AN OVERVIEW FOR THE WATER RESOURCES OF THE UNITED ARAB EMIRATES

Mamdouh NOUH
Halcrow International Partnership
P. O. Box 673, Sharjah, UAE
Email: NouhM@halcrow.com

Abstract

The water resources in the United Arab Emirates, as a Middle East arid country, were reviewed. Both conventional and non-conventional water resources were discussed from the view point of its feasibility and sustainability. Conventional groundwater resources; including groundwater, falages and springs, and surface water are insufficient to meet existing and future water demands. Non-conventional resources; including treated wastewater, desalinated water, and rainwater harvesting are resources that may be used to satisfy the water shortage for many years to come. Deep groundwater, import of water, and virtual water are less feasible than other non-conventional water resources. A comprehensive approach that integrates the various water resources is recommended as it provides sustainability with least costs.

1. Introduction

The United Arab Emirates is composed of seven Emirates: Abu-Dhabi (67,340 km^2), Dubai (3,885 km^2), Sharjah (2,590 km^2), Ra's al-Khaymah (1,684 km^2), Umm al-Qaywan (777 km^2), Ajman (259 km^2), and Al Fujayrah (116 km^2). The country lies in the south-eastern corner of the Arabian Peninsula to the north of Oman and Rub al Khali Desert. It can be divided into a number of regions. These are: the Mountainous region in the middle and east, the Batinah Coastal Plain, the Sand Dunes Areas in the centre and south, the Buraimi Oasis and the Western Coastal Plain along the Arabian Gulf (Figure 1).

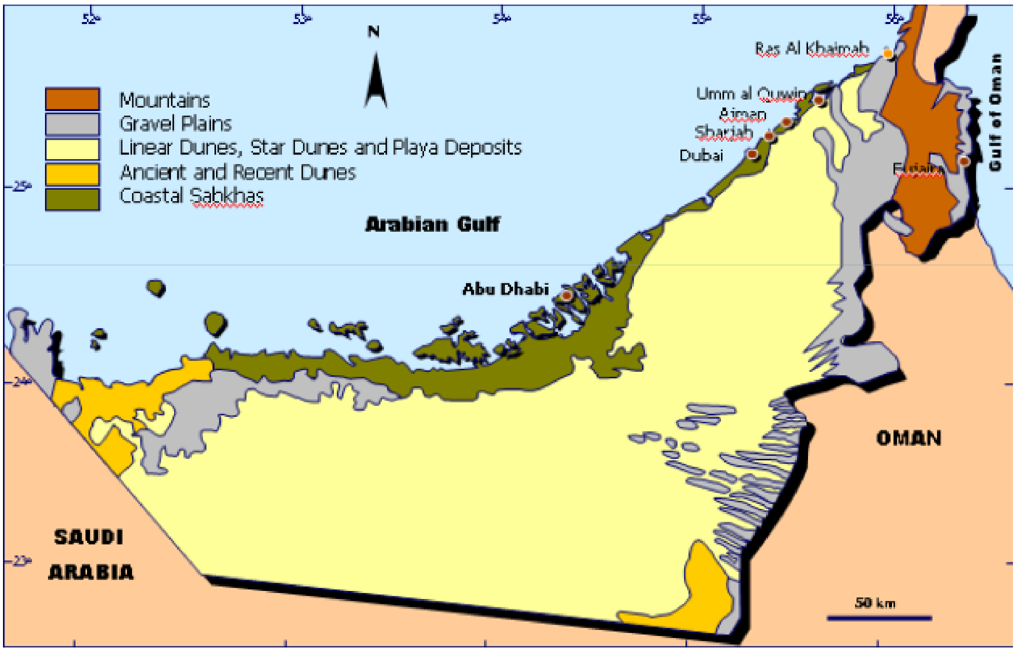

Figure 1: Physiographic Units of the United Arab Emirates

The mountain ranges, which run south from the Musandam Peninsula, are basically Tertiary folded mountains with an extremely complex and unidentified structure. Rock units from Palaeozoic to Upper Cretaceous outcrop in the mountainous region of the United Arab Emirates. They show a considerable amount of similarity to the rock units exposed and existing in the subsurface of the Omani mountains. Mentioned rock units belong to the Hawasina Group and the Sama'il Nappe Group. The former consists of a base of conglomerates, overtopped by calcareous shales with a succession of limestone conglomerates, cherty limestone and chert of mixed ages. The Mama'il Nappe Group consists of gabbros, basic dykes, and intrusives. Palaocene and Eocene rocks were deposited after these rock units. Rock units have been subjected to major erosion activities, and vast outwash gravel plains and alluvial fans have been formed.

