

Present Water Crises in Iraq and Its Human and Environmental Implications

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Abstract

Iraq is facing a serious water shortage problem now, which has not been experienced before. This is because of the reduction of flow of the Euphrates and Tigris Rivers which is due to the implementation of hydrological projects within the upstream part of the catchment and climate change. Mismanagement of water resources within Iraq made the problem graver. It is believed that serious discussion with all riparian countries to reach an agreement to share the water of the two rivers and their tributaries is desperately needed. In addition, a prudent scientific strategy should be implemented and put into practice to overcome this problem in Iraq. In addition, the key positions within the Iraqi Ministry of Water Resources should be given to people having real experience in the water resources sector to ensure discreet and prudent management of the problem.

Keywords

Euphrates, Tigris, Climate Change, Water Shortage, Iraq

1. Introduction

The Middle East is considered as an arid to semi-arid region where average annual rainfall does not exceed 166 mm [1] [2]. A good percentage of the agricultural land is rain fed while irrigated agriculture accounts for about 66% of the water demand [3]. Future prospects of the region indicate that water shortage problem will be more serious [4] [5] [6]. For this reason, fresh potable water is essential for life, socioeconomic development, and political stability in the region [7].

Iraq is located in the Northeastern part of the Middle East (**Figure 1**). The area of Iraq is 437,072 km² and the population is 39.3 million [8]. Tigris and



Figure 1. Location of Iraq within the Middle East.

Euphrates are the main two rivers of Iraq. The waters of these rivers come from Turkey (71%), Iran (6.9%) and Syria (4%) while the remainder is from Iraq. This implies that 100% of the Euphrates and 67% of the Tigris, waters come from outside Iraq respectively [9] [10]. Groundwater Resources reach 1.2 Billion cubic meters (BCM) and form only 2% of the consumed water. The flow of the rivers fluctuates from 10 to 40 BCM depending on the hydrological conditions with an average of 30 BCM [10].

Iraq was considered rich with water resources due to the presence of the Tigris and Euphrates Rivers till the 1970s. After that Turkey, Syria and Iran started to implement hydrological projects on the two rivers and their tributaries which affected the flow in these rivers. In addition, the quality of the water deteriorated due to irrigation back waters from upstream projects [11] [12] [13] [14] [15]. In this work, the problems that are affecting the flow and its implication on the population and environment of Iraq are discussed.

2. Euphrates and Tigris Rivers

2.1. River Euphrates

The river rises from the southeastern parts of Turkey. It is 2781 km long and is considered as the longest river in southwest Asia. Its catchment area is 444,000 km² of which 28% in Turkey, 17.1% is in Syria and the remainder 39.9% is in Iraq [12]. About 89% of the water of the river comes from Turkey [16]. Its flow at Hit city after it enters Iraq has an annual average of 30.6 BCM measured in the period 1938-1973 which had decreased to 22.8 BCM for the period 1974-1998 [16]. The flow now is 18 BCM per year [17] [18].

2.2. River Tigris

Tigris River like the Euphrates rises from the southeastern parts of Turkey. It is 1718 km long, which makes it the second longest river in southwest Asia. It

drains an area of 472,606 km² of which lies 17%, 2%, 29% and 52% in Turkey, Syria, Iran and Iraq respectively [13]. The flow of the Tigris River is considered natural until 1973 when dams were started to be built on the river and its tributaries [16]. The average annual discharge for the period 1931-1973 was 21.3 BCM and it decreased to 19.6 BCM for the period 1974-2005 [16] [18]. The discharge of the river at Baghdad was 1207 cubic meters per second (cumecs) for the period 1931-1960. It decreased to 927 cumecs for the period 1961-200 and it is 522 cumecs after the year 2000 [16] [19]. The decrease of flow is caused by building of dams on the main river and its tributaries.

