Indian J.Sci.Res. 17(2): 457 - 464, 2018 ISSN: 0976-2876 (Print)
ISSN: 2250-0138(Online)

STUDY OF WATER PRACTICES IN THE MIDDLE EAST COUNTRIES

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Abstract - The Middle East countries face an acute shortage of water due to arid climate and paucity of permanent lakes or rivers.Due to the increasing population and high standard of living people there is a huge increase in the demand of potable water.Most of the freshwater need in the Middle East is suppliedby desalination of seawater. Additionally, pressure on ground water extraction especially for irrigation has led to many wells being depleted or became saline. Many Middle East countries have increasingly been adopting new strategies for balancing their watershortages. Some Arab countries such as Saudi Arabia, Kuwait, Qatar, United Arab Emirates and Oman are suffering from water shortages. All these countries are trying to solve their water deficiency problem by using underground water and by heavily investing in water desalination process. Different countries like Palestine, Lebanon, Syria and Iraq are losing their grip on their national water. In terms of technological progress,Middle East countries has differentiated among themselves. In this respect, Turkey managed to develop itself and upgrade its social and economic conditions, but most of Arab countries are lacking behind.This paper shows the different water practices carried out in Middle East countries to conserve water, meet the demand and also preserve it for future.

Keywords - Water Demand, Desalination, Middle East countries.

I. Introduction

Water is the most precious and valuable natural resource in the world, vital for the growth of society, economy, agriculture, and industry. It is an analytical and comprehensive study from a socio-economic perspective that examines the water status facts, challenges, problems, and solutions in several Middle East countries including Lebanon, Jordan, Egypt, and Palestine. This paper discusses the various water resources present in the Middle East countries and their surface and ground water management, water supply and demands, rainfalls and precipitations, rivers, the water problems and their challenges, shortage of supply, and scarcity of rainfalls, the possible water solutions including water reuse and desalination.

Water shortages have been for a long time a serious problem in the Middle East as well as other parts of the world. The large and arid land of the Middle East has also been dependant on water which is provided by few rivers. This issue has been analysedand discussed by researchers and exploration associations [25]. None of the Middle East Countries enjoy water surplus with exception of Turkey. Fortunately, some Arab countries such as Saudi Arabia, Kuwait, Qatar, United Arab Emirates and Oman which suffers from water shortages enjoy surplus of fuel. These countries are trying to solve their water shortages by using underground water and heavily investing in water desalination. Other countries like Palestine, Lebanon, Syria and Iraq are losing their grip on their national water as a result of severe and perpetuated conflicts which have never ended since the First World War. Interms of technological progress Middle East countries are also differentiated [12].Water conservation strategies for the Middle East include reducing the use of potable water wherever possible, find alternative source of water for various water usage and increase the water efficiency. Many countries in Middle East and North Africa (MENA) have renewable water resources per capita of less than 1000 m^3/year; the level that defines water scarcity. Furthermore, the geographic distribution of these limited water resources is highly uneven. Over 80% of the region is desert and receives little or no rainfall. Water supply provisions under such conditions have always been a key policy issue. In the past it has been erratic rainfall and prolonged drought periods, widely believed to be manifestations of climate change, which have added a new dimension to the problem. This is particularly the case with Syria, Jordan, Israel and Algeria, which are facing severe water shortages. While supplies are constrained, the demand for freshwater over the years has continued to increase at a rapid pace. This increase in demand is a result of several interplaying forces. Across MENA, the agricultural sector is the prime consumer of water. In some countries, it accounts for over 80% of the total annual water withdrawals. Agricultural subsidies, improving irrigation and pumping technologies and the discovery of fossil groundwater reserves have helped expansion of agricultural activity. In recent times, there has been an increasing realization that the MENA region has to be more cautious when using a resource as indispensable and scarce as water. Planning agencies and water authorities feel that an incessant supply addition may not be the most pragmatic approach to deal with the water scarcity issue [24].