2. Meteorology

The eastern part of the country is mountainous, with elevation that reaches 1,000 m (a.m.s.l.). With the exception of the mountain ranges, the Emirates fall in the tropical, hot-desert climate zone. There is a marked difference between climate of the coastal areas, inland, and the mountainous and high elevated areas. Mean daily temperature is 27.6°C, and can be well above 42.0°C coupled with high humidity during summer. Contrarily, the climate of the mountainous areas can be described as mild with mean winter (December – February) temperature is about 20°C.

The direction of the dominating wind can be southerly, south-easterly, westerly, north-westerly or northerly. The summer winds are usually laden with moisture. The rainfall is extremely variable with time and space. The rainy season is from November to April. The country is hit by thunderstorms due to the instability of air masses over Saudi Arabia. Rainfall is often accompanied with thunderstorms causing heavy rainfall in a matter of few hours. This type of rain is responsible for flash floods, which may cause damage and lead to serious soil erosion. The average depth of rain varies from 235 mm in the mountainous area to between 20 and 90 mm elsewhere in the country, with large variations from year to year. The mean annual rainfall is shown in Figure 2.

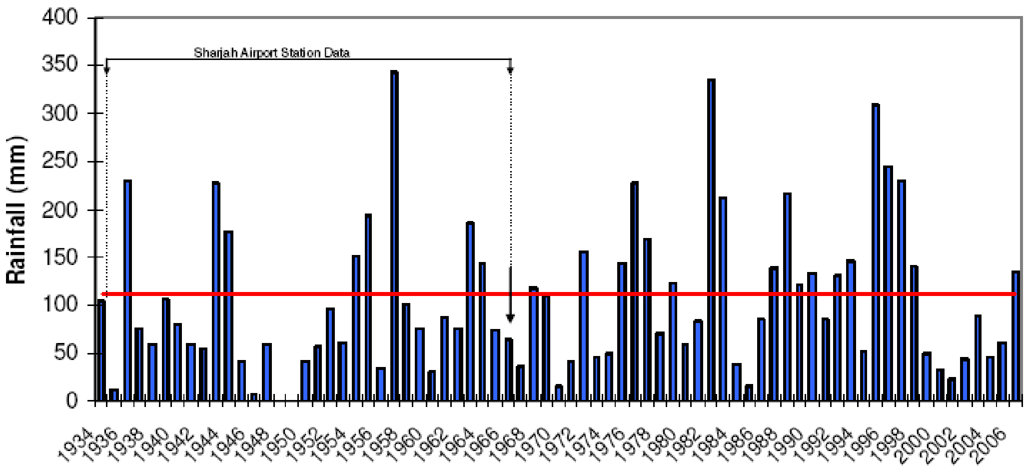

Figure 2: Yearly Variation of Rainfall in the United Arab Emirates

3. Surface Water

There are 27 major wades in the United Arab Emirates. The central area drains its water to the west; the southern area and the east coasts of the country drain to the east; the western slopes drain to the north and the rest drain their waters to the south. The principal drainage areas are shown in Figure 3.

The average annual volume of water carried by wades is about 150 millions m^3. Most of the surface water is discharged into the sea, seeps through the ground and joins the aquifers and collected in aflag (underground conduits reaching the water table and collecting groundwater in its higher part and conveying it to the lower part). Currently, about 45 falages are used for irrigation.

To avoid the loss of surface water to the sea, a number of recharge dams were constructed. The capacities of 114 of these dams are shown in Figure 4.

