Possible Scenarios of Iraqi Marshland Restoration for Future Water Resources Management

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Abstract. Agriculture is the only source of the Tigris and Euphrates Rivers in Iraq. Annually more than 70% of the available water is used for irrigation. The total amount of land that can be cultivated in Iraq is 12 million hec. Only 2.2 million hec in Tigris basin and 1.37 million hec in the Euphrates basin were cultivated in 2001. According to the development of the projects in Turkey and development irrigation in Syria for the Euphrates basin, Iraq will face reduction in the amount of water entering Iraq with 50% for Tigris basin and 80% for Euphrates basin and with deficit of 21-22 billion cubic meters for the coming year 2030. The existing area of marshland restoration equal to 58%. The study suggests in case to increase the area of restoration Marshland to 75%, it should be need water amount to 2.5 BCM or 70 m³/s continuously with existing discharge.

Keywords: Annual Flow; Flooded Area; Marshland Scenarios; Water management; Water resources of Iraq;

1. Introduction

More than 70% of the available water of Iraq enters the country that originates in Turkey and Iran (Italian et al., 2006). Most of water comes from the Tigris and Euphrates that originates in Turkey (Davis & Hanbali, 2005). Before the development of the hydraulic project on both river basins in the upstream countries, the average annual flow of Euphrates as it enters Iraq was estimated at 30 Billion Cubic Meters (BCM) out of which about 10 BCM per year drained in to the Marshes (Al-Ansari, 2013). On the Tigris prior to the construction of new dams and since records were kept the average annual runoff as it enters Iraq was estimated to be 21.2 BCM additional tributaries in the east added an average annual total of about 15 BCM from inside Iraq and 6 BCM from Iran. The huge water body exists where Tigris and Euphrates meet is the location of the Mesopotamian Marshlands. These marshes lie at the southern part of Iraq and are divided in to major areas (Hawaizah, Central, and Hammar) and nine to eleven smaller
Due to the political reasons in the 1990s, had a devastating impact on the ecosystem indigenous population and their economy. The marshland once estimated to be between 15,000 to 20,000 km$^2$ were reduced to about 2,000 to 3,000 km$^2$ by 2004 (Ayied & Reiss, 2019). If we consider the year 1973 as the maximum permissible flooded then the area will be equal to 10,000 square kilometers which are distributed in to three main marshlands which are the Central Marshlands of 3,121 km$^2$, Hammer Marshes with areas estimated 2,729 km$^2$ and Hawaizeh Marshes with area equal to 3,717 km$^2$ with additional part inside Iran estimates 640 km$^2$ called Alathem marshes (USAID, 2006). Figure (1) and Figure (2) represent the location of the marshes land in the south region of Iraq and the compression of marshes between maximum for year 1973 and minimum for year 2000 respectively.

2. The Southern Marshes

Before the drying of the southern marshes the area including lakes and reservoir covered about 4% of Iraq. The largest of marshes as known as the Mesopotamian marshes that include Huwaizah, central (also known as Qurna) and Hammar, flooding usually took place at the end of February or beginning of March and coincide with beginning of spring flood of Tigris and Euphrates Rivers. Central marsh used to receive Tigris flood water from Al-Musendak (downstream Kut) in addition to Butaira, Orieth, and Great Major (Ewaide & Abed, 2017). Huwaizah marsh receives water through the canals of Kahla, Mushrah and Micheriya as well as an additional flood water came from Iran through Tib, Dewerridj and Karkheh rivers that emerge from the mountainous region of Iran. The source of flood water to Hammar were from the Euphrates, Central marsh and Graff Canals (Makki, Abood, & Al-Umar, 2019). The restoration of the marshes is particularly challenging for many reasons, perhaps the most concern the current and the future delivery of water to Iraq via the Tigris and Euphrates. Given the volume of water that would require to meet the high evaporation losses in southern Iraq (2600-3000 mm/year) and accounting for the amount of water required to maintain through consume a significant amount to the total available supply in the catchments and would represent are unrealistic given other sector needs in the country, clearly there are decision to be made by the government of Iraq regarding the priority locations and extent areas to be restored (NWRC, 2010).

