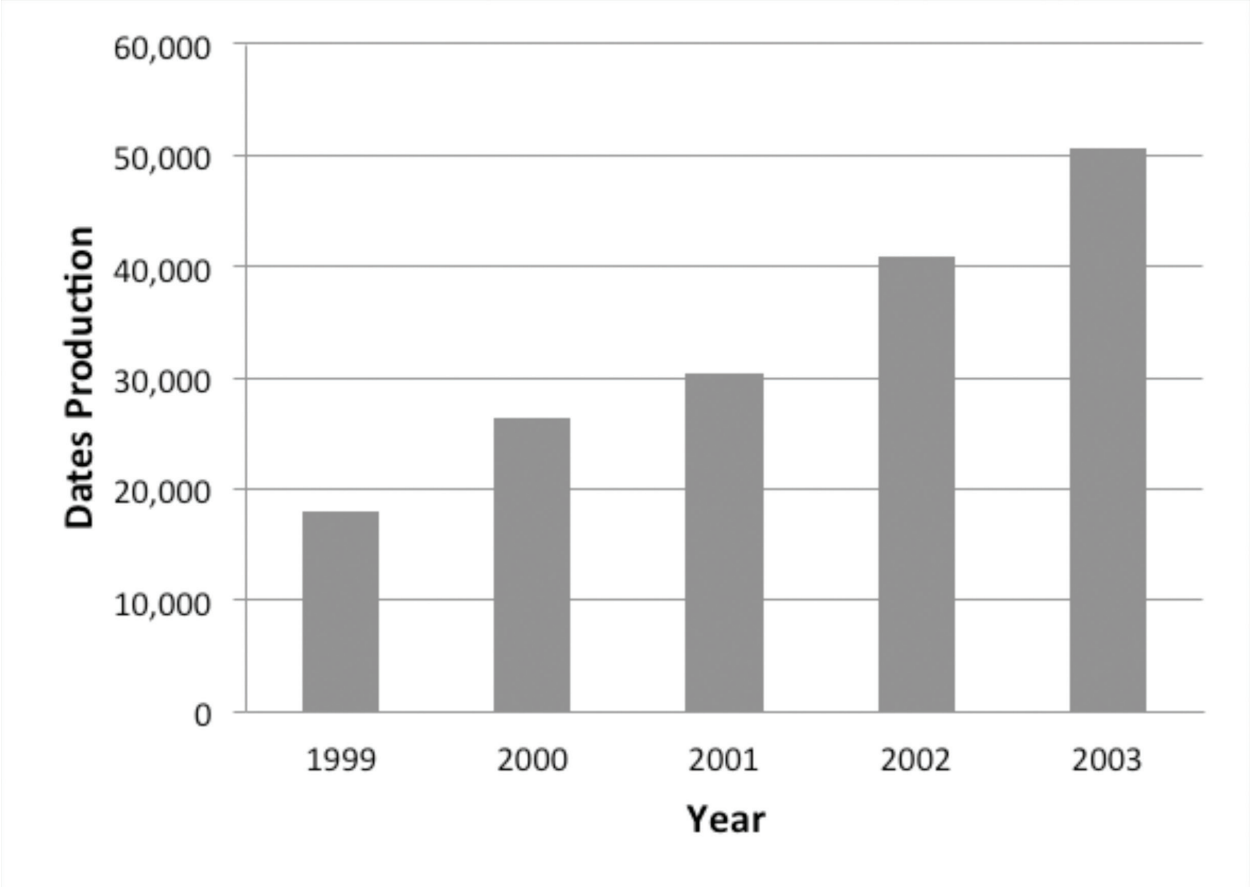

Figure 3: Dates production in the UAE (Source: FAO, 2008b).