مشكلات شح الموارد المائية في العراق والحلول الممكنة

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Problems of Water Resources Scarcity in Iraq and Possible Solutions

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Abstract

Iraq relies in its water resources on the waters of the Tigris and Euphrates and their tributaries. The country is located at the lower part of the catchment area of these rivers. The long term average annual flow that enters Iraq from these rivers is about 30 BCM from the Euphrates, 22.2 BCM from the Tigris, 24.78BCM from tributaries and 7BCM from side valleys between Iraq and Iran. Now, the flow of these rivers is decreasing due to climate change and hydrological projects established in the upper parts of the catchment. It is indicated that precipitation will decrease 15-25% during this century and this means that the flow of the Tigris and Euphrates Rivers will be reduced by 29-73%. This will cause a grave depletion of ground water resources. Turkey is trying to finish building 22 dams and 19 hydropower stations. Iran built 12 dams and diverted the flow of some tributaries inside Iran and blocked all the valleys that contributes water from its land to Iraq. For these reasons, Iraq is experiencing shortages in its water resources and there is some sort of friction and conflict between riparian countries within the Tigris and Euphrates basins because each country tries to secure its water resources. In this research, the factors affecting the hydro politics within these basins are Water scarcity, Climate change and Hydrological projects, population growth rate, Energy issues, Water mismanagement, Economic changes, Expansions of projects and technology, Political issues, international water laws and public awareness. In case the situation remains as it is, Iraq will experience many problems in health, environment, economy, and security. To solve the problem of water scarcity in Iraq two parallel lines of action are to be considered. These are:

A. Reach agreements with Riparian Parties
B. Develop Long-term Strategy that should take care of:

- Rehabilitating of dams, barrages & pump stations,
- Improving the efficiency of diversion and supply,
- Using of Nonconventional Water Resources,
- Irrigation modernization using suitable techniques,
- Developing a Public awareness program
- Developing human resources program and establishing an agenda for training
- Developing an agricultural plan that takes into consideration the possibility of reducing crops that consume a lot of water.

Key words: Tigris River, Euphrates River, Iraq.

1. Introduction

Iraq relies in its water resources on the waters of the Tigris and Euphrates Rivers and their tributaries (Figures 1 and 2). The basins of these rivers are shared by Turkey, Iran, Syria, and Iraq (Table 1). All these rivers originate from outside the borders of Iraq apart from Al-Adhaim tributary where its catchment is entirely lies inside Iraq (Figure 2). The long-term discharge of this tributary does not exceed 25 M^3/S. Long term records indicates that Iraq used to receive 30BCM of water from the Euphrates River and 21.2 BCM from the Tigris River while its tributaries contribute about 24.78 BCM [1]. In addition, 7 BCM of water brought by small wadies from Iran [1,2,3,4].

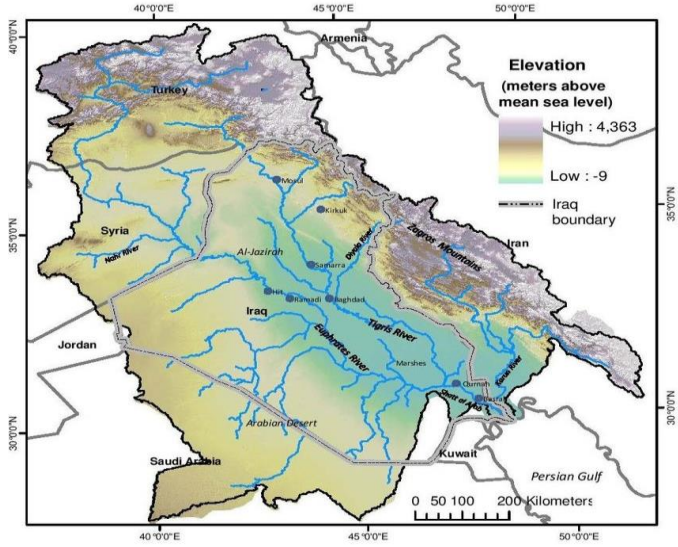

Figure 1: Catchments of Tigris and Euphrates Rivers.