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II. Quantitative Literature Assessment of different Water Practices

Out of many Middle East publications the most important of the literature from 2000-2016is included.Table 1 shows the different practices in each of the eight Middle East countries. Depending on the available water resources, different methods of conserving water are adopted. In many areas of the Arabian Peninsula, direct use of flood water for irrigation or groundwater recharge is small compared to the amount of available surface runoff. Water spreading involves the percolation of excess water into shallow groundwater alluvial aquifer. This method is used in Saudi Arabia, Yemen, Oman and United Arab Emirates. There are many examples of indirect artificial recharge projects in the Arab region. In Qatar water is collected in shallow depressions andinjected into the underlying aquifers through wells [1].

Table.1: Water Resources in Middle EastCountries

COUNTRY	DESCRIPTION
Bahrain	Receives Groundwater by lateral under-flow from the Damman aquifer, which forms only a part of the extensive regional aquifer system. There are no rivers, perennial sterams or lakes and dams.
Iran	Rainfall is highly seasonal. Helmand River and Arax River are the main water resources of Iran.
Iraq	Fed by two major rivers the Tigris and Euphrates both of which originates outside of Iraq.
Israel	The sea of Galilee and the Coastal Aquifer are Israel's main water storage facilities, with a combined storage capacity of about 2 billion cubic meters. Coastal aquifer is used for artificial ground water recharge.
Jordan	Jordan River and Yarmouk River are the major water resources.
Kuwait	Due to lack of natural resources, desalinated water, treated waste water and limited groundwater are used.
Lebanon	The Jeita spring is the source of drinking water.
Qatar	Groundwater and Desalination plants are the main water resources.
SaudiArabia	It is the largest producer of desalinated water in the world. Six Desalination Plants are located on the East Coast and Twenty-One Plants on the Red Sea Coast.
Syria	The Euphrates, Tigris, Orontes, and Yarmouk Rivers are the water resources of Syria. Euphrates is the most important source which flows from Turkey through Syria to Iraq.
UAE	Desalinated Water and Ground Water are the main source of water in Abu Dhabi Emirate. Ground water is used for agriculture in Al Ain and Liwa and Desalinated sea water is mostly used for drinking purposes.
Yemen	Surface water is an important source for irrigation in Yemen. The annual precipitation averages 500mm-800mm at Western high lands and less tha 50mm at coasts of Red sea and Gulf of Aden.

III. Study of Water Practices

A.Bahrain

Bahrain is an arid country, where there are no rivers, perennial streams or lakes and also no dams. It receives groundwater by lateral under-flow from the Damman aquifer. Non-conventional methods such as desalination and treated sewage effluents (TSE) are increasingly used to meet the water demand for agricultural, municipal and industrial purposes. Pollution, seawater intrusion and other issues continue to thwart non-conventional water resource methodologies andservices, creating a bottleneck for the water demand.

Key stone publications about Bahrain:

- **Hana Husain Al-Maskati (2011) -** found that there is no effective strategy for integrated water resources management; there is a high level of Non-Revenue Water (NRW) (38%); and limited reuse of grey water and water use saving devices. It has been concluded that improving water use efficiency should be a priority due to the current high water supply costs. There is a need for establishment of a national WDM committee with the Water Resources Directorate & proper legislation that enforces the use of WDM oriented policies.
- **Mohammed Saleh Al.Ansari (2013)** - An integrated water resources management plan is necessary to ensure the sustainability of any water supply management plan that is put into action since current capacity-increasing measures may not be able to keep up with the growth of population and demand in future decades.

B. Iran

Iran is the second largest country in the Middle East (after Saudi Arabia). Drying lakes and rivers, declining groundwater resources, land subsidence, water contamination, water supply rationing and disruptions, forced migration, agricultural losses, salt and sand storms, and ecosystem damages are the modern water related issues of Iran, which was once recognized as the pioneer of sustainable water management for thousands of years.