![Figure 1. Location of marshes land in south of Iraq (USAID, 2006)](image)
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4. Turkish and Syrian Infrastructures projects

Iraq is heavily dependent on the flow water from Tigris and Euphrates Rivers (Al-Ansari, 2013). Turkey, in particular and to lesser extent Syria, controls headwaters of the Euphrates and a major portion of Tigris and intends to fully exploit these reservoirs. Many dams with huge storage capacities have been constructed or are planned by the two countries on the main rivers channel or their Tributaries. Table (1) represent the status of these reservoir and dams

Table 1. Status of Reservoir in Turkey and Syria

| Name of the project | Country | Designed Storage capacity BCM | Current Status |
|---------------------|---------|-------------------------------|----------------|
| Kiban               | Turkey  | 30.9                          | completed      |
| Karkaia             | Turkey  | 9.58                          | completed      |
| Altaturk            | Turkey  | 48.7                          | completed      |
| Perigock            | Turkey  | 1.22                          | completed      |
| Karakamish          | Turkey  | 0.157                         | completed      |
| Tishreen            | Syria   | 1.90                          | completed      |
| Tabaka              | Syria   | 14.16                         | completed      |
| Bath                | Syria   | 0.09                          | completed      |
| Kiralkezi           | Turkey  | 1.92                          | completed      |
### 4.1 Turkish Projects

The projects currently being constructed, planned by Turkey on the Tigris and Euphrates are carry the name South East Anatolia project or GAP. The project consists of 22 Dams and 19 hydroelectric stations and number of irrigation Tunnels, Canals and projects. Turkey completed the first stage of the project for one of the largest irrigation canal in the world (Orfa tunnel) which takes the water from Ataturk dam to land situated beyond the Euphrates basin (USAID, 2006). Two new dams Brrecik and Karkamis, are being constructed on the Euphrates near the Turkish-Syrian border, enabling Turkey to be increase full control of the water of the river. In 1997 Turkey plan to irrigate 1.091 million hectares' in the Euphrates basin and 0.602 million hectares' in the Tigris basin. The total area prescribed for irrigation (within the framework of the completed development of the storage and irrigation project in the Euphrates basin) will be more than 1.6 million hectares (USAID, 2006).

### 4.2 Syrian Projects

The World Bank estimate that the agriculture lands cultivated in Syria on the Euphrates in 1965 was 213000 hectares. According to the information presented by the Syrian technical delegation during the negation of the joint technical committee on water in 1983, the area irrigated on the Euphrates basin at that year were 258000 hectares and their water requirement in the region were 3.87 BCM. The irrigation areas within the Euphrates basin in 1998 are estimated at 258000 hectares with plans to expand to about 778000 hectares. The current areas or the irrigated lands along Tigris basin is unknown but there are planned to irrigates up to 227000 hectares (USAID, 2006).

### 5. Data Collection and Results for Existing and Future Water Resources Management

#### 5.1 Existing Water Resources in Tigris River and its Tributaries

According to the study (USAID, 2006) the following quantity of water resources in Tigris and Tributaries rivers are distributed in the Table 2. The water resources as an annual average from the year 1990 to 2006 are recorded from National Water Resources Center/ ministry of water resources and the annual mean flow is equal to 42.8 BCM (Italian et al., 2006).

| Rivers          | Annual flow BCM | Outside Iraq % | Inside Iraq % |
|-----------------|-----------------|----------------|---------------|
| Main Tigris     | 19.43           | 100            | 42            |
| Khabor          | 2.1             | 58             | 42            |
| Greater zab     | 14.32           | 42             | 58            |
| Lesser - zab    | 7.07            | 36             | 64            |
| Al- Audhaim     | 0.7             | ---            | 100           |
| diyala          | 5.86            | 59             | 41            |
| Total           | 49.48           | 56% for Turkey | 32% for Iraq  |
|                 |                 | 12% for Iran   |               |

#### 5.2 Future Water Resources Requirement in Tigris River and its Tributaries

The average annual flow for Tigris and Tributaries rivers before and after 2030 as shown in Table 3 (USAID, 2006). The annual average flow required for Turkey, Syria and Iraq up to 2040 are presented...
in the Table 4.