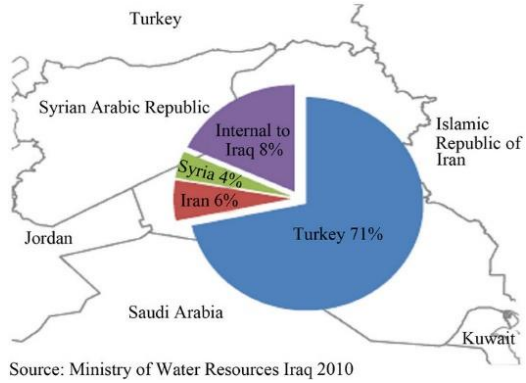

Figure 2: Source of water from the Tigris and Euphrates Rivers and their tributaries.

Table 1: The catchments of the Tigris and Euphrates Rivers include five countries in the Middle East, Southwest Asia.

Countries	Tigris River Catchment area		Euphrates River Catchment area	
	(Km^2)	(%)	(Km^2)	(%)
Turkey	57614	12.2	125000	28.2
Syria	834	0.2	76000	17.1
Iraq	253000	58	177000	39.9
Iran	140180	29.6	-	-
Saudi Arabia	-	-	66000	14.9
Total	473103	100	444000	100

Since Iraq is located at the bottom end of the Tigris and Euphrates basins (Figure 1) and for this reason any withdrawal of water in the uppermost catchments areas effects Iraq negatively. Due to the construction of dams in the upper riparian countries the flow of the rivers decreased tremendously [5,6,7,8]. This decrease of flow started in mid 1970s after the construction of Keban dam in Turkey and Tabaqa dam in Syria (Figure 3) [9]. Then the flow retarded more, and this can be noticed from the Shatt Al Arab flow where the annual flow of Shatt Al Arab was 919 cubic meters per second (CMS) during 1977-78 and dropped to 45 CMS in 2011 [10]. This is due to the construction of dams within the upper parts of the? catchments [9].

In this work, the conflicting issues on water resources of the Tigris and Euphrates Rivers basins are discussed and possible solutions to resolve these issues are given.

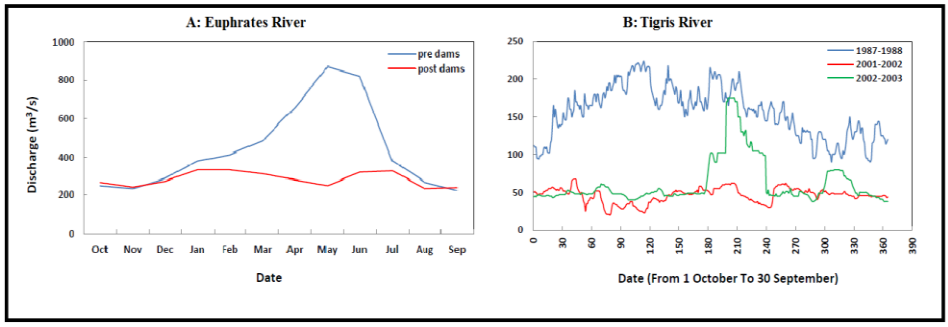

Figure 3: A: The Euphrates average monthly flow at Thi-Qar station during the periods 1950–1980 (pre-dams) and 1982–1997 (post dams). B: The average daily discharge of the Tigris River upstream of the Shatt al-Arab (near Qurna city) before and after the development in the basin (Modified after [6]).

2. **Causes of Conflict between Riparian Countries:**

Riparian countries within the Tigris-Euphrates basins are aware of the fact of climate change. For this reason, each country tries to augment as much as they can from the available water within these basins. This raised few

factors for conflict between these countries. These were summarized and discussed by [11,12]. These are:

Table 2: Water allocation per capita per year in Turkey, Syria, and Iraq

Country	Water Allocation (m3 /Capita/year)			
	1990	2000	2010	2020
Turkey	3223	2703	2326	2002[a], 980[b]
Syria	1636	117	880	760[a], 780[b]
Iraq	2352	1848	1435	1062[a], 950[b]

2.1. Water Availability

Turkish officials [13,14] always claim that the allocation per capita is good and accepted for Iraq (see table 2). The data proposed does not consider the effect of the GAP project on the flow of the rivers and it also ignores the volume of water required to restore the Iraqi marshes. On these bases Turkey claims that the existing water is sufficient for Syria and Iraq [15].