3. The Water Crises

The ongoing water crises are the worst that Iraq has experienced. A thorough scan of the crises shows that it can be attributed to two main reasons that can be summarized as follow:

3.1. External Reasons

3.1.1. Water Requirements in Riparian Countries

The main riparian countries on the Euphrates River catchment are Turkey, Syria and Iraq while on the Tigris catchment they are Turkey, Iran and Iraq. Each riparian country claims their required needs from these rivers, but when these claimed needs are added together, the required amount exceeds the flow of the river. Turkey and Syria claims that it requires 15.7 and 11 km³ respectively of the Euphrates water to irrigate their land while S Iraq require and 13 km³. To put these claims into implementation all the upstream countries started to build dams on the Tigris and Euphrates to ensure getting its claimed quantity of water for its needs because of the high fluctuation of the flow of the rivers. Accordingly, a large number of dams were built (Table 1). Turkey through its Greater Anatolia Project (GAP), which includes 22 dams (14 on the Euphrates) and 8 on the Tigris and 19 hydropower stations [20], has built most of these dams. Iran on its part has built number of dams on the tributaries of the Tigris River [17]. This includes building dams on Alwind, Karkha and Karun Rivers where all the water of these rivers were diverted inside Iran. In addition, most of the valleys on the eastern border with Iraq were diverted inside Iran. The flow of Shat Alarab has been reduced by 41% and salinity increased to 2408 mg/l in 2011 [16].

When the GAP project is completed, then 80% of the Euphrates water will be controlled by Turkey and when Ilisu dam is finished, 47% of the flow of the Tigris River will be drawn off [24] [25] [26] [27]. About 21 BCM of water used to be received by Syria from the Euphrates before 1990 while it is receiving 12 BCM now. Iraq used to receive 29 BCM which has dropped to 4.4 BCM now. This implies 40% and 85% reduction in the quantity of water which Syria and Iraq were receiving respectively [28]. This has caused a reduction of the agricultural land from 650,000 ha to 240,000 ha. Irrigation backwater caused deterioration of the quality of the Euphrates water also.

Table 1. Dams on Tigris, Euphrates rivers and tributaries (source [21] [22] [23]).

Dam	River	Height (m)	Purpose	Completion Date
IRAN				
Dez	Shatt Al-Arab/Karun	203	I/P	1963
Shahid Abbaspour (Karun 1)	Shatt Al-Arab/Karun	200	P	1976
Masjed Sulaayman (Karun 2)	Shatt Al-Arab/Karun	164	P	1976
Karun 3	Shatt Al-Arab/Karun	205	I/P/F	2002
Karun 4	Shatt Al-Arab/Karun	230	I/P/F	2010
Garan	Tigris/Diyala/Sirwan	62	I	2005
Darayan	Tigris/Diyala/Sirwan	169	I/P	2010
UpperGotvand	Shatt Al-Arab/Karun	180	P	2012
Lowe Gotvand	Shatt Al-Arab/Karun	22	P	1977
Karkha	Shatt Al-Arab/Karkha	127	I/P	2001
Seimare	Shatt Al-Arab/Karkha	180	P	2013
Khersan 3	Shatt Al-Arab/Karun/Karkha	195	P/F	2015
Turkey				
Çetin Dam (Alkumru)	Tigris/Botan	145	P	2016
Aslandağ	Tigris/GreaterZab/Bembo	60	I/M/P (future)	2012
Beyyurdu	Tigris/GreaterZab/Bembo	48	I/M/P (future)	Under Construction
Atatürk (Karababa)	Euphrates	169	P	1992
Balli	Tigris/Khabour/Hezil/Ortasu	49	I/M/P	Under Construction
Batman	Tigris/Batman	74	I/P	1999
Beyhan I	Euphrates/Murat	97	P	2015
Beyhan II	Euphrates/Murat	62	P	Planned
Birecik	Euphrates	62.5	I/P	2001
BurçBendi	Euphrates/Göksu	47	P	2010
Cizre	Tigris/Botan	46	I/P	Planned
Çoukurca	Tigris/GreaterZab/Güzedlere	45.5	W/M	Under Construction
Dumluka	Euphrates/Bugur	30	I	1991
Erkenek	Euphrates/Adiyaman	-	p	Operational
Göksu	Euphrates/Göksu	52	I	1991
Hecihider	Euphrates/Sehir	42	I	1989
Hancağiz	Euphrates/-	-	I	1988
Ilisu	Tigris	135	I/P/F	2017
Upperkaleköy	Euphrates/Murat	137.5	P	2017

