Management of Water Resources in the Middle East between Difficulties and Challenges

Salma Ajeel Fenjan[1]*, Ali Akbar Akhtari [2]

1- Ph.D. Student, Department of Civil Engineering, Razi University, Kermanshah, Iran.

2- Assistant Prof, Department of Civil Engineering, Razi University, Kermanshah, Iran

salma.civil66@gmail.com

Abstract

Water problems are more common in current century. It will continue to grow and become more severe and affect other sectors like energy, agriculture, environment, health and industry. Water management is necessary for the development of all these sectors. Integrated water resource management is considered as one of the best and basic approach for managing water resources. IWRM assist the countries to make an effort in order to deal with complicated and crucial water issues in a cost effective and sustainable way by considering the social, economic and environmental interests. The application of the IWRM approach and the related principles of integration, decentralization, and participation in the development and management of water resources in Middle East. Middle East countries are considered to be arid or semi-arid as the average annual rainfall does not exceed 166 mm . For this reason, the scarcity of water resources in the Middle East countries, represents an extremely important factor in the stability of the region and an integral element in its economic development and prosperity. In this paper We will discusses all the difficulties and challenges facing Integrated Water Resources Management (IWRM) and we try to find suitable suggestion for this. Case steady (Iraq)**.**

Keywords: IWRM , Middle East , Water Challenges , Meeting challenges, Iraq .

INTRODUCTION

FOR thousands of years, managing water has been fundamental to the development of human societies in the Middle East . In the cradle of civilization, the legal codes governing the cities of ancient Mesopotamia recorded in the Code of Ur-Nammu (ca. 2100 BCE) and the Code of Hammurabi (ca.1750 BCE). prescribed obligations for the proper use and maintenance of common water works[1]. Today, the countries of the Middle East region still depend on effective water resource management for their continuing welfare and future prosperity. The people of the Middle East now live in the most water-scarce region on Earth. In the coming decades, as populations grow, demand rises, and global climate change looms, per capita water availability in the region is projected to drop in half by mid-century. Meeting these challenges will require both enhanced innovation and reform within the water policy communities and economies of the Middle East countries and increased cooperation, data sharing, knowledge and capacity building between them [2].

Recent developments that have imposed substantial stress on societies and challenged policymakers, scientists, engineers, and planners alike include population growth, migration, industrialization, urbanization, pollution, and global warming and other environmental change. Today, growing water demand, decreasing water availability, and deteriorating water quality affect environmental quality, food security, municipal infrastructure, economic development, and overall human security in most societies of the Middle East region. Trans boundary tensions threaten international peace and stability[3].These strains pose serious challenges to regional prosperity and social order. It is no exaggeration to say that water policy and water security are as central a determinant of the future well-being of the Middle East countries as is governance or ideology .The quantity and quality of available water supplies create and constrain management choices for direct human consumption, sanitation, and commercial and industrial development. All these uses are critical to livelihoods, public health, and economic development, each of which is crucial to maintaining social and political stability .Trans boundary water issues complicate all of these elements[4].

Integrated Water Resources Management strategies seek more balanced consideration of both supply and demand dynamics, coordinating between multiple uses, stakeholder claims, and ecosystem needs, as well as across geographic areas Policymakers increasingly view the approach as not only a better way to manage water, but also as a more effective means to spur cooperation between riparian states. IWRM is based on the philosophy that all uses of water are interdependent, and that water exists both as a social and economic good. The primary challenge for most states in the Middle East region has been accepting that sustainable water management entails more than just resource exploitation for purposes of development and modernization. Part of this process has involved moving toward recognition that water resources are limited, and that water policy must focus not only on exploiting current sources and finding new ones, but also on educating water users regarding conservation techniques and demand management .In addition to optimizing human use of water, such awareness and education must encompass the stewardship of so-called “in-stream” water resources [5].

