The role of dams in securing the surface water in the northern and eastern parts of the United Arab Emirates (UAE)

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Abstract The scarcity of water resources in the United Arab Emirates (UAE) hinders its sustainable development. In order to improve this situation, decision makers initiated an integrated water resources management (IWRM) strategy to meet the increasing demands of water. One of the important strategies that is suitable for this arid region is the construction of different sizes of dams, mainly in the northern and eastern parts of the UAE. Some events of rainfall could generate flash floods during heavy and intense periods of rain of short duration. The surface water resulting after rainfall events is secured by building dams. The increasing water levels of boreholes downstream of the dams confirmed that a recharge to the aquifers has occurred. This paper is aimed to assess the important roles of dams on managing water resources and maintaining the security of surface water in the northern and eastern parts of the UAE.

Key words dams; surface water; United Arab Emirates; water resources

INTRODUCTION

The United Arab Emirates (UAE) is among those countries which have suffered from a shortage of water resources. The reduction of water quantity in the main aquifers of the UAE has led to serious problems. These problems include: lowering water levels, reduction of groundwater quantity, and groundwater deterioration. The continuation of these problems will affect the development and sustainability of water resources. The country has developed economically during the last few years and the population has started to grow every year. Due to the rapid economic developments in different emirates, the intense and regular immigration to the country has increased and continues to increase. As a result of this growth, water demands for domestic, agricultural and industrial activities have been significantly increased. The groundwater abstraction was 800 million m³ in 1997 and this amount of water was used to meet the agricultural demands. However, the municipal demands were estimated at 248 million m³ in 1997, of which about 70% was met by desalination plants, and the remainder by groundwater. The industrial demand of water was about 28 million m³ in 1997 (FEA, 2002). This has added enormous stress on groundwater.

The UAE is characterized by extreme aridity with low amounts of rainfall and high evaporation rates, which cause low rainfall recharge. Water demands have exceeded natural replenishment and groundwater became depleted in many regions causing groundwater deterioration and reduction of groundwater. Therefore, conventional water resources have become limited and shortage of water approaches crisis point.

Significant efforts have been initiated during the last few years in the country to solve the problem and to develop water resources in order to improve the current water situation. The current deficiencies in water resources require strong action from decision makers in order to come up with proper management options, and one of these actions was constructing different sizes of recharge dams in different parts of the country for better use of water resources and improvement of the storage of groundwater. The main objective of this paper is to assess the important roles of dams on managing water resources in the UAE.

PHYSICAL SETTING

UAE is located to the south of the Arabian Peninsula and to the southeast of the Arabian Gulf (Fig. 1). The country occupies an area of about 82 880 km², and the approximate population was 3.75 million inhabitants in January 2003. The steady increase of the population in the country can be attributed to strong economics, healthy social development, and political stability. The country is characterized by scanty rainfall and hot climate. The annual rainfall varies from 60 mm in the Liwa area to about 160 mm in the mountainous areas of the northern and eastern parts of the country (Ministry of Information and Culture, 2004). Most of the rainfall occurs during the winter season and occasions of heavy rain could happen during the summer and spring. The temperature ranges from 23°C to 50°C during spring and summer seasons, respectively (FAO, 1997; Rizk, 1999). The rate of potential evaporation in the country can exceed 2000 mm year⁻¹ (Jones & Marrei, 1982).

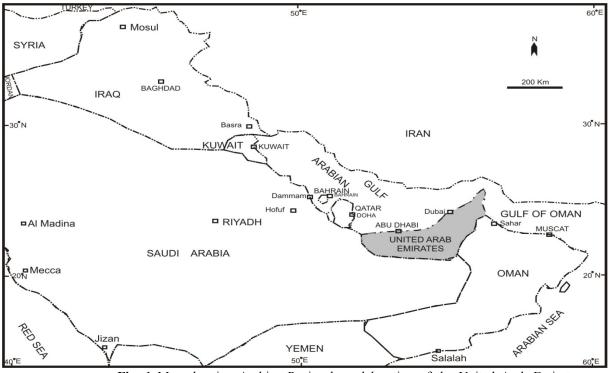


Fig. 1 Map showing Arabian Peninsula and location of the United Arab Emirates (modified from Alsharhan *et al.*, 2001).