Continued

Lowerkaleköy	Euphrates/Murat	115	P	Planned
Karakaya	Euphrates	158	P	1987
Karkamiş	Euphrates	21.1	P	2000
Kavsaktepe	Tigris/Khabour/Hezil/Ortasu	66	W/M	Under Construction
Kayacık	Euphrates/Sajur	45	I/P	2005
Keban	Euphrates	207	P	1974
Kirazlık	Euphrates/Botan	60	I/P	2011
Kralkizi	Tigris/Maden	113	I/P	1997
Musatatepe	Tigris/Khabour/Hezil/Ortasu	34.5	W/M	Under Construction
Silope	Tigris/Khabour/Hezil	79.5	W/M/P	2012
Silvan	Tigris/Batman	174.5	I/P	2017
Sirrntiş	Tigris/Birimşe	92	I	2013
Şirnak	Tigris/Khabour/Hezil/Ortasu	56.8	W/M	2012
Uludere	Tigris/Khabour/Hezil/Ortasu	55.5	W/M	Under Construction
Syria				
Baath	Euphrates	14	P, I, F	1988
Tabaqa	Euphrates	60	P, I	1975
Tishrine	Euphrates	40	P	1999
Upper Khabour	Khabour		I	1992

F: Flood Control; I: Irrigation; M: Military; P: Power; W: Water supply.

3.1.2. Climate Change

Data of climate records indicates that the Middle East and North Africa (MENA) is among the most vulnerable regions of the world to the potential impacts of climate change where increase of temperature is relatively high [29] [30]. This implies that there will be increase of the average temperatures, less and more erratic precipitation, higher transpiration and sea level rise (SLR). Drought will affect the agricultural life and water supply at Middle East [31] due to the fact, that most of the agricultural areas of MENA region are rain-fed [32].

Analysis of the rainfall and temperature records in different parts of Iraq indicates that there will be continues decrease of rainfall and increase in temperature in future [33] [34] [35] [36] [37]. The rainfall will take place in shorter periods and will be more intensive. This will cause high rate of sediment transport leading to decrease of the storage capacity of the reservoirs and low agricultural yield. In addition, the quantity of water infiltration will be decreased and consequently there will be depletion of groundwater resources. Dust storms are expected to increase.

3.2. Internal Reasons

It is very unfortunate that the political system, which was adopted in Iraq since 2003 onwards, depends on sharing power and filling key positions within the different ministries and government departments by the ruling political blocks and parties. Consequently, most of the ministers and director generals that held and are holding positions in the Iraqi ministry of water resources and other ministries using water are not competent, unexperienced and corrupt persons. This has resulted in a very grave situation as far as the water management of water resources of the country is concerned.

The situation concerning water resources can be summarized as follow:

- **Supply and Demand:** There is a gap between supply and demand [1] [10] [38] [39]. The overall water demand for Iraq ranges between 75 to 81 BCM of which irrigation requirement ranges from 22 to 39 BCM [10]. Real Irrigation efficiency ranges between 25% to 30% [10]. The overall agricultural land is about 3.5 million ha, and only about 50% is cultivated in recent years. If the whole area is cultivated the water required assuming good irrigation efficiency will be 50 BCM.