Location and description of Case Study:Iraq

Iraq is one of the Middle East and North African countries (MENA region).It is located in the eastern part of the MENA region. It is surrounded by Iran in the east, Turkey to the north, Syria and Jordan to the west, Saudi Arabia and Kuwait to the south and the Gulf to the southeast. The total area of Iraq is 438,320 square kilometers populated by about 32 million inhabitants. Iraq was ranked among the richest Middle Eastern countries with regards to water resources. The world witnessed the emergence of a magnificent ancient civilization that largely relied on agriculture with extraordinary irrigation systems. At now Iraq is currently facing a many difficulties and challenges. This difficulties and challenges to be more severe in the future where the supply is predicted to be 43 and 17.61 Billion Cubic Meters (BCM) in 2015 and 2025 respectively 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 [6].

Topographically, Iraq is divided into 4 regions . The mountain region occupies 5% of the total area of Iraq, restricted at the north and north eastern part of the country. This region is part of Taurus-Zagrus mountain range. Plateau and Hills Regions is the second region and it represents 15% of the total area of Iraq. This region is bordered by the mountainous region at the north and the Mesopotamian plain from the south. The Mesopotamian plain is the third region and it is restricted between the main two Rivers, Tigris and Euphrates. It occupies 20% of the total area of Iraq. This plain extends from north at Samara, on the Tigris, to Hit, on the Euphrates, toward the Gulf in the south. The remainder area of Iraq which forms 60% of the total area is referred to as the Jazera and Western Plateau. Iraq was considered rich in its water resources compared with other countries where the annual allocation per capita reached 6029 m_3 in 1995 and expected to be 2100 m_3 in 2015 [7]. Construction of dams on the Tigris and Euphrates and their tributaries outside the border of Iraq, the effect of global climate change and mismanagement of water resources are the main factors in the water shortage problems in Iraq.

Climate, Iraq is shaped like a basin containing the great Mesopotamian plain of the Tigris and Euphrates rivers. The climate is mainly of continental, subtropical semi-arid type. The mountain region is of Mediterranean climate. In general, rainfall occurs from December to February or November to April in the mountain region . During winter the average daily temperature is about 16˚C dropping at night to 2˚C with possibility of frost. In summer however, it is very hot with an average temperature of over 45˚C during July and August dropping to 25˚C at night (Figure1) . The annual rainfall in Iraq varies where it reaches 150 mm within the western desert, more than 1000 mm within the mountains at the north to about 200 mm at the eastern part of the country (Figure2).

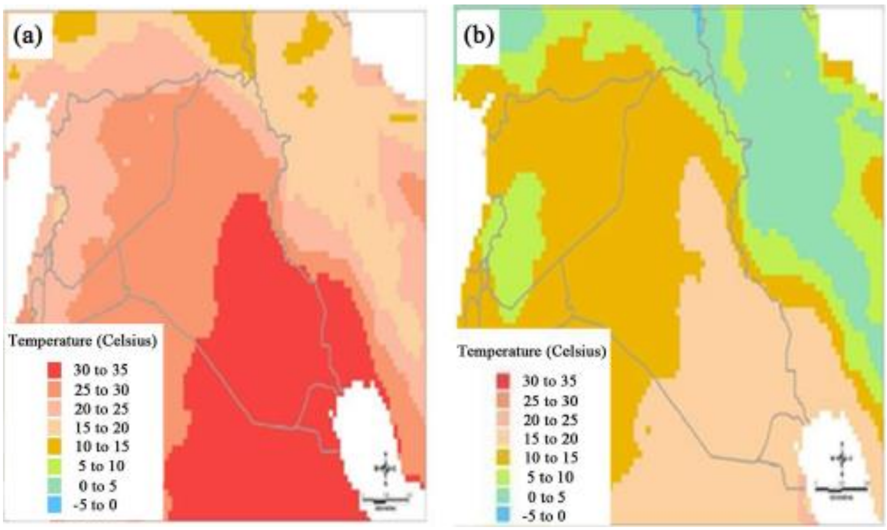

Figure 1. Mean maximum (a) and minimum (b) temperatures in Iraq[8].