2.2. *Population Growth Rate:*

There are 221.53 million inhabitants living within the Tigris and Euphrates basins in Syria, Turkey, Iran, and Iraq (Table 3). Since population growth rate is high in these countries particularly in Syria and Iraq, it is expected that the population will be 243.44 and 304.68 million in 2025 2nd 2050 respectively. This suggest that the increase in population is 10% in 2025 and 37% in 2050. In view of these figures, food self-sufficiency will enforce more water to be used for agricultural purposes. Now, the allocation for water for agricultural purposes within the basins is 84.35% (Table 3). Future need for water in this sector will be beyond the capacities of these countries. Iraq used to be grain exporter but after the Gulf war it became grain importer. This is due to problems in salinity and water logging and food security and food self-sufficiency will be one of the major concerns in Iraq.

Table 3: Population Characteristics within Tigris-Euphrates Basins

Country	Population (million)	Rate of Growth (%)	Projected population (million)		Percent Urban
			2025	2050	
Turkey	81.91	1.45	86.12	95.62 95.819**	71
Syria	18.28	3.7	23.41	34.02 34.90**	75
Iraq	39.33	2.78	47.19	81.49 83.65**	66.9
Iran	82.01	1.05	86.72	93.55 92.21**	73.8
Total	221		243.44	304.68	

2.3. Energy Needs:

Iraq and Iran used to export oil since the beginning of the twentieth century while Syria started to export oil in 2001 while Turkey has no oil reserves. For this reason, Turkey is trying to use hydroelectric power to cover about

40% of the energy required and this will reduce its imports of oil by 28 million tons. One of the goals for Turkey to achieve this is to complete the GAP project. This will decrease the flow of the rivers, and this might be the goal of Turkey to trade water against oil where several authors cited that the GAP project has number of internal and external goals.

2.4. Water Resources Management:

Old irrigation technique (flood irrigation) is the dominant method used within the basins this has exacerbated the water scarcity problems within riparian countries [16]. In addition, water supply canals are not covered and unlined and this enhances water loses. Chemical fertilizers and pesticide are extensively used, back flow from irrigated areas and dumping of municipal and industrial waste in the rivers accelerated the pollution of these rivers. In this case the water quality within the rivers in Iraq deteriorated due to its geographic location. This was reported by the Consulting Engineering Bureau at Baghdad University [17] and [9]. Salinity of Euphrates River at the Iraqi – Syrian border reached 1000mg/l while it the TDS for the Tigris at the Turkish – Iraqi border is about 280 mg/l and it reaches 1800 mg/l at Basrah [2].

2.5. Development of Economic Sector:

About 50% of the population from rural areas moved to urban areas due to the economic development in the Middle East caused by increasing of oil prices. This movement gave a negative impact on the water shortage problem since water consumption increased about 10 to 12 times its normal per capita as village dwellers [18]. The standard of living in Iraq and Syria relatively increased fast due to increased oil prices caused rapid economic developments. This raised the need for water in view of these developments in these two countries. Due to this, the claimed needs for Turkey, Syria and Iraq summed up to 149% of the total available water[19]. Turkey is trying to use its water as a commodity for bargaining where the president of Turkey in 1992 declared at Ataturk dam opening ceremony that “Neither Syria nor Iraq can lay claim to Turkey's rivers any more than Ankara could claim their oil… The water resources are Turkey’s; the oil resources are theirs. We don't say we share their oil resources, and they can't say they share our water resources” [20]. In addition, Turkey proposed Peace Pipeline and Manavgat River project focus to trade water with Mediterranean and Middle East neighbors [21].

2.6. Development in the Technical Sector:

To augment more water Turkey and Iran built several dams and are planning to build more dams. These dams cause an increase of evaporation due to the high temperatures in the region. In addition, existing irrigation techniques has high water losses, and this will lead to more water losses. New techniques were tried to be used in Syria and it faced plenty of

problems where farmers were not educated and could not understand and apply the new technologies [22].