**Table 3.** Amount of average annual flow before and after 2030 in BCM for Tigris and Tributaries (USAID, 2006)

| Item | Iraq-Turkey Border | Tributaries of Tigris |
|------|-------------------|-----------------------|
|      | Before | after | before | after |
| Mean Annual BCM | 19.43  | 9.16  | 30.05  | 23.33  |
| Quality of Water in PPM | 250 | 375 | 250 | > 375 |

**Table 4.** Expected average annual flow needed up to 2040 for Turkey, Syria and Iraq in BCM (USAID, 2006)

| Rivers | Turkey | Syria | Iraq | Total |
|--------|--------|-------|------|-------|
| Tigris | 6.50   | 3.0   | 41.8 | 51.30 |
| Euphrates | 18.50 | 11.50 | 23.0 | 53.0 |

From Table 2 which shows the annual average flow required for Tigris equal to 49.48 BCM and form National Water Resources Center the actual mean annual flow (1990-2006) equal to 42.8 BCM. In other words, there is deficit about 6.68 BCM. In future water resources in Tigris River, the water amount after 2030 equal to 32.69 BCM as mentioned in Table 3, while the quantity required after 2040 equal to 41.8 BCM as shown in Table 4, so it will give a deficit equal to 9.11 BCM. From final discussion, it clearly shows that Iraq will face with deficit equal to 6.68BCM before 2030 and this deficit will increase to reach 9.0 BCM up to 2040.

**5.3 Existing Water Resources in Euphrates River**

Iraq will receive only 25-30 percent of what used to enter the country three decades ago lagging behind the Euphrates river basin development. According to the previous study (Italian et al., 2006), the Euphrates River basin for Turkey (GAP) and development of Syrian Euphrates basin which propose three alternative scenarios which depend on the basis of entering water to Hit station in Iraq which is equal to 33.46 BCM.

**5.4 Future Water Resources Requirement in Euphrates River**

The water required in BCM in Turkey, Syria and Iraq for the period between 2010 to 2040 after developing the GAP in Turkey and developed agriculture in Syria (Middle alternative) it will get the following result shown in the Table 5.

**Table 5.** Water required for the year 2010 to 2040 in BCM (Bank, 2006)

| Year | Turkey | Syria | Iraq |
|------|--------|-------|------|
| 2010 | 10.814 | 9.405 | 13.241 |
| 2020 | 12.385 | 9.405 | 11.67 |
| 2030 | 14.365 | 9.405 | 9.69 |
| 2040 | 16.908 | 9.405 | 7.197 |
If refer to the Table 4, the amount of water required up to 2040 equal to 23.0 BCM, while the water entering Hit station up to year 2040 equal 7.197 BCM as shown in the Table 5. Hence Iraq will face a deficit of water equal to 16.0 BCM in Euphrates river. The information from the study (USAID, 2006) which was submitted to the ministry of water resources/ Restoration of Marshland Center and prepared by (USAID), the following information of water quantity and quality is shown in the Table 6.

**Table 6.** Quantity and Quality of the Euphrates River before and the expected after 2030 (USAID, 2006)

| Item                  | Year          | Turkey and Syria boarder | Iraqi and Syria boarder |
|-----------------------|---------------|--------------------------|-------------------------|
|                       | Before 2030   | After 2030               | Before 2030             | After 2030              |
| Average annual flow BCM | 32            | 14.2                     | 30.37                   | 8.48                    |
| PPM                   | 250           | 500                      | 457                     | 1250-1350               |

To make the comparison for water entering to Iraq, we will find the quantity of water after 2030 equal 8.45 BCM. Also quantity required for irrigation and other uses equal to 23.0 BCM. Therefore, the total deficit will be face equal to 14.55 BCM. The actual data collected from the control department/National Water Resources Center between water year 1931-1932 to 2005-2006 for Hit station at Euphrates river are divided in to three results parts depending three time periods. First period (1931-1932) -(1972-1973) the mean annual equal 30.70 BCM. Second period (1972-1973) -(1997-1998) the mean annual equal to 22.8 BCM. And Third period (1997-1998) -(2005-2006) the mean annual equal to 18.5 BCM.