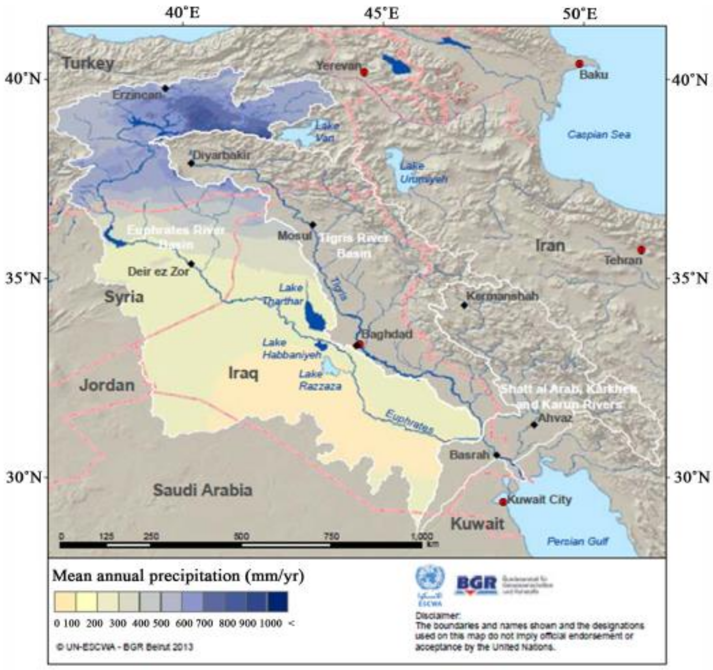

Figure 2. Rainfall map of Iraq[8].

The overall average annual rainfall is of the order of 213 mm per year. The rainy season begins in October and ends in April. It is evident from that annual rainfall increase from southwest towards northeast due to topographic effect. Furthermore, it can be noticed that individual topographic regions are characterized by their own climatic factors and rainfall values. It should be mentioned however, that despite the local climatic differences, all the regions have similar overall climatic features. This is due to the fact that Iraq as a whole is affected by its geographic position. The range of daily temperature varies greatly between day and night reflecting the continental climate. In addition, the trend in temperature increase is exactly the opposite to that of the rainfall's trend, where it increases from northeast toward southwest. The maximum daily temperature during dry season could rise to over 50˚C, while the minimum temperature during the wet season could reach −14˚C in Rutba and about −8˚C in Baghdad . It can also be noticed at the south, in Basrah in particular, that the temperature during summer is less than that of the surrounding areas due to high humidity resulting from being near to the Gulf. Sunshine records indicate that during dry period, May-September, the average is more than 500 cal/cm2/day while it is below this value during wet season (October-April).Meteorological record was used to calculate the evaporation and evapotranspiration values using penman method. The results show that the overall average evaporation and evapotranspiration is of the order of 1900 mm per year. Furthermore, the values show an increasing trend similar to that of the temperature increasing from northeast towards the southwest[8].

Iraq's Water Sources

Surface Water: The rivers Tigris and Euphrates with their tributaries form the main surface resources in Iraq. They join together in the south forming what is referred to as the Shat Alarab, which drains to- wards the Gulf . Most of the water from these rivers comes from Turkey (71%) followed by Iran (6.9%) and Syria (4%). The remainder, only (8%) is from internal sources. The World Bank [12] stated that 100% of the Euphrates water comes from outside the borders of Iraq while 67% of the Tigris water also comes from outside sources. They also stated that groundwater resources are about 1.2 BCM and form about 2% of the total water resources of Iraq [9]. The Iraqi water strategy is highly influenced by the Euphrates water where 100% of its flow comes from out- side the country. While only 50% of the Tigris flow comes from Turkey. According to the negotiations between riparian countries, Iraq is supposed to receive 58% of the Euphrates flow, which crosses the Turkish-Syrian border, while Syria receives 42%[6]. In this research, the all difficulties and Challenges facing Iraq will be reviewed and discussed, and recommendations will be given to solve the problems of water resources in Iraq.