UAE DAMS

The steady increase of the water demands in the UAE continues to grow due to strong and rapid economic development and a safe and healthy environment. At present, integrated water resources management has been implemented over a wide range to avoid serious problems that might occur and affect future supply of water. Building dams is one of the important actions toward sustainability in water resources management. In UAE, the types of dams can be classified into earth and concrete dams (Alsharhan et al., 2001). It was found that most of the dams built by the Ministry of Environment and Water (MEW), which are concentrated in the eastern and the northern parts of the country, are earth-type dams with the exception of two which are concrete dams. These two dams are Al Ghail in Ras Al Khaimah and Gulfa in Ajman and this might be attributed to the fact that the cross-sectional area of the stream channel is narrow, while these earth dams are constructed from available materials in plain areas. The first three dams established in 1982 by the Ministry of Environment and Water in the UAE are Ham, Bih and Gulfa. The Ministry of Presidential Affairs started to utilise their dams in 2000. There are about 114 dams constructed in the country with a total capacity of about 114 146 800 m³ (Table 1) (MEW, 2005).

The capacity of these dams varies from one dam to another and these variations are based on rainfall amount and number of dams. The size of UAE's dams differs and it is noticed that the size of dams constructed by the Ministry of Environment and Water is large, while the size of these dams established by the Ministry of Presidential Affairs is small. This can be observed from number of dams built by these two ministries and their total capacities. The largest volume of water accumulation designed in Ham dam is about 7 700 000 m³, while the lowest volume of water accumulation designed in Gulfa is about 120 000 m³. It is also noticed that the dams constructed by the Ministry of Presidential Affairs have the lowest capacity of water accumulation which is about 13 484 000 m³, although, the number of dams constructed is considered the largest. The height of these dams varies from 3 m in Al Ghail Dam of Ras Al Khaimah to about 33 m in Al Wurrayah Dam of Fujairah. Also the length of these dams varies from one to another, based on the size of area connected to the dam. The length can range from 2800 m in Ham Dam of Fujairah to about 26 m in Al Ghail Dam. The physical parameters differ from one dam to another. The dams constructed by the Ministry of Environment and Water are concentrated on eastern and northern parts of the UAE in Fujairah and Ras Al Kamiah, where the rainfall is high compared with other parts of the country (Fig. 2). The mountainous areas received an average of 150–160 mm year⁻¹ of rainfall, while the average rainfall in the coastal areas is between 110–130 mm year⁻¹ (Bakhit, 1998).

Organization	No. of dams	Capacity (m ³)
Ministry of Environment and Water (MEW)	21	47 762 000
Municipalities	35	52 900 000
Ministry of Presidential Affairs	58	13 484 800
Total	114	114 146 800

Table 1 The estimated number of dams in the UAE until September, 2005 (MEW, 2005).

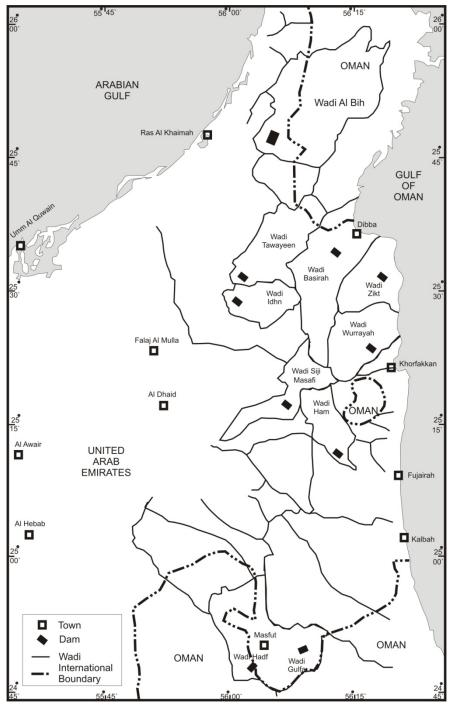


Fig. 2 Location map showing major dams and wadis in the eastern and the northern parts of the UAE (MEW, 2005).

