WATER REQUIREMENTS FOR MAINTAINING THE MARSHLANDS OF SOUTHERN IRAQ: *Desalination to Supplement Water Resources and Sustain the Ecosystems of the Marshlands*

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Summary

The Iraqi Marshlands are situated in the heart of the Mesopotamia which is considered the cradle of civilization. In 2016 the Iraqis have celebrated the event when UNESCO has named the marshlands as a world heritage site. It is an international recognition of its outstanding universal value. The Iraqis, with this inscription, were hoping that the neighboring countries will cooperate with Iraq on the conservation and sustainable management of the marshlands. It was a great step towards protecting and maintaining this vital wetland. Being protected under the international law it was thought that the neighboring countries will be obliged to supply Iraq with the right share of water that is coming from the two great Rivers the Euphrates and Tigris; nevertheless the severe dry season of 2017 and the non-availability of freshwater for the marshes as well as the suffering of some Iraq cities in the south of Iraq from acute shortages of drinking water is a clear evidence that the provision of an alternative source of freshwater supply is of essential importance. The number of dams that are already built and planned to be built by the four countries Turkey, Syria, Iran and Iraq are probably too many to be accommodated by the Euphrates and Tigris basins. Iraq is also considered as one of the most vulnerable areas where the temperature rise, as a result of the global warming phenomenon, would be noticeable. The growth of population over the next thirty years shall produce more severe stresses on the two rivers' freshwater resources and the possibilities that the Marshes will gradually disappear is very likely to happen, a future that reminds us of what has happened to the fourth largest freshwater lake in the world "the Aral Sea" that has dried out and now it's only ten percent of its former size. Desalination has contributed, over the last sixty years, as a reliable source of safe and clean drinking water and for other applications as well. Making safe drinking water available to every individual is a necessity as well as an ethical obligation. This publication is an attempt to provide a different but viable perspective on how to tackle water shortages problem by using the desalination technology to produce water to supplement freshwater resources for the Marshlands and the local community in the south of Iraq to make it self reliant.

This provision to supplement freshwater supply is recommended by desalination in a program of development that aims at sustainability as the final goal. The immediate step to meet the pressing needs of freshwater is by the use of the existing fossil fuel resources in thermal desalination. Since fossil energy resources are limited, unsustainable and have undesirable environmental impacts such as climate change, it is suggested that these be finally replaced by alternative sources of energy that are renewable. The abundance of free solar energy incident over the land must be the ultimate source to be exploited not only for freshwater production but also for electricity generation ensuring sustainable life with energy and water security for all generations in the future.

The paper also emphasizes other correct measures and appropriate actions such as the

wise use of water, co-ordination with neighboring countries, agreement on water allocations and the implementation of the right management approach, viable steps that will be involved in the restoration of the marshlands.

1. Introduction

The Iraqi marshlands are one of the world's largest ecosystems, serving as an indispensable source of essential services, not only to immediate surroundings, but to the entire region, including beyond Iraq's borders. Stretching across three Iraqi governorates, in many ways, the challenges confronting the Iraqi Marshlands are a microcosm of all Iraq's challenges, and the way in which they are addressed has the potential to demonstrate, on a broader level, strategies to move forward Iraq's development agenda [1].

The Ministry of Water Resources of Iraq has set a goal to restore the Marshlands to 75% of 10,000 km² which is considered the 1973 levels on one hand. On the other hand, there is uncertainty about what that would require in terms of quantity of water for the marshes as well as the needs of the marshland's population. This is reflective of Iraq's broader challenges in data collection and analysis, not only with respect to water resources management, but also in terms of overall evidence-based policy-making (See Figure 1).

Figure 1. An area of the Iraqi Marshlands located on the Euphrates River. The surface area of Iraq is 437,072km^2. The coastal regions are equivalent to approximately to 56 km^2

Grasping the true magnitude of the degradation of the marshlands that has taken place over the past 40 years will require an assessment of the full extent of services that Iraqis have lost as a result [1].

Water scarcity, highly saline and unsafe drinking water on one hand and the land degradation, lack of support that the marshes used to provide for benign climate, soil fertility and clean water on the other, are matters of serious concern that will affect the Iraqi's livelihood within the marshlands and beyond.

Two seasons of severe drought that occurred in 2008 and 2017, together with withdrawal and diversion of water upstream, are two examples of how the lack of rain fall influenced drastically on level of water in the marshes and also it shows the necessity of a supplementing source of water for the maintenance of the marshlands. Also supplement of safe water can be provided as drinking water to cities that are facing scarcity of fresh drinking water in the south of Iraq.

Desalinated Water for Iraq's Southern Cities

The GCC countries share common features, they all lack natural water resources and rainwater is also scares. The area covered by the six countries is approximately 2.55 million kilometer square and the total population is 48 million projected to be 56 million by 2030. Table 1 shows the population of the six gulf countries according to 2013 data. They all depend on desalinated water from the Arabian Gulf for their domestic and industrial needs.