2.7. Political Fragmentation:

The excessive use of surface water and groundwater and water pollution became one of the prime sources of friction and tension. As an example, is the 1967 war between Israel and Arab states where water was one of the underlying causes as well as the Israeli occupation of Lebanon in 1982 where they occupied Litany River and diverted its water. Israel is extracting 40% of its water from aquifers beneath the West Bank and Gaza [18]. Number of dams were built on the Tigris and Euphrates in Turkey and Iran without any consultation with Syria and Iraq and this also raised friction [6]. Another example is the tension between Syria and Iraq in 1974 over the Euphrates water sharing. Prediction models for future surface water and groundwater resources show their depleting in the Middle East [9, 23]. This led the UN Secretary General Boutros Boutros-Ghali to say in 1985 that the next war in the Near East would not be about politics, but over water [24].

2.8. International Water Laws:

During the United Nations General Assembly on the 8th of July 1997 approved the Law of the Non-Navigational Uses of International Watercourses. Turkey, China, and Burundi voted against this law[25]. This law states the principals and mechanisms that should be followed to avoid dispute escalating to the level of acute conflicts and it has no legally binding international obligations for countries to share their water. It is suitable for non-arid regions and not for arid region like the Middle East[3]. In view of this, agreements will depend upon the goodwill of the countries involved within the drainage basin, degree of national interest and both internal and external power available for the country to pursue its politics.

2.9. Public Awareness Program:

Although Iraq and Syria are experiencing water shortage problems now, other riparian countries are expected to experience water shortage problems in future also. Countries concerned are supposed to design a strategy for public awareness program. This should include promotional activities, implementing the activities and monitoring and evaluating their effectiveness. Politicians and policy makers; water planners and managers, and social marketers are to be educated about the importance of water conservation in the potable water supply sector and how it may be approached, so that they can take part in national water awareness program and promoting it to society.

3. Causes of Water Shortage in Iraq:

Tension and friction and sometimes escalated leading to war between countries in the Middle East due to water shortage problems. As far as the Tigris and Euphrates Rivers they are very valuable source of water for

Turkey, Iran, Syria, and Iraq. It should be mentioned however, they never reached to an agreement that gives reasonable share of water for each of them where they always claim that what they get is scares and water is over exploited[26,27] or extremely highly stressed[28].

3.1. Hydrological Projects in Riparian countries

This situation caused friction between riparian countries. As a result, individual countries took unilateral actions and implemented projects that have degraded the entire basin and reduced its domestic and agricultural usefulness. In addition, political factors and military events were involved in this conflict. Turkey and Iran taking advantage of their geographic position being the upper riparian countries and having relatively the strongest political power in the region which will allow them to obtain the desired quantity of water.

In view of this Turkey and Iran continued to build dams (Tables 4 and 5) on the Tigris and Euphrates and their tributaries. All these activities effected Iraq negatively and highly contributed to the water shortage problem in Iraq.

Table 4: Dams built and planned by Iran (source: [7]**.**

	Dam	River	Year of Operation	Height (m)	Capacity (Km3)	Type
1	Karka 1	Karkha, Tigris	1952		7.8	I
2	Kohrank 1	Karon, Shatt Al Aarab	1954	10	0.32	Diversion
3	Dez	Dez,karon, Shatt Al Aarab	1962	203	3.3	Hp,I
4	Karon 11	Karon, Shatt Al Aarab	1976	200	3.13	Hp
5	Kofand down	Karon, Shatt Al Aarab	1977	65	0.071	Hp
6	Khashlak	Serwan,Diyala, Tigris	1979	89	0.215	I
7	Shankasem	Barkon, Tigris	1966	49	0.215	I
8	Bazaft	Bazaft,karon, Shatt Al Aarab	Planned	211	0.45	Hp
9	Karkha 2	Karkha,Huwaza, Shatt Al Aarab	1998-2000	127	5.9	Hp,I
10	Karkha 3	Karkha, Shatt Al Aarab	2002	177	0,061	I, Hp
11	Karon 2	Karon, Shatt Al Aarab	2002	177	0.261	Hp
12	Ghafoshan	Ghafi,serwan, Tigris	2004	123	0.55	I, Hp
13	Kohrank 2	Karon, Shatt Al Aarab	2005	15	0.01	Hp
14	Karon 3	Karon, Shatt Al Aarab	2005	205	2.97	I, Hp
15	Sulaiman shah	Ghafi,serwan,Diyala	2006	50	0.05	I, Hp
16	Karon 4	Karon, Shatt Al Aarab	2010	230	2.19	Hp
17	Upper Kofand	Karon, Shatt Al Aarab	2012	180	4.5	I, Hp
18	Azadi	Zamankan,diyala, Tigris	2012	64	0.07	D, Industry
19	Gheran	Gheran, Serwan,Diyala	2013	62	0.11	I
20	Semar	Karkha, Shatt Al Aarab	2013	180	3.2	Hp