Key stone publications about Iran:

- **KavehMadani (2014)** –suggests some crisis exit strategies like, water management should shift its mode from crisis (reactive) management to preventive (proactive) management. A proactive management paradigm cures the problem causes rather than its symptoms, manages water rather than controlling it, and benefits from effective nonstructural (soft) solutions (e.g., regulations, institutions, taxation, monitoring, population control) as much as it benefits from structural (hard or engineering) solutions (e.g., dam construction, water diversion, using irrigation sensors).
- **Ebrahimnia M., Jafari Bibalan B. (2017)** states that, the Iranian government has stepped forward to establish river basin organizations (RBOs), starting with the RBO Zayandeh Rud as a pilot. RBOs are considered as the appropriate institution for implementing integrated water resources management (IWRM), as they can act as coordinating bodies between the sectors and governance levels.

C. Iraq

Iraq is one of the Middle East and North African countries (MENA region), fed by two major rivers, the Tigris and the Euphrates, both of which originate outside of Iraq. These two rivers account for 98% of Iraq`s surface water supply. It is facing a serious water shortage problem, which is expected to be more severe in the future where the supply is predicted to be 17.61 Billion Cubic Meters (BCM) in 2025, while current demand is estimated to be between 66.8 and 77 BCM. It has been estimated that the Tigris and Euphrates river discharges will continue to decrease with time, and they will be completely dry by 2040.

Key stone publications about Iraq:

- **Nadhir. A. Al-Ansari (2013)** - reviews the serious water problems and suggests that prudent and quick measures need to be taken by the government to have a strategic water management vision, research and development, improving agriculture and sanitation sector as well as public awareness program to overcome this problem.
- **Abd-El-Mooty (2016)** - emphasizes the serious water crisis due to the decrease in the quantity and degradation in the quality of the water reaching Iraq by the two rivers Tigris and Euphrates. The present rate of water consumption for agricultural, municipal, and industrial use and the expectation of the increase in population size and expansion of the agricultural land in future until 2100 were analyzed. Some of the discharged fresh water to the Arabian Gulf represents a loss of fresh water. It is suggested that, this water can be saved by constructing a new dam, upstream in Basra city.

D. Israel

Israel has three main water sources: Lake Kinneret, the Mountain Aquifer and the Coastal Aquifer. Approximately two-thirds of the water in Israel originates & remains stored naturally underground and is pumped from wells or springs. The water shortage in Israel has resulted in use of alternate sources of water such as Sewage water that has been purified for irrigating crops, floodwater that is trapped by dams, and desalinated water. Storing this water and improving its quality using suitable technology will significantly increase the amount of available water.

Key stone publications about Israel:

- **Jonathan Chenowath (2010)** - has made a scenario analysis which suggests that by 2050 the population of Israel, will have grown from 17.2 million to between 21.1 and 38.5 million people. These population scenarios are compared to a range of water resource scenarios that consider the effect of climate change, a possible redistribution of the region's shared water resources as a result of a peace agreement. It shows that under all possible population-waterscenarios combinations considered the water resources of Jordan and Israel remain above the minimum threshold required for social and economic development.
- **Alan Tal (2008)** –has discussed thatIsrael's successful development of desalination facilities has led to changes such as, increased privatization of water production and supply as well as subsidy reduction and differential pricing for consumers.
- **SblomoKimchie (2010) -** has stated that the average pre-capita domestic water consumption has large variations (between 30-120 m^3/yr.). In order to supply the growing water demands, the available additional water resources which can help are desalination, water import, recycling of treated wastewater, increase rain by cloud seeding, increase storage of flash flood water, saving the national

water resources, subsidy reduction and differential rate pricing for consumers.

- **Dalit Ben-Zoor (2015)**–has discussed that Israel has developed advanced technologies that promote efficiency and conservation, like construction of desalination plants along the coast of Israel, runoff water purification through bio-filters, construction of reservoirs, fight against desertification, (Israel is the only country in the world where there are more trees today than there were 100 years ago) and construction of artificial wetlands and even water security (cyber). Now, Israeli water sector enjoys a surplus supply of water. It's success in water technologies, has made Israel to be considered a world leader in water management.