Country	**Population**
United Arab Emirates	9205651
Saudi Arabia	28,290000
Qatar	2,035000
Oman	3869000
Kuwait	3250500
Bahrain	1318000
TOTAL	47969130

Table 1. Population of the six Gulf countries (2013 data).

Comparing the six southern cities: Basra, Mesan, Wasit, Muthana Theqar, Kadissya with the GCC countries, one reaches the conclusion that Iraq's south is a gulf region. Its coast line is 58 km long. It can support more than one large power station and desalination plant. Table 2 shows the area and population of the six southern cities

The current study addresses several important issues
1- Provide potable water (or freshwater) for the people.
2- Gradually Shatt el Arab will be filled with freshwater again.
3- It will help in filling the marshes.
4- Provides the much needed electricity.
5- It will counteract the actions of Iran and turkey.

An enduring solution that ensures freshwater security both for a part of the marshes and for the people to drink, would be worthy of immediate consideration. Unless steps are taken now to address the issue, future generations will suffer.

City	**Population**	**Area (km^2)**
BASRA	2796000	12070
MEESAN	1059644	16072
WASIT	1360000	17153
MUTHANA	775900	51740
THEEQAR	1979000	12900
KADISSEYA	1320000	8153
TOTAL	9290544	118088

Table 2. Area and population of the six southern cities

2. Review of the Recent History and the Current Situation

2.1. Review of the Recent History

The Iraqi Marshlands were once the largest wetlands in southwest Asia, extending across more than 20,000 km². Vast in size and abundance of resources, the marshlands represented an ecosystem of vital importance to nature and human life in the region, serving the local communities as an essential habitat with means of livelihood. Characterized by great biodiversity and cultural richness, the marshlands used to serve as a permanent settlement and migratory flyway point for numerous bird species, as well as a central habitat for the Gulf's freshwater fish [1].

Iraq is in a comfortable position; it has the human and financial resources to protect and develop the marshlands for the sustenance, enjoyment and even prosperity of future generations. However, the ultimate outcome will depend on the collective will to harness these resources and thereby implement policies and actions for sustainable development of the marshlands as a unique social, cultural and ecological system for the benefit of all Iraqis.

While in 2011 roughly 38% of the original marshlands area has been restored, most of the efforts that have been made to date remain fragmented, poorly coordinated, and with limited impact.

2.2. Current Situation of Tigris and Euphrates Basins

2.2.1. The Ideal Situation: An Ecosystems Approach

The three riparian countries Turkey, Syria and Iraq should have agreed on a long term basis, not only to share and derive benefits of the freshwater flows of the two rivers Tigris and Euphrates in a sustainable manner but also to consider the two river basins from the

head of the rivers in south east of Turkey to the lowest point downstream at the Arabian Gulf coast as an integral region and a holistic approach, an approach that considers the basin's ecosystems as a whole. Supply of the services along the rivers' basins will then be maintained and the sustainability of both rivers will be ensured.

The basic premise of the ecosystem approach is that nature provides many of the services needed for survival and development, such as food and freshwater; and some less obvious benefits, such as storm protection, pollination, and cultural goods. These services are essential for the support of stable habitats, economic systems and human populations [1].

Availability of upstream water supplies will ensure the quantity, quality and timing of (hydrological system) the water to the marshlands area. Management policies at macro-level to control the upstream water usage, climate control and drought should have been identified and coordinated by central government along with neighboring countries (Turkey, Iran and Syria). The ebb of tidal flows, an important natural function to the marshlands and its ecosystems that serve to filter out the pollutants and sediment annually has to be maintained.

2.2.2. Lack of Long Term Agreement

Supply driven approach in the context of the issue of the Iraq Marshlands, is centered on the core of Iraq's trans-boundary challenges with its neighbors. The revitalization of the marshlands is largely dependent on the constant in-flow of freshwater, especially in those areas of high soil salinity. Turkey, Syria and Iran as well as Iraq have constructed a number of dams on the Euphrates, Tigris and Karkheh Rivers and corresponding tributaries (such as the Caroon (Karun) River), and this is thought to have reduced the amount and quality of water reaching southern Iraq and subsequently increased the level of salinity in the Shatt Al-Arab [1].

What is considered as sustainable development for south eastern side of Turkey turned out to be an environmental disaster downstream of both Tigris and Euphrates river basins in Iraq. The most affected one at present time is the Euphrates basin. Sustainable development of the two river basins must be based on the recognition of the need to manage and balance the benefits derived from the ecosystems of the basins as a whole rather than simply managing the natural resources in a part of it.