21	Gafa	Serwan,Diyala	2013	86	0.172	I, industry
22	Zafia	Shaheni, Serwan	2013	54	0.017	I, industry
23	Azad	Serwan,Diyala	2014	115	0.3	I, Hp
24	Asfahan	Harod,karon, Shatt Al Aarab	2015	71	0.05	Drinking
25	Safelah	Lower zab	2017	79	0.0163	Hp
26	Kharsan 1	Karon, Shatt Al Aarab	2015	195	1.158	I, Hp
27	Karsan 2	Karon, Shatt Al Aarab	Planned	240	2.3	Hp
28	Karsan 3	Karon, Shatt Al Aarab	2015	176	1.1	Hp
29	Zamkan	Zamkn,diyala, Tigris	2017	65	0.023	I
30	Daryan	Serwan,diyalah, Tigris	2018	146	0.316	Hp
31	Herwa	Serwan,diyalah, Tigris	2018		0.012	Water diversion
32	Nawsood tunnel	Water diversion to Karmanshah	2018	48.3 km long	1.0	Water diversion
33	Azkalah	Serwan,diyalah, Tigris	2018	65	0.03	Water diversion
34	Saradesht	Tigris, L.zab	2018	116	0.0545	Hp
35	Amer abad	Serwan,diyalah, Tigris	2019	30	0.018	I
36	Ramshad	Serwan,diyalah, Tigris	2018	35	0.006	Water diversion
37	Bakhteyari	Karon, Shatt Al Aarab	2018	351	4.845	Hp
38	Zalaki	Diz,karon, Shatt Al Aarab	design	210	1.51	Hp
39	Lerwa	Diz,karon, Shatt Al Aarab	design	210	0.52	Hp
40	Rodbad	Diz,karon, Shatt Al Aarab	2017		0.23	Hp
Hp: Hydroelectric power generation I: Irrigation						

Table 5: Dams built and planned by Turkey (source: [1]**.**

Dam	**River**	**Height (m)**	**Purpose**	**Completion Date**
Çetin Dam (Alkumru)	Tigris/ Botan	145	P	2016
Aslandag	Tigris/Greater Zab/Bembo	60	I/M/P (future)	2012
Beyyurdu	Tigris/Greater Zab/ Bembo	48	I/M/P (future)	Under Construction
Atatürk (Karababa)	Euphrates	169	P	1992
Balli	Tigris/Khabour/Hezll/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
Burç Bendi	Euphrates/Goksu	47	P	2010
Cizre	Tigris/Botan	46	I/P	Planned
Çoukurca	Tigris/Greater	45.5	W/M	Under Construction

	Zab/Guzedlere			
Dumluka	Euphrates/Bugur	30	I	1991
Erkenek	Euphrates/Adiyaman	-	P	Operational
Goksu	Euphrates/Goksu	52	I	1991
Hecihider	Euphrates/Sehir	42	I	1989
Hancagiz	Euphrates/	-	I	1988
Ilisu	Tigris	135	I/P/F	2017
Upperkalekoy	Euphrates/Murat	137.5	P	2017
Lower kalekoy	Euphrates/Murat	115	P	Planned
Karakaya	Euphrates	158	P	1987
Karkamis	Euphrates	21.1	P	2000
Kavsaktepe	Tigris/Khabour/Hezil/Ortasu	66	W/M	Under Construction
Kayacik	Euphrates/Sajur	45	I/P	2005
Keban	Euphrates	207	P	1974
Kirazlik	Euphrates/Botan	60	I/P	2011
Kralkizi	Tigris/Maden	113	I/P	1997
Mustatepe	Tigris/Khabour/Hezil/Ortasu	34.5	W/M	Under Construction
Silope	Tigris/Khabour/Hezil	79.5	W/M/P	2012
Silvan	Tigris/Barman	174.5	I/P	2017
Sirrntis	Tigris/Birimse	92	I	2013
Sirnak	Tigris/Khabour/Hezil/Ortasu	56.8	W/M	2012
Uludere	Tigris/Khabour/Hezil/Ortasu	55.5	W/M	Under Construction
F: FloodControl I/ IrrigationM:MilitaryP:PowerW:Watersupply				

