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Iranian Tropical Water Project on Sirwan River and its impacts on some environmental aspects in Garmian Region

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Abstract

Sirwan River is regarded as a lifeline for Garmian Region. The prevailing climate in the areas that the river goes through is a semi-dry. Iran proceeded lately to establish water projects, dams and reservoirs along the river inside Iran without taking into account the Iraq`s shares. The TWP project consists of (13) dams with a capacity of (1.7) billion m3, and a number of diversion tunnels which are constructed on Sirwan River. Nousod tunnel is a part of TWP and one of the largest tunnels dedicated for water converting around the world. It was constructed to convert more than (70) m3/sec of water from TWP dams to outside of Sirwan River basin. The Iraqi Kurdistan Region is one of the hardest hit of those Iranian policies, specifically Garmian area that will suffer from major crises as a result of draining some of the headwaters of Sirwan River. Thus, the problem of water shortage will appear and negatively affect the agricultural sector. This will lead to decline agricultural areas that fed by the river. In addition, agricultural production will be reduced, and there will be difficulty to address the declining in the required amount of water in the study area.

1 Introduction

As the main factors of human life, water is considered as significant for drinking in addition to other related purposes to human life and human nature. Recently, scarcity of water in the Middle East has occurred as a result of climate change, increasing population and mismanagement of water resources [1]. Iraq as a whole especially (Kurdistan) increasingly and frequently suffering water scarcity. Iran also is suffering a significant water crisis since ten years, which led to lack of water, and it is expected to lead to a major water shortage in the future [2]. Iranian experts commented that the country will suffer a great shortage of water. Also, they have indicated that about two-thirds of Iran's total water (10.2 billion cubic meters) exiting the country and goes to Iraq [3]. Iran is working hard to make the issue of boundary water with Iraq as a national security issue and is working on the ownership of the waters of the rivers entering Iraq. Therefore, they worked to draw up a new water policy for Iran which is based on the policy: (every drop of water in the country must be exploited). Iran took advantage of the internal political instabilities in Iraq; so, proceeded to construct large dams and water projects along the borders between the two countries [3]. One of the significant projects is the Tropical Water Project TWP, which is a comprehensive water management project in the Sirwan River basin. This project is one of the strategic projects of Iran and it aims to increase the agricultural area and change the rain fed agricultural lands to irrigated lands by surface water [4] [5]. So that lack of water resources will ultimately generates conflict between both countries in the coming years. Last year and as a result of Iranian water projects, the flows of Sirwan River (tributary of the Tigris) had fallen significantly. As a result of this project, the ones who pay the highest price are the people in Garmian (South of Kurdistan Region), as they will be at risk of displacing and losing their livelihoods. Construction of TWP inside Iran has influenced the inflow rates of Sirwan River and negatively impacts Garmian Region especially on the agricultural and environmental reality. This research aims to clarify the available information on TWP and investigate its agricultural and environmental impacts on Garmian Region.

2 Study area

The Garmian region is a semi-autonomous administration within the Sulaymaniyah Governorate. It lies between latitudes (34,15,33-35,11,5) with longitudes (45,54,20-44,29,41), figure (1). The study area is bordered from the south by Diyala Governorate, from the north by Sulaymaniyah Governorate, from the west by Kirkuk Governorate, and from the east by the Iranian border (Kermanshah Governorate). The area of the Garmian region is (6828.6) km2, that is, in proportion to (8.674%) of the area of Kurdistan Region of Iraq, which is (78736) km 2 [6]. The area of arable lands is about (1667880) du, of which (213189) du are irrigated lands which depend totally on Sirwan River and it channels, and (1403691) du are rain fed lands that depend on precipitation.