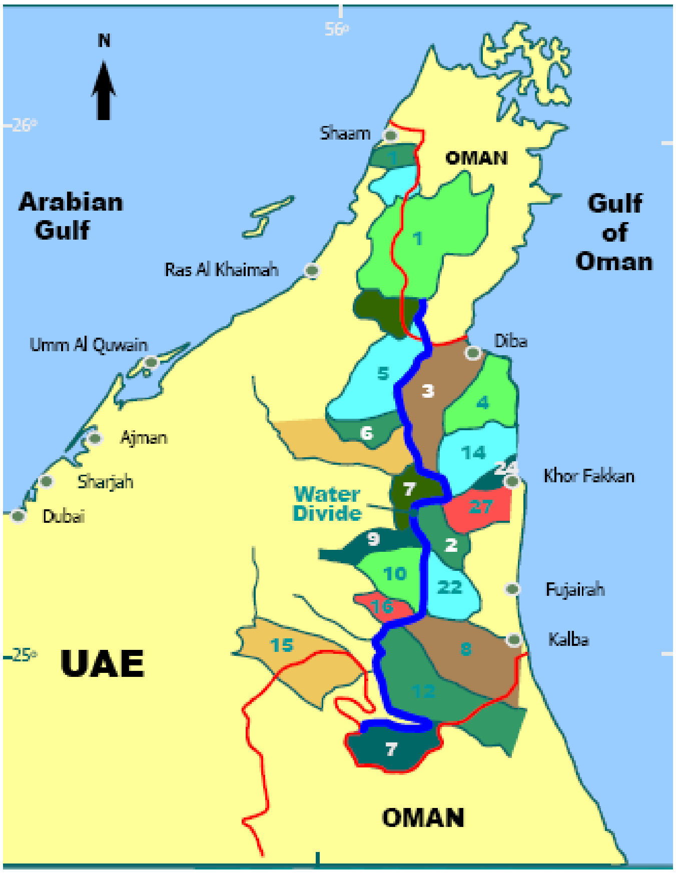

Figure 3: Drainage Basins in the U. A. E.

.

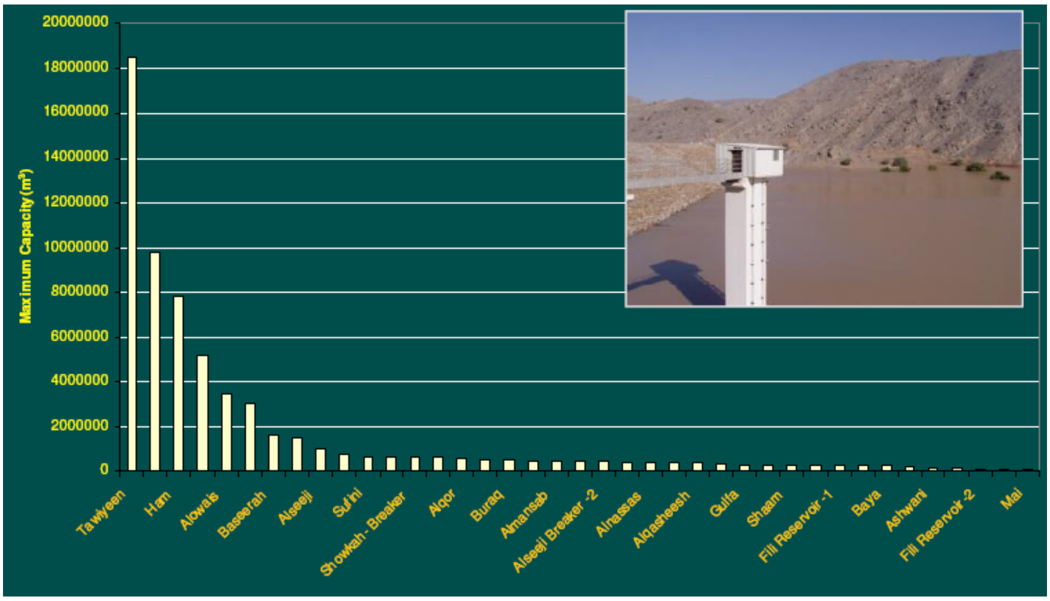

Figure 4: Capacity of Recharge Dams in the U. A. E.

4. Groundwater

Groundwater is the major natural water resources in the country. The main aquifer systems are shown in Figure 5, with potential movement as shown in Figure 6.