E. Jordan

Jordan is the fourth water poorest country in the world in a regional system defined by uncertainty and instability. Water supply in Jordan comes primarily from the Jordan river valley, groundwater, rainwater collection, and limited desalination plants.The unsustainable abstraction of groundwater and the depletion of groundwater aquifersare major problems facing the water sector in Jordan.

Key stone publications about Jordan:

- **Elaine Denny (2008)** – recommends to adopt a comprehensive, long-term water strategy that incorporates continuous updating of the water network, assessing whether mega projects offer the most efficient and sustainable use of limited funds, to shift production away from water-intensive & low-yield crops, step up enforcement of existing water laws, transfer of authority from Water Ministry officials to law enforcement officials and increase Jordan's bargaining leverage during water negotiations with other riparian states (Syria, Israel) and regional peace efforts.
- **Mousa S. Mohsen (2006)** – has suggested that recycled waste waterto be used for more agricultural purposes,desalination process and modern irrigation techniques should be adoptedin order to reduce the usage of water and to solve the water shortage problems in the country.
- **Saad Merayyan (2014)** –has stated that water shortage is due to large populationin Jordanand the water demand can be supplied by increasing the level ofpractices such as agricultural technology, recycling waste water, water treatment plant, etc.
- **Raed Abu Saud (2009**) - has discussed Jordan's vision for 2022, in spite of increased population and economic growth as, introducing an efficient and effective institutional reform, enforcing more effective management of groundwater and surface water, extraction from groundwater should be drastically reduced, limiting and reducing the water consumption, while not ruling out new supply infrastructure. The processes deteriorating water quality must be halted.

F. Kuwait

The country essentially has one limited natural water resource that is groundwater, while the majority of the country's demands are met by seawater desalination. No clear plans are being followed. The desalination and wastewater reuse are only bounded by economic considerations.

Key stone publications about Kuwait:

- **M. Al-Senafy (2008) –** analyses thedevelopment of water resources using a brief study and concludes that Supply management methods and Demand management methods are the alternative methods of water conservation.
- **M. Al-Senafy (2011**) **–** stated that to achieve lowering the consumption of fresh water in the country, distributor aerator method has been used. This study has proved that the way of saving water should have priority in water management.
- **F. M. Al Ruwaih (2011) –** states that groundwater level has declined and water quality is being deteriorated due to exploitation of the aquifers and also rainfall is seasonal. Therefore, the sustainable water resources for future is by using seawater desalination method. The recycled waste water can be used for irrigation and industrial purposes.
- **Vincent Kotwicki (2011)** presents a model which demonstrates that, by usingwastewatertreated by reverse osmosis (RO) for toilet flushing and watering the gardens, water consumption demand can be stabilized at present levels over a 20-year period.

G. Lebanon

It is difficult to accurately assess water resources availability in Lebanon because of limited and contradictory data. There are over 2,000 springs. Springs and groundwater are the main sources for drinking water supply in Lebanon. 4 main rivers flow entirely inside Lebanon and 2 important rivers are shared 1 with Syria and 1 with Israel. Even though Lebanon is water-rich compared to Jordan, Israel or the Damascus, the country's per capita renewable water resources are below the threshold of water poverty set at 1,000 cubic meter per capita.

Key stone publications aboutLebanon:

- **Sene. K. J. (2009) -** highlights that, flows in the 1960s, were well above average, and due to the high inter-annual variability in flows, records of many decades are required to adequately define the aspects of the flow regime. Therefore, it is necessary to resume hydrometric monitoring in Lebanon, in order to characterize and manage existing water resources adequately and to detect any future trends in flow behavior, which may arise from climate & land use changes and changing patterns of demand.
- **El-Fadel. M (2010)** examines increased pressure on Lebanon's water resources requiring the formulation and implementation of a comprehensive management plan to meet future water demands. Water resources are described with the corresponding present and future water balance, environmental stresses, and constraints facing the water sector in Lebanon.
- **Shaban A. (2011)** has discussed that agriculture has a major role in exerting pressure on water resources. Therefore, to improve the efficiency of the whole agricultural system it is recommended to adopt sustainable agricultural practices such as organic farming, suitable crop rotations, etc. and gradually replace surface irrigation with systems as drip irrigation or sprinklers, adjust irrigation schedules and water quantities according to the increasing crop water demand.