DAMS AND WATER RESOURCES MANAGEMENT

During the last few years, withdrawal of water from main aquifers in the UAE has increased drastically in order to meet water demands. It is expected that the water demand will continue to rise annually. Man, through agricultural, industrial and domestic

uses has played a significant role in reducing the amount of water in the main aquifers. This causes catastrophic problems to the availability of water resources and introduces other problem such as seawater intrusion. Freshwater resources are reduced and unevenly distributed. Decision makers in the country started to resolve this problem to save enough freshwater for future generations. Constructing different types of dams of different sizes is a major step toward to achieving sustainability of water resources and growth of economical development. This action will result in the better use of runoff water.

Dams in UAE have been constructed to conserve water resources, feed or recharge the aquifers and natural springs, and protect from flood damage. Water held behind the walls of dams recharges the aquifer. As a result, water levels will continue to rise significantly in the affected area. The highest increase in water level downstream of the dams was 49.82 m in Gulfa Dam in 1994, whereas the lowest rise in water was 0.21 m in Ham Dam in 1984. The total water accumulation of Gulfa Dam associated with the highest water level rise is about 0.102 million m³ and this might be ascribed to infiltration of runoff stored behind the dam and the affect of rainfall that precipitated in the Oman because this dam has a border with Oman. While there was no water accumulation in Ham Dam in 1984 and there was a slight rise in water level, this could be due to the quick infiltration of a small amount of rainfall (31.9–46.1 mm) that was witnessed in the area during 1984. The same observation was recognized in many dams during different years. Increasing water level after flood events fluctuates seasonally for all the dams studied, indicating that the period of recharge to main aquifers has happened (Fig. 3). In general, the fluctuation is based on rainfall amount. magnitude of recharged water, water accumulation behind the dams, and silt sedimentation. The relationships between water level rise (m) for downstream wells associated with each dam and total water accumulation have been established (Fig. 4).

These relationships showed that the water level rise is correlated with water accumulation in some years, indicating that the infiltration of rainfall has occurred, whereas in other years this relationship is absent and this is related to the silts and sediments deposition at dam sites. This is confirmed when a relationship between water level rise and total rainfall amount for Al Bih Dam in Fujairah was constructed. This plot showed that the relationship between water level and rainfall amount is slightly correlated indicating that recharge was happened in some years and the sediments and depositions of silt reduced the infiltrated rainfall in another years (Fig. 5). The estimated annual erosion of the sediments in the UAE is about 442 thousands m³ (MEW, 1992). Accumulation of these sediments at dam sites may greatly reduce the water infiltration rate and minimize the water level rise or even reduce the level of water in some cases due to the pumping without infiltration of accumulated water. The water accumulation can be utilized in future if this water stored. However, water is also lost due to the high evaporation rate in the country. In order to increase the infiltration rate, periodic maintenance to those dams and removal of the silt and sediments from dam site should be assessed after each flood event. Another objective of constructing various dams in UAE is to protect the areas from flood damages. During the last few decades, the rainfall in the UAE has increased considerably (Al-Shamsi, 1993 & Ministry of Communication, 1996). This increase caused accumulation of water behind the dams. If the dams had not been constructed in these locations, the heavy intense rainfall could cause serious disasters to property and affect the economic development of the country.