Figure 5: Main Aquifer Systems in U. A. E.

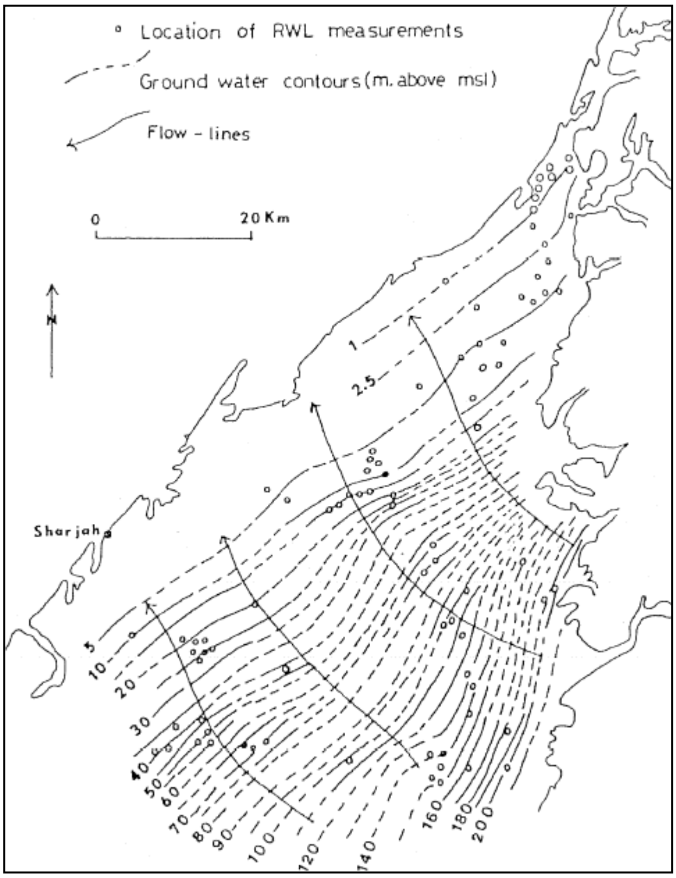

Figure 6: Groundwater Potentials in the U. A. E.

The aquifer systems are:

a) Alluvial aquifer system: It is composed of extensive terrestrial deposits of boulders, cobbles, pebbles, and sand. The total volume of water stored in these alluvial gravels is 5,280 x 10^{9} m^{3}.

b) The Batinah Coastal Plain Aquifer: It is composed of alluvial fan material consisting of coarse sand, gravels and boulders, ending up with fine-grained sebkha deposits in some locations. The yield of wells is high, and the depth of water table is usually shallow and a few meters above the sea level. The total renewable resources are adequate for development.

c) The Deep Carbonate Aquifer System: It is composed of thick carbonate rock sequences underlying the southern of Abu Dhabi. The aquifer is under artesian conditions with a hydraulic head at or near the ground surface.

The quality of groundwater is generally poor (about 10,000 ppm) and decreases with depth to reach 4,000 ppm. Better quality of water (1,000-1,500 ppm) can be encountered in shallow wells tapping the aquifers. However, decrease in quality is recorded recently due to salt water intrusion resulted from excessive and uncontrolled water withdrawals. Figure 7 shows typical changes in the water quality.