As far as the sanitation sector is concerned water losses are high and the infrastructure of the system is not working efficiently [40]. In any case, the demand for sanitation is 5 BCM. Additionally, the hydropower sector (including evaporation from reservoirs) and restoring the marshes requires 10 and 16 BCM respectively. The available water does not exceed 75 BCM [41] [42]. Assuming the situation remains as it is now, then water supply will drop [38] and the demand will be 66.85 BCM [43] or 77 BCM [44].

- **Potable Water Distribution Network:** About 33% of the people in Iraq do not have access to safe water and sanitation [1] [45]. Water distribution services have deteriorated and only 73% and 40% - 45% of the people in urban and rural areas are serviced respectively. More information indicates that 79% of the population has access to drinking water (92% in urban and 57% in rural areas) [46]. This indicates that 21% have no access to drinking water, and 16% have daily problems while 7% have weekly problems, 15% have less than weekly problems and only 41% have a reliable source [46]. The estimated water shortage in the domestic sector is 1.7 BCM [45]. The efficiency of the domestic distribution network is 32% and still deteriorating with time [10] and the demand reaches 11 MCM per day [45].

As far as water treatment is concerned, only 8% of the population is served in 14 cities out of 252 cities [10]. In view of this situation, most of the sewage water is directly discharged to the rivers without any treatment and the treatment plants require replacement, rehabilitation and upgrading [10]. The domestic and sewage water networks are damaged which causes mixing of drinking water with swage causing infections to the people [10] [46] [47] [48] [49].

- **Water Quality:** Upstream projects on the Euphrates and Tigris Rivers caused return irrigation flow water quality to deteriorate [15]. It is expected that

more deterioration will take place due to future implementation of irrigation projects in upstream countries [15] and continuous discharge of sewage and industrial affluent (about 500,000 cubic meters) in the rivers [47]. For these reasons the water quality in both rivers are deteriorating downstream where TDS values reach about 2000 mg/l in Basra [15] which does not meet the WHO standards [43]. This has caused large number of people to suffer from different diseases particularly due to the leakage of both drinking water distribution and sewerage systems causing high contamination [41] [46] [48] [49]. Due to salinity increase, 4%, 50% and 20% of the land are severely, medium and slightly saline [50].

- **Desertification:** The continuous decrease in the flow and increase of salinity of the rivers had caused about 45% of the area of Iraq to be affected by desertification [51]. According to IAU [43], 20,000 farmers and fishermen left their farms and 40% of the agricultural cropped areas reduced. In addition, large number of trees was destroyed during both Gulf wars. All these factors increased the desert areas and caused very frequent dust storms.
- **Water Resources Mismanagement:** Prior to 2003, the ministry responsible for the water resources in Iraq was referred to as the “Ministry of Irrigation”. After that, the name of the ministry was changed to be the “Ministry of Water Resources”. The political system in Iraq after 2003 is based on sectarian and political quotas. For this reason most of the water resources ministers and director generals within this ministry since 2003 onward are not specialized and unexperienced in the field of water resources. This made the problem of water scarcity graver. Examples of mismanagement in the past couple of years can be summarized as follow:

1) Absence of water use planning or rational strategy for reservoirs operation and water management. For this reason, the reservoirs now are almost empty.

2) Iraq is known for its salinity problems since the dawn of civilization [51]. Due to water logging and salinity, 50% of the land was degraded in the 1970s. For this reason, the Ministry of Irrigation launched great efforts to restore the agricultural lands to its previous fertility through implementing drainage systems. The Ministry of Water Resources has neglected its duty to maintain and upkeep of all these projects, which had costed hundreds of millions dollars, and left them without any real maintenance or rehabilitation and as a result, only 15% of the drainage system is in operation now.

3) Drowning shallow areas with water like very shallow areas of the marshes. This increased the evaporation and consequently salinization of these lands.

4) The irrigation projects are designed so that certain lands are to be irrigated and the amount of water is calculated according to the agricultural requirements. The ministry diverted the canals to private lands against all the regulations just to satisfy some persons with political influence or for unknown reasons.