River Tigris: The River Tigris rises in the southeastern part of Turkey on the southern slopes of the Touros mountain range and drains an area of 472,606 km² which is shared by Turkey, Syria and Iraq. Its total length About 1718 km (Table 1).About 58% of the basin lies in Iraq. Three major tributaries (Butman Su, Karzan

and Razuk) join the Tigris before it reaches the Turkish/Iraqi border. The mean annual flow of the river does not exceed 64 m^3/s and it increases at Razuk to 413 m^3/s. It enters Iraq at Fiesh Khabur where the Khabur tributary joins the main river at a small distance to the south. The mean annual flow of the Khabur is 68 m^3/s. The River Tigris flows towards the south and reaches the first major city (Mosul). Its mean discharge at Mosul reaches 630 m^3/s. The Greater Zab River joins the Tigris about 60 km south of Mosul. The confluence of the two rivers is situated midway between Mosul and Sharkat cities. his tributary drains an area of 25,810 km^2 of which about 62% lies in Iraq. This tributary is one of the large with a mean annual flow of418 m^3/s.
Further south, the Lesser Zab tributary joins the Tigris at Fatha. This tributary drains an area of 21,476 km^2 (25% in Iran) with a mean annual flow of 227 m^3/S whiles the mean annual flow of the of Tigris reach 1340 m^3/S down-stream of this confluence. South of Fatha, the Adhaim tributary joins the Tigris. This tributary drains an area of 13,000 km^2 and lies totally in Iraq. The Tigris River mean discharge at Mosul city prior to 1984 was 701 m^3/S and dropped to 596 m^3/S afterward. This implies a 15% decrease of the river discharge[10].

River Euphrates: The River Euphrates is 2781 km long and rises from the southeastern part of Turkey. It drains area of 444,000 km^2 shared by four countries (Iraq 41%, Turkey 28%, Syria 17% and Saudi Arabia 14%)(Table 1). The Rivers Karah Su and Murad Su join together in the southeastern parts of Turkey at Kuban forming the River Euphrates. The River enters Syria at Jarablis where it runs 675 km and then enters Iraq. Thirty kilometers south of Jarablis, the Sajor tributary joins the Euphrates. Further down- stream, two tributaries, the Balikh and Khabur, join the main river after which it crosses the Iraqi border at Hasaibah. The mean daily discharge of the Euphrates River inside Iraq (at Hit) is 909 m^3/s [6,11]. Inside Iraq, no tributary contributes water to the river. The river supplies a number of small canals in the central and southern parts of Iraq for irrigation purposes. Some of its water is diverted to the Habaniya reservoir during floods, which is situated about 40 km south of Ramadi. About 135 km south of Faluja, the Hindiya barrage diverts a maximum discharge of 471.5 m^3/s to small parallel tributaries [12]. The Euphrates channel south of Kifil is divided into two main channels (Kufa and Shamiya), and they joins again at Mushkhab. Further downstream, the channel splits again about 25 km south of Shanafiya and rejoins near Simawa. Then the river enters Hamar marsh, where it forms two main channels within Hamar marsh. One of the channels (northern) joins the Tigris River at Qurna orming (known as the Shat Alarab River) while the other channel joins the Shat Alarab River at Karmat Ali. The Euphrates River mean discharge at Hit and Haditha cities prior to 1972 was 967 m^3/S and dropped 553 m^3/S after 1985. The percentage decrease in river discharge is 43%.

Table 1. Drainage area of the Tigris and Euphrates River basin[6].

Country	Tigris Catchment area (km2)	Country	Euphrates Catchment area (km2)
Turkey	57,614	Turkey	125,000
Syria	834	Syria	76,000
Iraq	253,000	Iraq	177,000
		Saudi Arabia	66,000
Total	471,606	Total	444,000

Shatt Al-Arab River: Shatt Al-Arab River is formed after the confluence of Tigris and Euphrates Rivers at Qurnah in Iraq (Figure 3). Its total length is 192 km and its drainage area is 80,800 km^2. Its width is about 300 m near Qurnah and increases downstream to 700 m near Basra city and to about 850 m near its mouth at the gulf area. Karun and Karkha Rivers usually contributes 24. 5 and 5.8 billion cubic meters (BCM) annually respectively(Figure 3) . This forms about 41% of the water of Shatt Al-Arab. Its annual discharge at Fao city reaches 35.2 × 10^9 m^3. Shatt Al-Arab River is characterized by its high sediments which resulted in the formation of large number of islands during its course.