3.2. Climate Change

The Middle East region has been noticed to be one of the mostly affected areas in the world due to climate change[29,30]. In this context, the temperature is rising while rainfall is decreasing. These effects all aspects of life [31]. Large number of research has been conducted about this topic and various models were used and all suggested the same general results. In general, as far as the Tigris and Euphrates basins, it has been noted that during this century the decrease in rainfall varies from 15 to 25% and this suggests decrease of flow of the Tigris and Euphrates Rivers by 20 to 73%. This will have a grave depletion effect on ground water resources. ainfall will be decreasing in all parts of Iraq [29, 30, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42]. Even though it is decreasing, there will be certain events where intensive rainfall will take place in short period of time (see Figure 4)[43, 44, 45, 46, 47, 48, 49]. This event is very negative because it causes floods[50,51] destroys houses, farms, and infrastructures (Figure 5). In addition, large volume of sediments will be eroded from agricultural areas, and this weakens. The productivity of agricultural areas. These sediments will be deposited in low areas like reservoirs, and this will reduce the storage capacity of reservoirs.

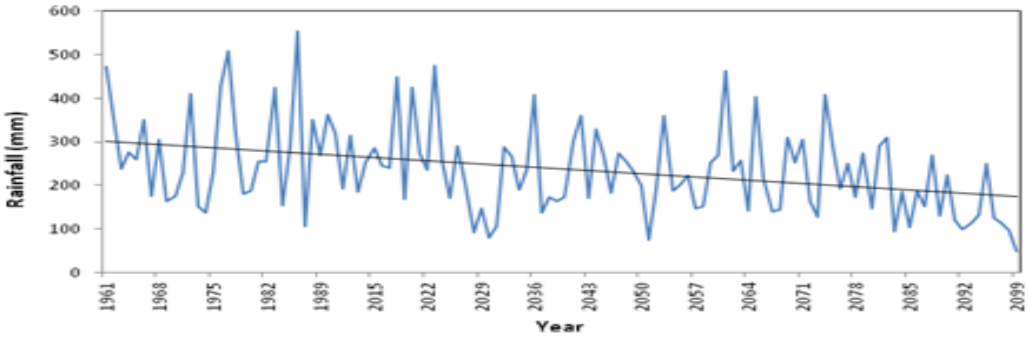

Figure 4: rainfall decrease during 21 century in Sinjar area, Iraq (source: [43]**.**

Figure 5: Flood in Erbil City, Iraq 17 December 2021. (a) Flooded street; (b) Damaged vehicles blocking a street; (c) Remains of muddy flood water; (d) Blocked Street with mud; (e) and (f) Flooded streets; (g) Inundated cars and height of the flood water in a street in Dara Too district.

Such water events can be used positively in case there are water harvesting schemes. In having such schemes millions of cubic meters of water can be harvested [52,53,54].

Temperatures are expected to rise also at least 2^0C. This will increase evaporation [29, 30, 39]. As a result, with rainfall decrease and increase of temperature, the natural vegetative cover will be decreased, arable land area will be reduced and this hits agriculture, total area of lakes and other natural water bodies will be reduced, desertification will b extended, and more dust storms are expected. International organizations reported that about 100,000 dunums of agricultural land is lost annually. In addition, thousands of farmers left their lands dure to water scarcity and bad water quality [1, 50, 55, 56, 57, 58, 59]. Dust storms are expected to massively increase (Figure 6) [60].