5) An Italian company called TREVI was contracted for about 350 million US

Dollars to do mainly grouting operations in Mosul Dam for 18 months. This contract was renewed for another year for about 100 million US Dollars. Iraqi local staff carried out these operations since 1986. If we consider the cost in case the Iraqi staff will handle the grouting operations, we can save at least 70% of the 450 Million US Dollars. Other contracts have been awarded even without informing the public. Reasons for such actions if not satisfactorily explained can only be taken as acts of corruption to which all the responsible persons must be brought to accounting. Similarly, all other violations which have been committed in running the water management sector during these years must be investigated and all responsible people should be brought to justice. A firm and tough policy towards corruption must be instated. Transparency in the actions of the Ministry of water resources sector should be respected and upheld.

4. Discussion

The Euphrates and Tigris basin are shared by four main countries. These are Turkey, Iran, Syria and Iraq. Iraq being the lowest downstream country is the most effected country by any projects on these rivers and their tributaries in the upstream countries. These countries do not have any agreement about water quotas and or a comprehensive plan for the future management of the catchments of these rivers [14] [28]. Because all these individual countries claim that they have water shortage problems so water is over exploited [41] [52] [53] [54]. This has caused certain conflict between these countries like the tension between Iraq and Syria in 1975 and in the friction between Turkey and Syria in the 1980s [55]. Since Turkey is the riparian hegemon, then there should be some intensive efforts to bring Turkey to the table of negotiations and discussion. The help of an international partner that have the political, technical and financial power to convince all parties [14] [19] can do this. Reaching a solution is vital because the low flow and climate change has led to an abnormal rise of temperatures in Iraq and Syria as well as enhancing dust storms [56] [57] [58] [59] which have very negative consequences on humans and the environment (see **Figure 2** and **Figure 3**).

While trying to reach an agreement with riparian countries, Iraq should take quick measures to construct a prudent and scientific strategy to overcome the water shortage problems. The Iraqi Ministry of Water Resources claims to have a long-term strategy. In this context, no one has seen this strategy or its implementation. Even if such strategy exists, the results are negative indicating that this strategy does not work and should be changed. Al-Ansari [14] [19] [40] suggested a long-term strategy that can be put in practice to overcome this nightmare. This strategy can be summarized as follow:

- 1) Strategic Water Management Vision: In this context, an integrated water master plan is required. The plan is to be put by individuals that have expertise in water resources at the ministries of Water Resources and Agriculture. Experienced university staff are to participate as well as NGO's. It will be a good idea

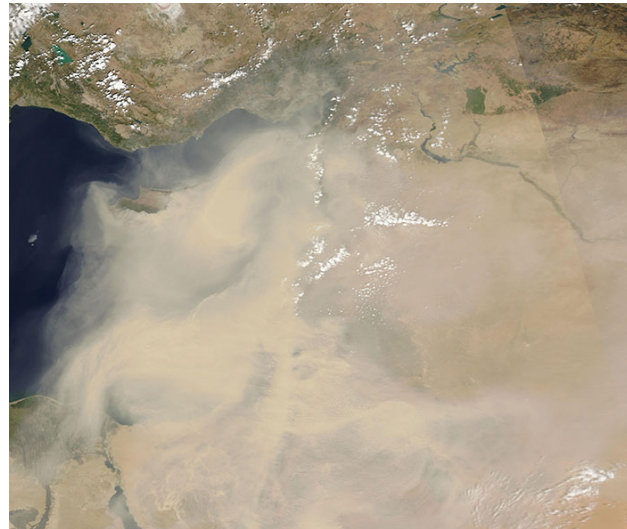


Figure 2. The extent of the dust storm on 8 September 2015 as seen from the Moderate Resolution Imaging Spectroradiometer (MODIS) satellite. Image accessed from NASA Worldview: worldview.earthdata.nasa.gov. (Source [57]).