H. Qatar

Qatar is situated midway along the western coast of the Arabian Gulf. It consists of flat rocky surfaces including some hills which reach an altitude of 100 m above sea level. The majority of the country is sandy desert covered with scrub plants and loose gravel. Quatar's main source of water is desalination of seawater for drinking water supply and groundwater abstraction for agricultural purposes.

Key stone publications about Qatar:

- **M.A. Darwish (2012)** – has analyzed all the methods of increasing water resource such as, Dual distribution sysem, TWW technology, increase the storage capacity and Integrated water managemet plan, by which the water scarcity problems can be solved.
- **Saleh Al-Nabit (2016)** gives a comprehensive overview on water sources and uses, in the State of Qatar. The main source of water is desalination of seawater for drinking and groundwater for agricultural purposes. The re-use of treated wastewater has already become an important alternative source of water for irrigation. The available statistics shows that, there is still potential to increase the re-use of treated wastewater. All these measures together will contribute to water security and food security and to sustainable development according to the Qatar National Vision 2030. This also gives an important step to support knowledge based decision making in the water sector.

I. SaudiArabia

Saudi Arabia is one of the driest regions in the world and has nearly 27 desalinated plants.Due to lack of rainfall severe water demand issues has been found. About 50% of drinking water comes from desalination, 40% from the mining of non-renewable groundwater and only 10% from surface water.

Key stone publications about Saudi Arabia:

- **Khodran H. Al-Zahrani (2011) –** hassuggested to conserve water resources by using managerial approach of WDM (Water Demand Management). By comparing other water efficiency methods WDM is found to be efficient to increase the water supply in Saudi Arabia.
- **Omar K. M. Ouda (2013)**–reviews thedifferent water conservation practices in Saudi Arabia. A three weeks survey has been conducted in the form of a massive water conservation program to enhance water-using efficiency in the country. Water conservation tool has been installed in some of the homes but in most of them is is not being installed because of its cost. This installation method has reduced the water demand to a certain extent.
- **Thomas M. Missimer (2012) –**has discussed that the conventional ground and surface storage reservoirs are not feasible to meet the strategic storage requirements, but must be used to manage the distribution system considering the daily demand fluctuation and short-term emergency needs like fire flow. Aquifer storage and recovery (ASR) is an economic and viable technical solution to meet the critical need for the long-term storage, which can potentially store billions of cubic meters of desalinated water.

J. Syria

The major rivers of Syria are shared with neighboring countries. There are nearly 165 dams. Population growth and urbanisation increases the pressure on water resources, resulting in groundwater depletion and pollution. There is no legal framework for integrated water resources management. The

institutions in charge of water resources management often lack the power to enforce regulations. Water resources policies have been focused on the construction of dams, development of irrigated agriculture and occasional interbasin transfers and construction of wastewater treatment plants including the use of reclaimed water for irrigation.

Key stone publications about Syria:

- **Haddad G. (2008)** - states that, Water balance for Syria indicates most of the basins to be in deficit. This will be exacerbated further especially if the country's population continues to grow at its current rate (about 3%) and water use efficiency is not increased effectively. New water resources are extremely expensive to develop. Therefore, shifting from water development to water management, is necessary to reach sustainability in water use and agriculture. The numerous hurdles and challenges towards proper management of the agriculture sector, can be overcome by suitable planning and implementation of management, institutional and policy measures.
- **Kaisi (2006)** has stated that, Syrian water resources are limited as compared to the increasing demand size. Agricultural sector is the largest consumer of water. Attention should be given to meet the necessary needs by constructing dams and governmental irrigation projects. Increase of water loss due to evaporation because of low-efficient traditional earth canals can be transferred to piped canals for conveyance and distribution, conducive to the use of modern techniques in on-farm irrigation. Scientific research in the field of water management has to be improved.