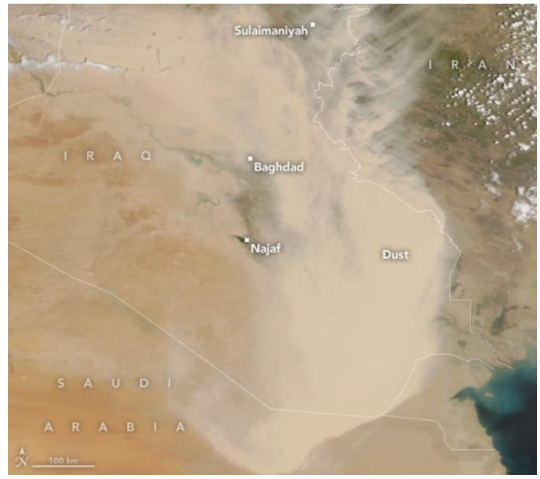

Figure6: Dust storm (16 May 2022) Aqua MODIS image

This indicates that in case the situation remains like this, then Iraq will suffer from different problems such as human health, energy, food, and water scarcity.

3.3. Water Management in Iraq:

The Iraqi Ministry of Water Resources adopted a strategy known as "Strategy for Water &Land Resources in Iraq" which was set by Italian companies in 2014. This strategy was supposed to be implemented for the period 2015-2035. Looking at the water resources situation in Iraq now, it clearly reflects the dis efficiency and failure of this strategy. This is due to the following reasons:

- No scenarios were given for expected future problems in the water sector due to climate change and hydrological projects in riparian countries.
- Allocating fair and just for each governorate and Kurdistan region. This is very important where [61] stated that if this coordination does not exist it will form strategic threat to Iraq. Problems between farmers in different governorates can be solved by putting fair and just water shares.
- Changing on going irrigation techniques that has high water losses.
- No public awareness program was suggested for farmers and public.
- Changing the regulations and rules concerning water resources.
- Restructuring the ministry of Water Resources organizational structure where it has more than 12000 personals according to UN reports [62].
- Reasonable pricing policy for water consumption rates should be adopted.
- Adopting new non-conventional water resources (e.g., rainwater harvesting, desalination and wastewater treatment and re-use) and considering groundwater recharge.
- Planning to use water saving crop strains and avoid crops with high water requirements as well as using high intensity crop rotations to make maximum use of residual soil moisture at the end of each season.
- Setting human resources development program.

4. How to Resolve Water Shortage Problem in Iraq

Iraq is in the lowest part of the basins and for this reason it is the most effected country relative to others. This enforced the government to take quick action to overcome the water shortage problem. In view of the current problems and future expected problems, it suggested that the Iraqi Government should act in two parallel lines. These are:

A. On International Level:

It is inevitable that quick measures are to be considered to overcome the tension and to resolve any conflict among the riparian countries. Past experiences of negotiations with riparian countries did not lead to any agreements. For this reason, the strategy of negotiation should be changed. In this context, Iraq should involve the economic and security issues in the negotiations.

These two factors are of prime importance for Turkey and Iran because their economy relies heavy on the goods that is exported to Iraq where Iraq imports an equivalent of about 16 billion US dollars of goods from each country. In addition, there are many companies from both Turkey and Iran executing projects in Iraq. This fact makes the national budget of the two countries highly relies on what they are gaining from Iraq. As far as security is concerned, the opposition political movements against Turkey and Iran located in different parts of Iraq gives a big threat to these governments. If these two factors are used by the Iraqi Government, then it most probably will get the required water from Turkey and Iran.

B. On National Level

A long-term strategic plan for the management of water resources should be implemented irrespective of the changes in the external or internal politics and should be based on "Resources Dependence Theory". According to this theory it assumes that the good human resources, finance, and information as well as good international relations exists [63,64,65]. Ministry of Water Resources, Ministry of Municipality and Public Work, Ministry of Agriculture, staff at universities, private sector, NGOs, and representatives of regional and international organizations concerned should all work to design such a strategy.

The suggested strategy should address the following main items:

B.1.Water Management Vision:

Rehabilitation of the existing infrastructure which should cover water treatment plants, power plants as well as pumping stations should be a priority. Programs for public awareness should be implemented so that all the population can have a good idea about the problem. Instructions are to be given, so that individuals know how to deal with this problem. Human resources development programs are also important to upgrade the knowledge of engineers and technical staff with new technologies and ideas that can help to overcome or minimize the problem and institutional agenda including employment and training is to be defined. Non-conventional water resources are to be exploited like rainwater harvesting, wastewater treatment and re-use as well as desalination of salty water. Inter-ministerial coordination should be used which includes more decentralization including budget in irrigation, water supply and sanitation sectors are to be practiced. In addition, private sector should be asked to be involved in the investment. In view of the new status and conditions, the regulations and laws that protects water resources and reducing water consumption is to be adopted.