Constructions of dams by Turkey on the Euphrates has led to a severe scarcity of water, total drought in many places in the downstream of the river basin and non-availability of water even for drinking purposes for some of the cities in 2017 in the south of Iraq. Under The Southeastern Anatolia project (GAP), Turkey's master plan is to construct 22 Dams, fourteen on Euphrates basin and eight on Tigris basin; 11 of them are already in operation since 2012, two more dams are under construction and very well in progress and 6 other dams are still part of the master plan for agriculture and production of electricity [2].

The Tigris Basin has several sub-basins that are shared between Iraq and Turkey or between Iran and Iraq. The main shared tributaries are the Feesh Khabour, the Greater Zab, the Lesser Zab and the Diyala. With capacity of more than 27 billion cubic meters (BCM), the tributaries of the Tigris significantly contribute to total flow of the Tigris [3].

The southernmost point in Iraq contributes nothing to the already existing flow of the Tigris River, the only exception to this being the tributaries originating in Iran. In recent years, however, this flow has also been stopped due to the construction of the Karun dams, three in total, on the tributaries in Iran. This has led to a high increase of salinity of the Shatt Al-Arab as the sea water flows upstream. In 2008 Iraq had a severe dry season. This critical situation has sparked new negotiation between the three countries. Turkey, then agreed to supply 400 to 500 m^3/s, but only up to the end of October 2009 [2]. As a matter of fact until now there is no long term agreement between the three countries for better and wise water resource allocations of the two Rivers basins.

2.3. Marshlands Size Fluctuations

As of 1970 the size of the Marshlands has degraded for various reasons. The two main factors that led to these changes were upstream damming and systematic draining. Restoration efforts have had mixed results since 2003. Re-flooding projects helped the area to recover nearly 50% of its extent by 2006 [1]. The changes in size could be summarized as follows:

- Pre-1970 area: The Iraqi Marshlands were once the largest wetlands in southwest Asia, spreading across more than 20,000 km^2
- In 1973, the permanent measured area was more than 8,000 km^2
- The 1983's physical size of the marshland was 7,875 km^2. This corresponds to 75% of the 1973 area
- Following the desiccation in 1980, 1990 and 2000 the only remaining marsh was a portion of Al-Haweza on the southern border with Iran and about 90% of the marshlands area was desiccated.
- In 2003 and after the fall of the previous regime, the Euphrates river water has been re-diverted back to the marshes and about one fifth of the marshlands were rehabilitated and restored.
- In 2006, the recovered area was about 50% of the 1973 size which is 7,875 km^2.
- By 2009, the re-flooded area fell to 2003-values -one fifth due to drought and reduced flow from Iran.
- As of January 2011, the marshlands area had recovered to 45%. The recovery rate from January 2010 to January 2011 was as high as 21%, thanks predominantly to projects undertaken on the Euphrates in Thi-Qar and Basrah to divert water to the Al-Hammar marsh.

2.4. Dynamic Changes of Water Volumes of the Marshes

The calculated water volume is measured by the quantity of water flowing through and stored by marshlands. Historically the volume fluctuated both seasonally and annually. Also it is related to the percentage of the marshes area. Recent estimates by the Ministry of Water are as follows: The figure for 1973 is 14.8 BCM per annum. Another estimate is 6.5 BCM per annum or 45% of the 1973 figure. In January 2010 it was 5.5 BCM. In 2002 and before re-flooding, it was approximately 2 BCM. In 2006 it was high - over 9 BCM. By 2009, the re-flooded area fell to 2003-levels due to drought and reduced flow from Iran.

2.5. Current Status and Physical Definition of the Marshlands

The Marshlands area has expanded by one-fifth since January 2010 to the current (2011) 45% of its original size (1973). UNESCO report [1] suggested that, if this rate of recovery could be continued, the Government of Iraq's goal to restore the marshlands area to 75% would be achieved within 4 years.

2.6. Physical Definition of the Marshlands Size

There is no one common definition to describe the area. The Ministry of Water Resources, for example, describes the area in terms of individual marsh units (e.g. Haweza, Central and Al-Hammar Marshes, which altogether constitute an area of 5,560 km²). Iraqi environmental scientists attribute a much larger area of 35,600 km² as the "Tigris Euphrates Alluvial Salt Marsh Eco-region."

Other refers to the area covered with water at certain dates and they are as follows:

- A marshland area of 7875 km² which is approximate to the level in 1983. The area includes a network of three major marsh systems (Al-Haweza 1,377 km²), Central 2,420 km²) and Al-Hammar 1762 km²) and 8 minor marshes including Al-Sinnaf, Auda, Al-Ezz river marshes.
- An area for the marshlands that was available in 1973 which is 10000 km².