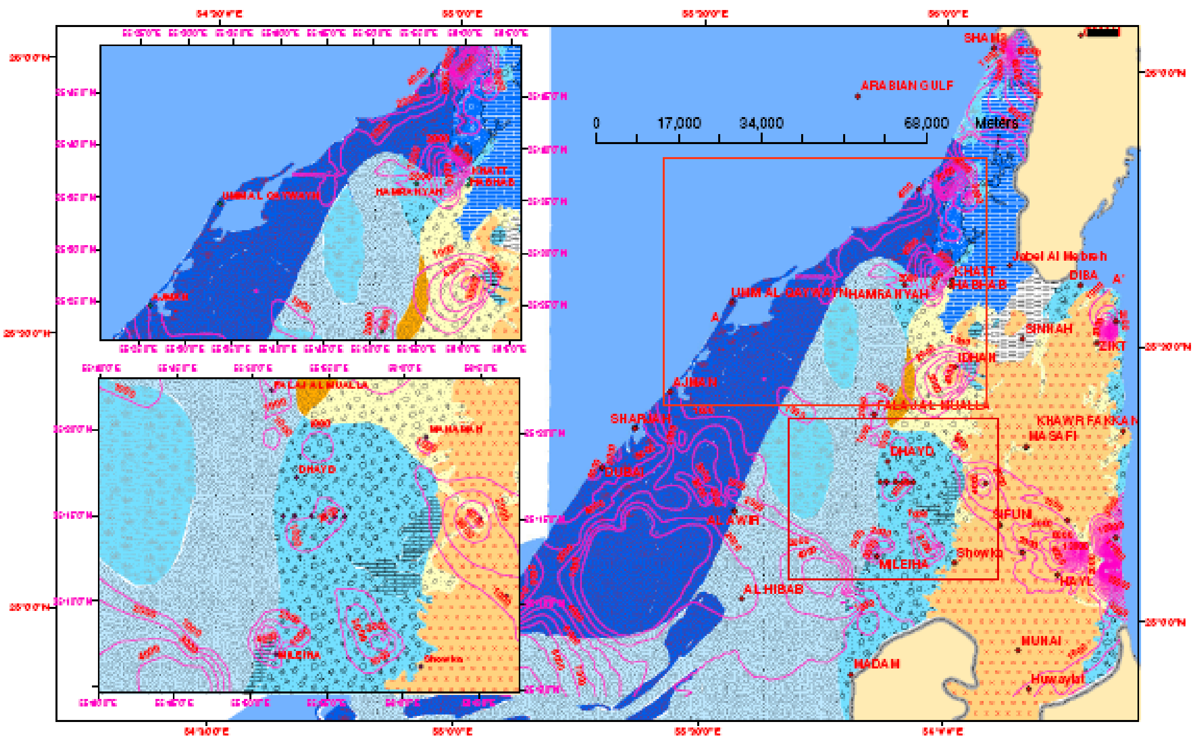

Figure 7: Increase in Groundwater Salinity Caused by Salt Water Intrusions

5. Existing Water Demand and Conventional Water Resources

As the renewable water supply is not sufficient to meet water demands of various sectors in the U. A. E., treated wastewater and desalinated water are used. The renewable water supply, as shown in Figure 8, is less than 250 m^3 /year/capita. The current water demand together with the existing use of water from various sources is shown in Figure 9. Inspection of Figure 9 indicates that the major water supply is from groundwater. However, due to the generally poor quality of groundwater, more emphasis was placed on the use of treated wastewater, among other non-conventional water resources.