B.2. International and Regional cooperation and coordination:

The government should define clearly the Institutional and technical needs for cooperation that to be practiced with UN organizations and international institutions and organizations (e.g., UNEP, UNDP,

UNESCO, FAO, WMO etc.) and universities should be asked to give their experience in this matter.

B.3. Irrigation and Agriculture

New agricultural strategic plan is to be put in practice. In such a plan, high-water consuming plants are to be restricted and most efficient irrigation techniques that are suitable for the local conditions of soil, water availability and quality, crops are to be adopted. Water supply- distribution systems are to be maintained and developed to reduce the losses and increase conveying efficiency. To reduces evaporation losses and infiltration losses, closed conduits are to be used as conveying system. These systems are more conserving in land use and protects irrigation water from contact with saline water table. To improve soil leaching and reduce soil salinity, the drainage systems of cultivated lands are to be improved and the most effective modern drainage techniques such as perforated pipe drainage system in collecting and treating drainage water are to be adopted. It is also very important to avoid the return of drainage water to the rivers. To protect the quality of water, the use of chemical fertilizers and pesticides are to be reduced. Institutions should reflect decentralization, autonomy, and farmer empowerment and private investment in the agricultural sector should be encouraged. The farmers and technical staff should be trained to use new suitable irrigation techniques (drip irrigation and sprinkler irrigation).

B.4. Water Supply and Sanitation

Improving drinking water distribution networks specially diversion and supply down to the point of use which is most cost effective and leakages from the sewerage networks should be repaired and improving their efficiencies to prevent any source of pollution from these networks. New technologies like Information communication Technology (ICT)are to be adopted to improve the services. To reduce the pollution of groundwater due to the leakage from old septic tanks, new sewerage systems are to be installed to connect the neighbors that are not serviced and convey the sewage water to the sewage treatment plants. To satisfy the increased consumption of domestic sector new sewerage systems are to be installed. In such plants, membrane bioreactor technology can be used m to reuse the treated water and to prevent water losses and pollution efficient projects should be put in practice.

B.5. Research and Development

Reliable climatological, hydrological, geological, environmental and soil data are to be put in a data bank so that researchers and decision makers can use them. Research activities should concentrate on new technologies in water resources and agriculture that suites Iraq environment and conditions. Research on new techniques is to be conducted like water harvesting can be very effective and is relatively cheap cost wise and

climate control with water recycling Greenhouses can save large quantities of water also pioneer projects which help in augmenting water resources, developing land productivity, minimizing water use and consumption are to be executed. Training courses for engineers, and decision makers about up-to-date technologies are to be given as well as courses for farmers oriented on the use of new irrigation technologies. Outlines for public awareness programs for water use and agricultural activities is to be organized. Universities are to be encouraged to give arid regions hydrology courses. Prizes are to be awarded for new innovations, pioneer research and smart ideas in water resources, agriculture, and their management. Groundwater management program for the utilization of groundwater is to be adopted to prevent its exhaust and pollution.

5. **Conclusions**

Consumed water resources in Iraq mainly comes from the flow of the Tigris and Euphrates Rivers and their tributaries. The flow of these rivers and their tributaries drastically declined, and Iraq is facing serious water shortage problem. The decline of flow in these rivers is attributed to three main reasons. These are, climate change, hydrological projects in riparian countries and the ongoing water management strategy of water resources in Iraq. To overcome this problem, long term strategy is to be adopted and implemented. This strategy is to be executed irrespective of who is governing the country. The strategy should consider two main topics. The first is the share of water for Iraq from the rivers rising in riparian countries. The second is internal management of water resources in Iraq taking into consideration the ongoing problems and expected future problem. For the former, economic and security including water issue are to be used in discussions with riparian. These issues are very important to these countries which will force them to reach an agreement with Iraq. As far as the later topic, the strategy should consider rehabilitating of existing hydrological projects, improving the efficiency of diversion and supply, using of nonconventional water resources, irrigation modernization using suitable techniques, developing programs for public awareness and human resource as well as developing an agricultural plan that takes into consideration the possibility of reducing crops that consume a lot of water.

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