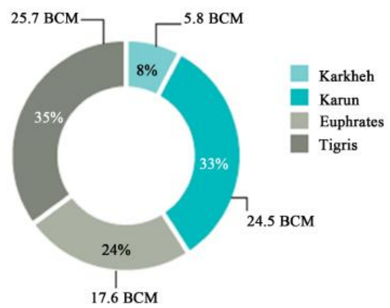

Figure 3. Water contribution to Shatt Al-Arab River [8].

Groundwater: Kahariez mountain channels and hand dug wells were common practices in the ancient history of Iraq. Some of these wells and Kahariez are still in use now. Large numbers of villages were previously built near springs and later wells were dug to provide water for the inhabitants. The geographic distribution of springs and wells marked the travel routes in ancient Iraq. Development and utilization of groundwater started in 1935 where the first groundwater well was mechanically drilled .This development went through four main stages:

1. Stage one: this stage started in the mid-1930s to the beginning of the 1950s. During this stage wells were drilled without any scientific investigation or studies. Drilling operations were executed to provide water for villages and remote areas. Few basic reports on groundwater resources were written during this stage.
2. Stage two: this stage started during the 1950s toward the end of the 1960s. This stage is marked by the activities of foreign consultants and contractors. Companies like Parsons and INGRA carried out countrywide surveys for groundwater resources in Iraq. A numbers of wells were drilled to for the purpose of the study required. This operation resulted in a huge survey report on the groundwater resources of Iraq published in 13 volumes.
3. Stage three: this stage started at the end of the 1960s. The most important feature of this stage was the availability of Iraqi geologists and drilling engineers to drill the required wells all over Iraq. This stage was relatively poor in its scientific research and studies where field drilling operations were predominant and hundreds of wells were established.
4. Stage four: this stage started during the 1970s and marks scientific research for groundwater investigations and utilization. This was executed by national and foreign organizations and companies. The Ministry of Irrigation (now Ministry of Water Resources) was the official body responsible for these operations and practices During this period the state company for water wells drilling was established.

Despite the large number of groundwater wells that exists now, ground water utilization in Iraq forms a minor percentage (5% - 7%) of the water resources of the country despite its extensive use . Ground water resources in Iraq are described in details by Al-Ansari [13].

Statement of the Problem: Iraq receiving only 40% of it demands from surface water. As a downstream country, more than 90% from the water surface is supplied by neighbor countries (~80% from Turkey), and the average of annual precipitation is ~150 mm with high rates of evaporation as a simi-arid region. More than half of the precipitations provided from outside of the country's border, within the last decade 1/3 from the two major Rivers have been fallen with expectation of further drops in the near future. Many of farmers lose their jobs where 36% of the local economy relay on agriculture. Not least the reduction of the water supply makes the country lose ~20% from the power planet and hydroelectric sector. Essentially, there are two types of challenges surrounding the water dispute: external and internal[14].

External Challenges: Globally, big concerns exist over climate change and its impact on water resources. Various research efforts have shown that climate change directly influences the hydrological cycle through warming the atmosphere. This warming will significantly alter precipitation patterns in terms of timing, quantity, intensity, and form. This alteration will result in changes to watersheds, water quality, and the allocation of water flow [15]. Population increases will further confound global worries over water resource scarcity. The international community and the United Nations made huge efforts to draft and pass a law that would address these issues.