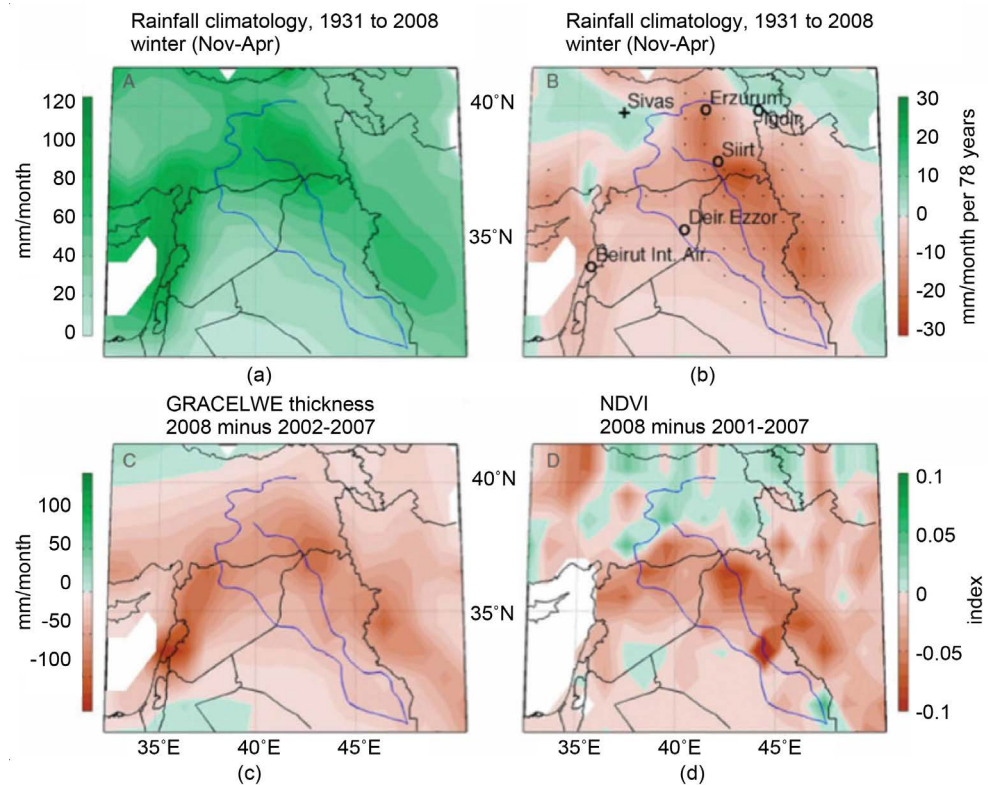


Figure 3. The Fertile Crescent has been steadily drying since 1931, and recent changes have exacerbated the trend. Map (a) shows winter precipitation from 1931 to 2008. Map (b) shows winter rainfall change from 1931 to 2008. Map (c) shows a steep decline in groundwater between 2008 and the mean of the previous six years using data from the Gravity Recovery and Climate Experiment (GRACE) satellites. Map (d) shows a decline in vegetation between 2008 and the mean of the previous seven years using Normalized Difference Vegetation Index data from the Moderate Resolution Imaging Spectroradiometer (MODIS) satellite instrument. (Source [58]).

to include representatives of regional and International organizations concerned. The plan should include the following:

- Rehabilitation of infrastructure, which should cover dams, barrages, weirs as well as pumping stations.
- Improving the efficiency of distribution networks specially diversion and supply down to the point of use.
- Irrigation modernization using suitable techniques. Present methods should be very restricted and new less water consuming techniques should be adopted e.g. drip irrigation.
- Public awareness program is vital so that all the people appreciate the serious problem they are facing.
- Defining institutional agenda including employment and training.
- Supply and demand should be considered. In this context, new non-conventional water resources (water harvesting, treated wastewater) should be considered and evaluated.
- Private sector is to be enhanced to be involved (especially for infrastructural investment).
- The extent of restoring the marshes should be considered in view of water availability.
- Review and amend all the legislations and laws governing the water sector and water use to exercise better control of water sharing between all users and to ensure the proper use of water which should be treated as a rare commodity and stop all types of waste or misuse. The government must also enforce the application of these laws by using its proper instruments to solve individual and tribal conflicts over water issues in the light of the stipulation of these laws.
- A new policy towards water pricing should be introduced to stop water misuse and waste by introducing proper tariff based on the real economic value of water on one hand and to hinder this misuse and waste. Collection method should be based on actual used quantities and away from any type of corruption or manipulation.
- Inter-ministerial coordination is very important. This will save time, effort and money. More decentralization including budget in irrigation, water supply and sanitation sectors are to be practiced.