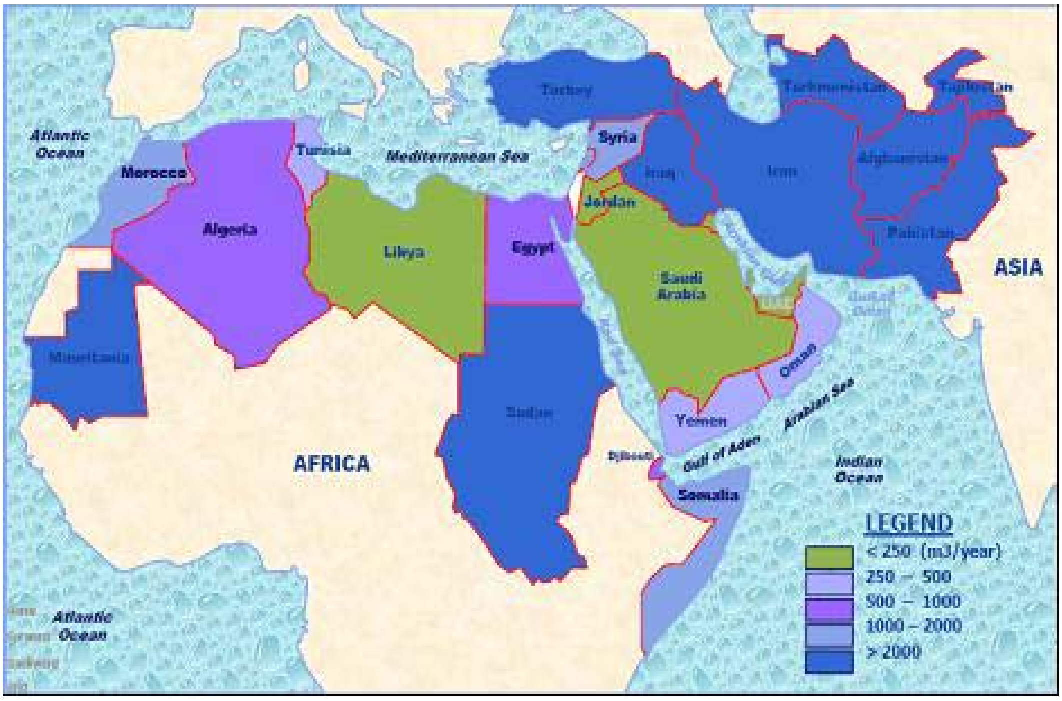

Figure 8: Renewable Water Supply per Capita

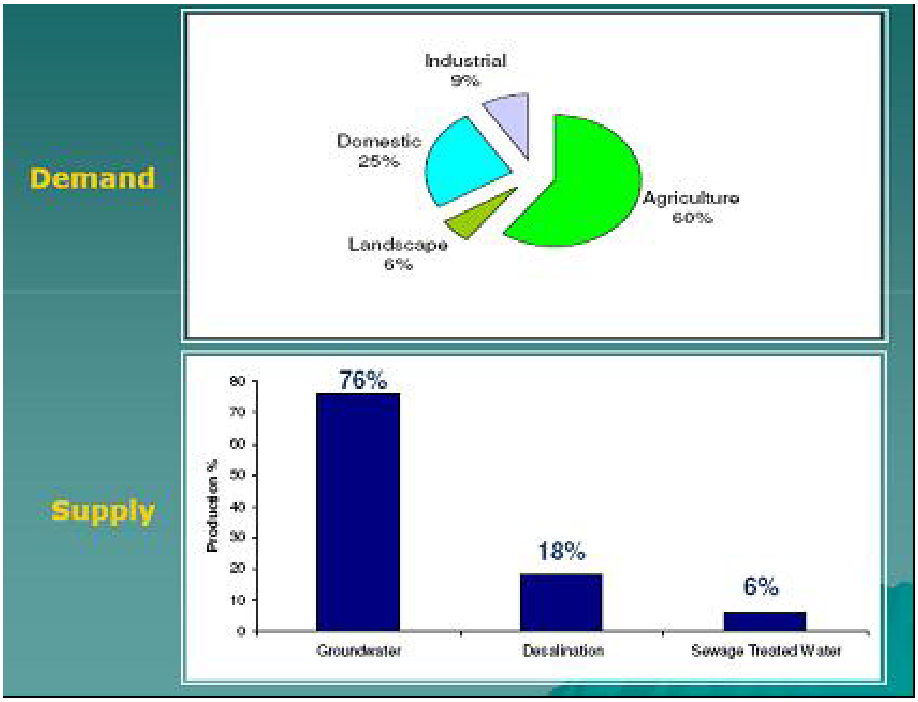

Figure 9: Current Water Supply and Demand of Water in U. A. E.

6. Non-Conventional Water Resources

In addition to treated wastewater and desalinated water, there are a number of non-conventional that may be used to meet the water shortages. These are:

a) Deep, Fossil or Non-rejuvenated Groundwater. This refers to withdrawal of deeply situated (hundreds of meters below ground surface) groundwater. Data collected from deep wells up to 1,000 m in the northern provinces indicated that the potential storage capacity of the deep groundwater reservoir is limited.

b) Transport of Water. This group includes inter-basin (trans-boundary) and intra basin transport. Initial investigations indicated that the costs of transporting this type of water are much higher than alternative methods such as desalination and wastewater reuse.

c) Rainwater harvesting and Cloud Seeding. Although this method is used in some other Arabian countries such as Jordan and Oman, no trial was reported on using the method in the United Arab Emirates. The reason for this is the small amounts of received rainwater (see Figure 3).

d) Virtual Water. This group includes import of goods, e.g. meat, rice, and sugar, which need substantial amounts of water to produce them. To produce one metric tonne of wheat, say, the farmer needs 1,000 m^3 of water. Importing a million tonnes of wheat is equivalent to importing 10^9 m^3 of water. Statistics gathered by FAO give an estimate of virtual water contained in food imports in 1994 in UAE. as 3.4×10^6 m^3.