Internal Challenges: Iraq still has a long journey ahead of itself before it achieves proper water resource management; many water shares are wasted either directly to the Gulf or through evaporation due to a lack of irrigation planning and water harvesting. Unfortunately, within the last 50 years, Iraq has not given priority to such a vital issue or at least drawn sufficient attention to it. This is partly due to its past and current involvement in several wars and its focus on oil production to generate national income. However, the absence of competent water resource management is not the only reason for Iraq's unfortunate and vulnerable position. Complex political conditions have led to uncertainty surrounding water policies. Article 110, Paragraph 8 of Iraq's constitution and Article 114, Paragraph 7 serve as examples of the detrimental effect of contradictory policies. The former grants the federal government responsibility over handling water resources coming from outside Iraqi borders, while the latter gives local, provincial governments the authority to formulate internal water resource policies and to regulate usage of water resources [16]. This clear contradiction could lead to internal disputes in the near future on the central government in Baghdad, Where the local politicians could potentially misuse water resources as political tools. Iraq faces major threats. If the country allows the current situation to continue, severe consequences will arise.

Shared Catchments : The Euphrates, Tigris and Shatt Al-Arab Rivers catchments are shared between the countries neighboring Iraq as shown in **Figure 4** and **Table 2** and **Table 3**. Due to the fact that all the major rivers in Iraq are shared with neighboring countries several agreements were signed with neighboring countries [8] .

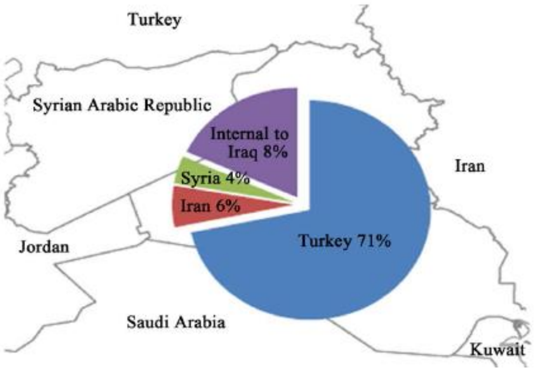

Figure 4. Source of water for the Tigris and Euphrates Rivers

Table 2. Rivers of Iraq and riparian countries[17] **.**

River	Riparian Countries	Main Shared Tributaries
Euphrates	Iraq, Jordan, Saudi Arabia, Syria, Turkey	Sajur ,Jallab/Balikh ,Khabour
Tigris	Iraq, Syria, Turkey, Iran	FeeshKhabour, Greater Zab,Lesser Zab, Diyala
Shatt Al-Arab	Iraq, Iran	Tigris ,Euphrates, Karun ,Karkheh

Table 3. Contribution of countries to Euphrates and Tigris Rivers [18] .

Tigris and Euphrates Rivers		Turkey	Iraq	Syria	Iran	Total
Discharge	%	78.1	8.1	0.5	13.3	
	Billion m3/year	65.7	6.8		0.5	84.2
Drainage area	%	20.5	46.0	9.0	19.0	
	Billion m3/year	170,000	469,000	77,000	37,000	819,000
River length	%	33.5	51.0	15.5	-	
	km	1630	2478	754	-	4862

Turkish Water Projects: In 1977, the Turkish government set a huge project referred to as Southeastern Anatolia Project (GAP) [19] (GAP, 2006). The component of the project includes 22 dams and 19 hydraulic power plants which are supposed to irrigate 17,000 km^2 of land. The project is supposed to develop the southeastern provinces which cover 9.7% of the total area of Turkey which forms 20% of the agricultural land of the country. The overall volume of water to be captured is about100 km^3 (while the required water to irrigate the supposed area is about 29 km^3) which is three times more than the overall capacity of Iraq and Syrian reservoirs. Despite the continuous claims of the Turkish Government that GAP is purely development project, it seems that there are number of internal and external goals involved [20]-[25]. When GAP project is completed, then 80% of the Euphrates water will be controlled by Turkey [26]-[27].

Conclusions and Recommendations: Iraq is facing water scarcity problem due to external and internal factors. External factors cannot be solved independently or in short term actions or planning like global climatic change and abusive water policies by riparian countries. In addition, these themes are to be addressed with regional and international cooperation. In this context, there were number of agreements signed by riparian countries (especially Turkey, Syria and Iraq) for the water allocated. Turkey considers the Euphrates and Tigris as Trans boundary Rivers that falls under Turkish sovereignty as long as it is within its territory. Based on this, Turkey regards that it is not possible to share a commodity that constantly changes in quantity and quality, and in time and space due to the variable conditions of the hydrological cycle. While from Iraq and Syria point of view, these rivers are "international rivers" that should be treated as a shared entity by all riparian countries.