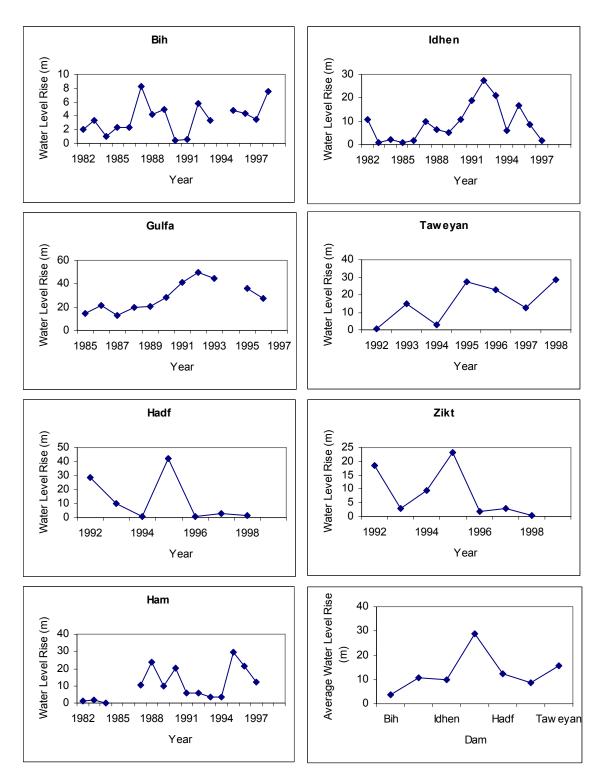


Fig. 3 Water level rise for downstream wells at dam sites for selected dams in the northern and eastern UAE.

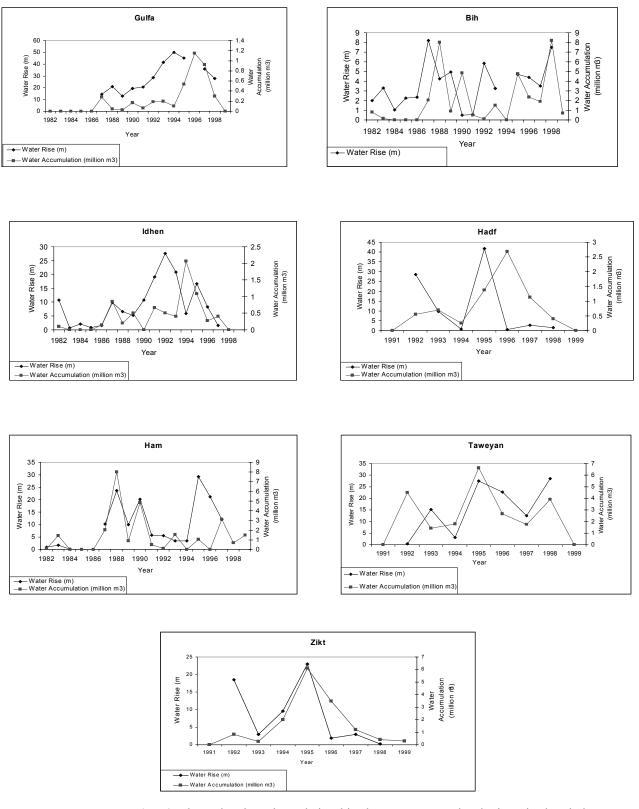


Fig. 4 Plots showing the relationship between water level rises in boreholes downstream of the dam and water accumulation for selected dams in the northern and eastern parts of the UAE.

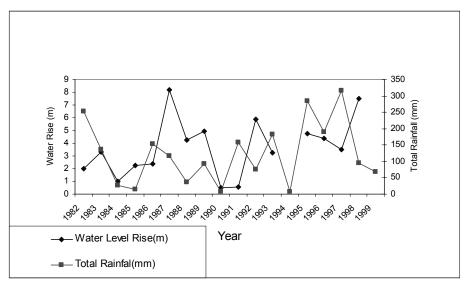


Fig. 5 The relationship between water level rise (metre) for borehole downstream Al Bih Dam and total rainfall (mm) in Ras Al Khaimah Emirate.

CONCLUSIONS

The water resources in the UAE are limited and this precious resource has continued to deteriorate and reduce significantly due to heavy consumption from the main aquifers. Demands for water have increased in the country to provide a sufficient amount of water for domestic, agricultural and industrial uses. Events of heavy rainfall are recorded in the country and in order to better manage the rainfall, dams at various locations have been constructed. The major objectives of these dams are to recharge and feed the aquifers, and protect the areas from flooding. Rainfall is seen to recharge the aquifer as increasing water level is observed. The water level rise is correlated with water accumulation in some years, indicating that infiltration of rainfall occurred. However, in other years this relationship is absent and is related to the deposition of sediments and silts at the dam site. This can greatly reduce the rate of infiltration and minimize the water level rise, even if there is rainfall. For better utilization of water accumulation behind dams, the periodic removal of sediments from dam sites will help to increase the filtration rate and significantly increase water level.

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