7. Environmental and Social Impacts

In addition to the high unit price of the non-conventional water compared to the unit price of conventional water, there are some detrimental impacts to the environment and adversely affect the interest of society. The major undesirable impacts will be briefly reviewed in the following:

a) Quality of Treated Wastewater. The quality of treated wastewater must be acceptable for the purpose of use. Agricultural reuse of wastewater commonly results in an "actual risk" to public health, especially in developing countries.

b) Availability of Energy. The UAE. uses oil to operate desalinated plants. There is hardly any attention to other sources of energy like hydropower and solar energy. Desalination of water might be detrimental to the environment depending on the possibility of disposal of the waste.

c) Groundwater Abstraction. Abstraction of groundwater at rates exceeding the safe yield will lead to considerable drawdown. As a consequence, the lift head of the pumps withdrawing water will grow larger in time in the event of non-artesian aquifer. Consumption of fuel needed to pump water will keep increasing, and thus may have some effect on the environment and on the cost price of extracted water. It is likely to have salt water intrusion with negative effects on the extracted water quality.

d) Transfer of Water. The transfer to water scarce country, though a convenient solution to water scarcity problem, is a risky one. On one hand, the country transporting water might realize at a certain moment that she is in bad need of its own water for the interest of her own population. At such a moment, she will stop exporting all or part of what used to be tradable, excess water. Besides, at times of crises between water-exporting and water-importing nations, water trades could easily be brought into jeopardy.

e) Virtual Water. This aspect is in a certain sense similar to imported water, except that water in the former option is embedded in a diversity of communities, and in the later it is still in the liquid state. Both are easy options if prices are paid.

8. Conclusions

For countries in arid regions, in general, and the United Arab Emirates, in particular, treatment and reuse of wastewater can be the main, if not only, water resource whose quantity will continue to increase as more water, is used by urban/industrial sector, and can thus provide a rational and sustainable basis for a limited level of agriculture in such severely water short countries. The amount of treated wastewater may reach as much a 100 m^3/person/year which is enough water to meet most normal fresh food demands of the urban population. While desalination seawater presently costs at least one US dollar/m^3 and can rarely serve as an economically rational source of water for agriculture, treated wastewater is relatively cheap. Water harvesting of flash floods represents another source of fresh water for urban use. Water collection and treatment should adhere with the WHO guidelines for human health and environment protection. However, it would be wise for countries to make their own independent judgments in establishing health regulations for wastewater reuse and flash flood harvesting, free from the social, economic and political forces that shaped the American standards. Thus, governments can pursue wastewater recycling and reuse problems with a sense of confidence that they are promoting a multivalent strategy of water conservation coupled with environmental and public health protection.

An integrated approach is recommended. In the approach, social factors should be considered. The decision-maker should be able to consider resource allocation problem in terms of technically defined alternatives and to make investment decisions on the basis of the systematic integration of economic, environmental and social goals.

When multi-objective techniques are combined with macro-economic planning models, water development anjkjjd utilization are allowed to take place in accordance with social, environmental and economic objectives to yield the optimum integrated benefits. Such techniques have been successfully used in water-short regions of China in recent UN assisted projects.

9. Acknowledgements

The help received from the Ministry of Environment and Water for supplying data used for the analysis is very much appreciated. Appreciation is extended to Halcrow International Partnership (Sharjah, UAE) for providing facilities to compile information included in this paper.

10. References

Nouh, M., (2006) *Sustainablity of Water Resources in the Arab World*, ACSAD, Beirut.

Shahin, M., (2007) *Water Resources and Hydrometeorology of the Arab Region*, Springer.

UAE Country Report, *Water Resources and Their Utilisations in the UAE*, (1986) Document, the Panel on Water Resources and their Utilisations in the Arab Region, ACSAD-AFESD-KFAED, Kuwait.

USAID, *Water Resources Action Plan for the Middle East*, (1993) Bureau for the Near East, USA.