Long term expectations of the decrease of rainfall and temperature increase due to global climate change will inevitably reduce the quantity of the internal water resources and increase the desertification in Iraq which already reached 75%. Turkish water projects (GAP, Ilisu…etc.) will control 80% of the Euphrates water and 47% of Tigris River flow to Iraq. At least, 696,000 ha of agricultural land will be abandoned influenced by these projects. The diversion of the water of Karun and Karkha tributaries inside the Iranian borders caused very high increase of the salinity in Shatt Al-Arab. It is believed these problems are to be solved by discussion and cooperation between riparian countries under the UN umbrella so that it takes a formal international cover. In addition, facing the expected climate change cannot be achieved unless the countries of the region act collectively. About 85% of water withdrawal water in Iraq is consumed for agriculture. Where, only 1.9 million ha out of 4 million ha of arable land are cultivated in recent years. Even with the degradation in the productivity of the industrial sector, the hydropower consumption including the evaporation from reservoirs reaches 10 BCM/annum. A plan to reduce the domestic consumption from 350 to 200 liter/capita/day is proposed parallel with other plans to supply potable water to 91% of the population by 2015. Internal problems and related issues of water scarcity can be solved independently in relatively short period of time. These are related to mismanagement of water resources inside Iraq, such as water losses in the distribution networks, overuse of water by inefficient irrigation systems, pollute water resources by sewage feedback, increase water salinity…etc. Iraqi government is to adopt water demand management instead of water supply management policy. Iraq suffers from many problems in its infrastructures whether those related to water losses through its water distribution networks, water overuse in old irrigation schemes, pollutes fresh water sources by back water from irrigation and sanitation. The efficiency of the distribution network is very poor (32%) and it is deteriorating with time.

The following recommendations are believed can help to overcome the water shortage problem in Iraq:

Strategic Water Management Plan: There is a great need for an integrated long term “National Water Master Plan” is to be designed and put in practice immediately. This plan should be a long term plan for at least 30 years. All authorities concerned should participate (e.g. Ministry of Water Resources, Ministry of Municipality and Public Work, Ministry of Agriculture, Water Resources staff at Universities, private sector, NGO’s and representatives of regional and International organizations concerned) in this national plan. Water demand management is believed to be the backbone of such a plan. It should also consider the following:

- Rehabilitation of infrastructure which should cover water treatment plants, power plants as well as pumping stations. - Defining institutional agenda that includes employment and training. - New irrigation techniques should be a priority also (e.g. sprinkler and drip irrigation). - Private sector is to be enhanced to be involved in the investment.

Water Supply and Sanitation:

- Efficiency of distribution networks of drinking water specially diversion and supply down to the point of use which is most cost effective should be improved.- Sewage networks leakages should be repaired and their efficiencies improved to prevent any source of pollution from these networks. - New efficient projects should be put in practice to prevent water losses and pollution. - Operation and maintenance activities are to be improved e.g. using ICT. - New sewerage systems are to be implemented in areas that are not serviced. The sewage water is to be conveyed to the sewage treatment plants to reduce the pollution of groundwater from the leakage from old septic tanks.

Irrigation and Agriculture:

- Maintaining and developing the conveying systems to reduce the losses and increase conveying efficiency. Closed conduits are to be considered as conveying system that reduces evaporation losses and infiltration losses. It is also conservative in land use and protects irrigation water from contact with saline water table.
- Reducing the use of chemical fertilizers and pesticides that can decrease the water quality when back irrigation water discharges to the rivers. - Institutions should reflect decentralization, autonomy and farmer empowerment.

Research and Development:

- Training programs for technicians, engineers and decision makers about up to date technologies are very important. - Groundwater resources are still not exhausted, big efforts should spend to manage prudent using of this source and protect it from all kinds of pollution. - Universities and institutes should set special courses in arid region hydrology.

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