K. United Arab Emirates (UAE)

UAE is a federation of seven emirates Abu Dhabi, Dubai, Sharjah, Umm al-Quwain, Ajman, Ras Al Khaimah and Fuajaira.Water resources in the UAE can be classified as Conventional (surface water, ground water) and Non-Conventional (Desalinated water, Treated waste water). It hasone of the highest per capita water consumption rates in the world therefore it faces several water management challenges such as scarcity of ground water, high cost of producing drinking water, etc.

Key stone publications about UAE:

- **MohamedM. M. (2014) -**studied the sustainability of water resources in Al-Ain city, using WBM (Water Budget Model) to evaluate the groundwater recharge (such as inflows and outflows). Due to this model, evaluation of groundwater level has become efficient and helpsin management of the resource.
- **MohsenSherif (2007)** – has analysed the waterresourcesof Wadi Ham and has stated that, water quality has been affected by heavy salinity levels. Therefore, this source cannot be used for domestic purposes. A model has been proposed to restrict the seawater intrusion in aquifer. By this process saline water can be dispersed and quality of ground water shall be preserved.
- **Zein S. Rizk (2003)** – has analysed the various reasons by which the water conservation has been spoiled in UAE. Deteroriation of ground water is the major factor and also the level of water is decreased annually. It has been concluded that this water crisis can be reduced by increasing the practices such as construction of storage dams, implementing new irrigation techniques, sewage treatment, desalination, etc. for conserving water.
- **Brooke (2005)** - describes the status of the various water resources in the coastal zones of UAE and the water management issues and challenges associated with it. UAE has a coastline of 1318km in length and both conventional and nonconventional water resources are located on or close to this coastline. Conventional water resources include wellfields and onshore and offshore springs and non-conventional sources of water include desalination plants and treated wastewater plants. Major water management issues like ground water depletion, salt water intrusion, the environmental impacts of the desalination plants, etc. were critically analyzed and the tools and measures to be followed in order to improve groundwater management in the coastal zones are recommended.

L.Yemen

Yemen has a predominantly arid climate with extreme water scarcity.There are around 800 small and medium sized dams used for rain water harvesting. Agriculture of Yemen, mainly depends on the groundwater resources.Water conservation is currently challenged by rising water demand, aquifer depletionand expansion of irrigated agriculture, urbanization, and loss of natural recharge. The common results of groundwater depletion felt by the local communities are, increased well depths, increased pumping costs and reduced water quality.

Key stone publications about Yemen:

- **Craig Giesecke (2012)**-presents the background information on Yemen's water crisis, identifies

international assistance efforts, and describes potential solutions. The primary factors contributing to water scarcity are population increase and illegal drilling of wells. Broader influences are lack of government capacity and climate change. The World Bank focus largely on capacity building and infrastructure improvement. Solutions identified include strengthening state institutions, improving agriculture and irrigation efficiency and increasing water management information capacity.

- **Qahtan Yehya (2015) -** states that strong support is needed to steer the attempts of the National Water Resources Authority to develop and improve country wide organized information system, to develop guidelines for predictions, estimations and indicators in information, to conduct specific and targeted training programs. Donor coordination to support water resources management programs and proper capacity building is essential.
- **TahaTaher (2012) -** discusses that the groundwater management in Yemen has increasingly been cast in terms of crisis, triggered by rapidly declining water tables around cities and in the main agricultural areas. In some places in Yemen, communities have implemented local rules that have reduced conflict and provided more reliable and equitable access to water. This trend towards groundwater governance is described, and how the process of local management could be nurtured and how it could contribute to rebalancing water use.

IV. Conclusion

Due to the immense population growth and economic development along with climate change, scarcity of water has increased commonly in all the Middle East countries. Thisanalysis of various scenario shows that under all possible population-water scenarios combinations, the water resources of Middle East countries remain less than the minimumthreshold required for social and economic development, except Israel.Therefore, the various technologies such as, Desalination plants, Pilot project dam, application of Modern techniques for irrigation, Tariff reforms, Planning of water management, Survey programme on water conservation management and Water conservation tools or Water Imports are required, to satisfy the water demand and to solve the water issues in the Middle East Countries.

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