The total average for the three periods equal to 25.0 BCM while the required amount equal to 30.37 BCM as mention in table (6) and this will give deficit equal to 5.77BCM before 2030 and it will increase after 2030 to reach between 15-16 BCM.

According to the data analysis, the results clearly shows that Iraq will face deficit equal to 21-22 BCM for both Tigris and Euphrates Rivers and this amount will increase if we consider the average flow in Hit station equal to 25.0BCM instead of 33.46 BCM.

**6. Scenario of the Restoration of the Marshland**

In order to make the restoration it is necessary to supply with great amount of water while Iraq face with deficit of water due to the development of the irrigation projects in the riparian countries.

The dried area of the marshes has been used by constructing houses and as cultivation areas but in spite of that it could be possible to restore these marshes and bring it back to the previous condition. The following information are collected from the Marshland Center/MOWR and (Italian et al., 2006) which consist these facts

a) The flooded area of the Marshland considered equal to 100% as it was existing in 1973.

b) According to the above the area flooded of the Marshlands equal to 9567 Km$^2$ inside Iraq and 640 Km$^2$ inside Iran.

c) The Marshland distributed in the three parts, Central Marshes (Qurna marshes) with area equal to 2729 Km$^2$, Hammar Marshes with area equal to 3121 km$^2$, and Huwaza marshes with area equal to 3717 km$^2$

It is necessary to consider that the area of the Restoration will be increased or decreased according to the change in the hydrological cycle (wet season, normal water year and dry season) and the area to be flooded cannot interfere with existing projects such as the agriculture area constructed in the dried area of the marshes and field oil project by Mathematical programing (Hec-RES-SIM).
6.1 Scenario (1) by taking the flooded area between 0-25%
It is similar to year 2000-2002 and the area flooded equal to 2400 km² as shown in Figure 3a (Italian et al., 2006)

6.2 Scenario (2) by taking the flooded area between 25-50%
This alternative will be similar to year 2005 and the area will be flooded equal to 2400- 4800 km² and this will have achieved in normal water year as shown in Figure 3b

6.3 Scenario (3) the percent of flooded area between 50-75%
In this alternative is similar to year 1990 and the total area will be flooded between 4800- 7200 km² and this can have achieved during the wet water year and also will not crossed with the existing project but it needs to help from the riparian countries to supply with sufficient water Figure 3c

6.4 Scenario (4) the percent of flooded area between 75-100%
This alternative is similar to water year 1973and the area will be flooded between 7200-10000 km² as shown in Figure 3d this proposal will crossed with the existing projects and need to supply with water from the riparian courtiers.

From these alternative Scenarios number (3) is recommended to flood the marshland area with 50 – 75% and can covered an area between 4800-7200 Km². Figure 4 indicate the flooded area for short and medium term in order to restore the marshes (Italian et al., 2006).

7. Conclusion

1- According to the development of the projects in Turkey for GAP and the development of irrigation projects in Syria for the Euphrates basin, Iraq will face a reduction in the amount of water entering with 80% for Euphrates basin and 50% for Tigris basin and with deficit between 21-22 BCM for the coming years (2030), the restoration will face reduction of water and then will affect the area of the restoration.

2- The study analyzed the area of the existing flooded that is equal to 58% and it will need to increase to 75% of flooded area which will require additional amount of water to 2.5BCM or 70 m³/sec

3- In this study if flooded are 75%, then the total area of the marshes to be flooded equal to 7200 km² hence the evaporation will be great amount so it need to discharge continuously.

4- The operation of the restoration of the marshlands needs to cooperate between Iraq and the riparian courtiers in order to supply with sufficient water and the indication show a reduction in the marshlands due to the deficit in the water in the near future.
Figure 3. Different Scenarios of Marshland a. flooded area 0-25%, b. flooded area between 25-50%, c. flooded area 50-75% and d. flooded area 75-100%

Figure 4. Proposed 50-75% Area Marshland Restoration

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