2) Regional cooperation and coordination: Before starting any discussion with any organization, the institutional and technical needs for cooperation should be defined. Iraq should concentrate its efforts on trans-boundary resources. This can be achieved by discussions with all riparian countries with the help of a mediator that has good political, technical and financial capabilities. Iraq from its side can give incentives to upstream countries so that they will seriously be involved. In addition, UN organizations, International institutions and well known universities can be approached for scientific and technical cooperation.

3) Irrigation and Agriculture: In this sector, plenty of efforts are required. As a

start, farmers should be trained to use modern irrigation techniques before implementing these techniques. In addition, institutions should reflect decentralization, autonomy and farmer empowerment. Other measures should include:

- Modernizing the irrigation and drainage system.
- Enhancing the private investment in the agricultural sector.
- Using suitable techniques in irrigation (drip irrigation and sprinkler irrigation) and closed irrigation systems.
- Maintenance of irrigation and drainage projects.
- Partially built dams should be completed and starting to build new dams.
- Water harvesting techniques are to be used.

4) Water Supply and Sanitation: Distribution and collection networks are in very bad conditions. This necessitates quick maintenance and restoring distribution and collection networks and services are to be improved.

5) Research and Development: A data bank should be established that includes all reliable data required (climatological, hydrological, geological, environmental and soil) to be used by researchers and decision makers in water resources and agricultural research. Researchers and postgraduate students are to be allowed to have access to the data. The research should highlight the needs and suitability of new techniques in water resources and agriculture to the environment in Iraq. An institute can be established to perform these tasks as well as:

- Establishing training programs for technicians, engineers and decision makers about up to date technologies.
- Executing research to import new technologies in water resources and agriculture which suits Iraq environment.
- Projects, which help in augmenting water resources, developing land productivity, minimizing water use and consumption should be, carried out.
- Setting the outlines of public awareness programs both for water use and agricultural activities.
- Giving advice to universities and institutes to set special courses in arid region hydrology.

6) A thorough examination should be made to all of the organization structures in the water sector to ensure efficiency of work and quick response to arising problems as the present structures proves to be flabby, over staffed and inactive.

5. Conclusion

Building of dams and implementation of irrigation projects in the upper parts of the catchment as well as the effect of climate change have caused reduction of the flow of the Euphrates and Tigris Rivers and their tributaries. For these reasons, Iraq is facing a serious water shortage problem now and in the future. The Iraqi Ministry of Water resources mismanagement made the problem even worse. On the regional level it is believed that overcoming the problem requires discussions and negotiations with all riparian countries. This task is very hard to

achieve and requires a mediator that has political, financial and technical capabilities that can convince all parties. Iraq on its part as being the lowermost country within the Euphrates and Tigris catchment should give some incentives to Turkey so that it considers the problem seriously. This requires also that the Iraqi government in general and the Ministry in particular should take this matter as an existential threat affecting the livelihood of the People of Iraq and act accordingly. Both the government and the Ministry have not done so far enough in this respect and they both need to put more work and effort on this. At the same time, on the local level Iraq the Ministry should put a prudent and scientific strategy for the management of its water resources and apply it correctly. All influences affecting the fair water distribution must be stopped, whether political, tribal or otherwise, and corruption in all its forms must be eradicated starting from the top down to the bottom.

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