3. Trend Analysis for the Years (1970-2050)

3.1. Absence of an Integrated Water Resources Management Approach (IWRA)

Since the beginning of the 1920s, the three countries Turkey, Syria and Iraq have failed to have a clear long term agreement on the allocation and wise use of the water resources of the two river basins of Tigris and Euphrates. Instead, Turkey and Syria have over-exploited the situation and proceed independently with their own plans to utilize the two rivers' freshwater resources for agricultures and power generation.

Turkey's initial idea to investigate and utilize the water resources of Euphrates and Tigris came in 1920 from Ataturk, the founder of the Republic. The GAP (southeastern Anatolia project) was planned in the 1970s. Seven dams were completed and are in operation since 1987 through 2013 on the Euphrates basin, four dams were completed and are in operation since 1998 through 2012 on the Tigris basin and ILLESU dam is completed and the lake before the dam is to be filled during the filling season starting March 2018.

Syria had constructed 3 large dams on the Euphrates basin for the purpose of agriculture and power generation. Iraq had constructed a large Mosel dam on the Tigris and six dams (one partially constructed) on its tributaries [5].

Iraq has also Haditha dam on the Euphrates in the north. Since 2017, Iraq is trying to convince Turkey to consider carrying out the filling of the lake Illesu dam in stages so that Iraq will be able to fill some of its storage capacity in order to avoid a possible severely scarce water season. Over the history of the last half a century, Iraq was always, when demanding a fair share of water allocation, at the mercy of Turkey which had full power

over any decision in this regard.

3.1.1. Changes of the Flow of the Rivers and Their Qualities

a) Availability of renewable freshwater resources among many concepts that quantify the water scarcity and stress, the information that is hereby discussed was based on a definition of water scarcity of 1,000 m^3 or less per capita annual availability of freshwater resources, and of water-stress between 1,000 and 1,700 m^3 as a per capita annual availability [6]. As far as Iraq is concerned, the renewable freshwater resource has declined from 4,556 m^3 per capita in 1962 to a critically low level of 1005 m^3 in 2014 [4].

b) Population of Iraq, past, present and future

Iraq's population was 6.5 million in 1955, 38 million in 2017, and is expected to reach 81 million in 2050.

The 1005 m^3 annual per capita scarce water level corresponds to 2017's population of 38 million. Considering the additional future dams that will be built by Turkey, Syria and also Iraq, the growth of the Iraq population in 2050 to 81 million and in the absence of the appropriate allocations of water resources between the four countries, these key factors shall produce higher stresses on the freshwater resources. Within the span of next thirty year (2020-2050), the available poor level of water of even lower than 500 m^3 per capita that Iraq would have to face should not go unnoticed.

c) Stresses on the freshwater resources of Euphrates and Tigris basins

The major dynamic factor that causes stresses on the available water supplies is the growth of population. Turkey's population shall grow from 81 million in 2018 to 95 million in 2050. Syria's population growth currently is 18 million and expected to rise by 2050. The population growth in these three countries (Turkey, Syria and Iraq) shall produce more severe stresses on the freshwater resources of the two rivers Basins. The high stresses that shall emanate from competition over water are matters of serious concern for all these users. Stresses include unprecedented demands for agriculture (particularly irrigation and drainage), the provision of domestic water supply and sanitation, industry, energy production, environment / amenity (including the tourism), and changes in pattern of consumption as a result of industrialization, rural / urban shifts, migration, and unaccounted use of water [7].

d) Change in water quality

The change in quality and flow of the upstream rivers has altered the properties of the water in the marshlands. The water in the marshes has numerous contaminants such as untreated domestic, industrial waste and pesticides. The water salinity has doubled. It has high level of phosphorous and the bacteriological content has exceeded the WHO standards

e) Change of patterns of water consumption

- Pre-dam flow of the Euphrates: in the 25 years following beginning of the

heightened dam construction in 1973, the Euphrates decreased to only 38% of its pre-dam flow; seasonal flooding, key to maintenance of the marshlands ecosystem, was significantly tampered.

- The pre-1970 is the pre-dam flow, the area of wetland was vast in size and abundance of resources
- The flow of the Tigris and the Euphrates is expected to decrease further by 2025, with the Euphrates declining by more than 50% and the Tigris by more than 25% [1].
- Water is withdrawn, stored in dams or diverted upstream. Upstream water supplies which are essential life support to the marshlands are diminishing.
- Recent drought in 2008 has reduced the flooded area of the marshlands to one fifth of the 1973 level
- Reduction of the water flowing into and out of the marshlands and into the Gulf
- Disrupting tidal flow is contributing to changes in the natural properties of marshes' water and soils.
- Higher salinity levels, as well as a decrease in plankton and organic carbon levels, appear to be reducing soil fertility and threatening the availability of freshwater for drinking, agriculture and human consumption. Water in the Marshlands has doubled in salinity in recent years (2011).

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