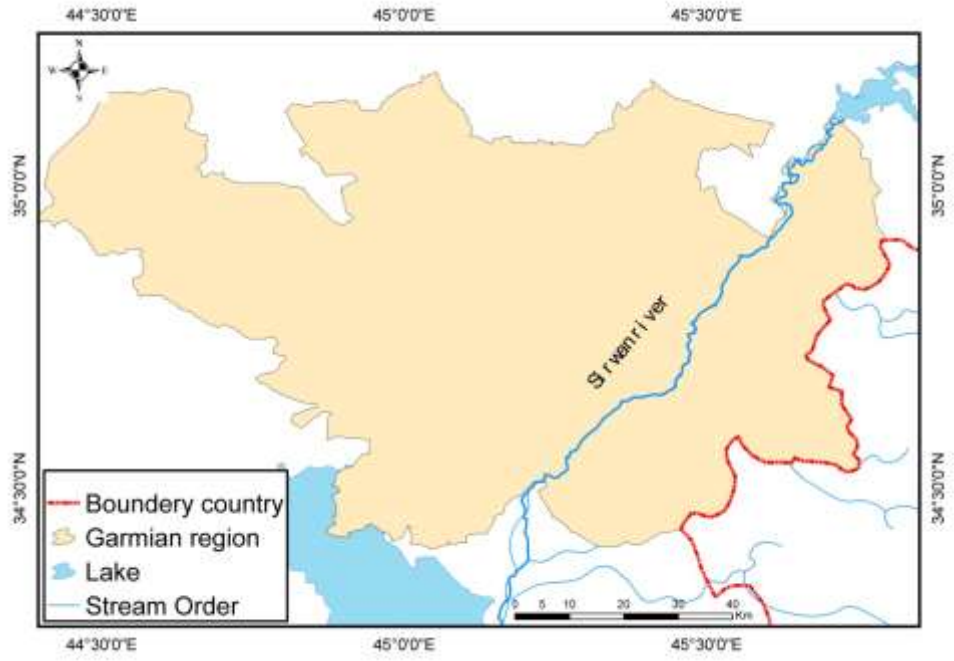

Figure (1) the study area

3 Materials and Methods

All the details (relevant information and data) of the TWP on the Sirwan River basin have been collected from Iranian official documents. In respect to Garmian region, all the information and data were collected from official authorities. During summer 2021, some water quality parameters were tested in seven locations. The electric conductivity EC, turbidity and dissolved oxygen DO were measured immediately in site by using a portable WTW conduct meter, turbid meter and Do meter. However, NO3 was measured using ion selective electrode probes ISE after the samples were arrived within 24 hours. The results were compared to a study conducted on the same locations in 2018. Also, the percent of normal precipitation index (PNPI) were used in order to determine drought situation in last 20 years in Garmian based on stations data.

3:1 Tropical Water Project

This project is one of the strategic projects of Iran and it aims to increase the agricultural area and change the rain fed agricultural lands to irrigated lands; as well as, supplying drinking water for cities and for industrial purposes. Another objective of this project is to irrigate more than (400,000) du of agricultural land [7]. Iran considers that Sirwan River (the fifth largest river in Iran) is a right that is unique to Iran alone, and will not cross the borders anymore as it was in previous times without cost or without return (a reference to Iraq). This project consists of two parts:

The first Part: Starts with Daryan Dam and ends in Azgele Dam, table (1) and figure (2). In this area, the surplus water coming out of these dams is collected and intercepted from entering Iraqi territory through the Nousod Water Tunnel. So, more than (1) billion cubic meters is transferred annually to the Tropical regions in Iran (second part of the project) which starts from the (Azgala dam) to irrigate agricultural lands in Ilam province and some parts of Al-Ahwaz province [8]. The estimated length of the project is more than (450 km) from Kermanshah Province to Ilam Governorate (Dehleran and Mahran) [9].

3:2 The TWP parts

3:2:1 Daryan Bawah Dam: The reservoir capacity of this dam is estimated to be at (338) million m3. The dam consists of two water tunnels, the first of which is (989) m long and the second (1034) m [10]. The aim of this dam is to secure irrigation water for agricultural lands.

3:2:2 Herwi Dam: It is located (30 km) southern the Daryan Dam, the storage capacity of this dam is (30) million m3 [11]. This dam is considered as one of the most dangerous dams on the Sirwan/Diyala River, as it prevents the entry of water from the Daryan Dam into Iraqi lands.

3:2:3 Zimkan Dam: It is located on the tributary of Zimkan, one of the main tributaries of the Sirwan River in Iran. The storage capacity of this dam is (23) million m3 [12]. The main objective of this dam is to irrigate more than (2121) du and it converts approximately (7200) du of rain fed lands to irrigated lands [13].

3:2:4 Gawshan Dam: The storage capacity of this dam is (550) million m3, and the aim of building this dam is to convert water through a (water tunnel) at a rate of (30 m 3 / second) to the (Karkha) basin in Al-Ahwaz (Khuzestan) in order to irrigate more than (120,000) du of farmland [14].

3:2:5 Garan Dam: This is located (20 km) from Mariwan city, and was built on the (Garan) tributary within the River Sirwan basin. The storage capacity of this dam is (110) million m3 to irrigate more than (40,000) du of agricultural land [15]. It is also a major source for supplying drinking water for Mariwan city.

3:2:6 Azad Banir Dam: This dam is located on the Korah tributary, which is one of the Sirwan River tributaries. The storage capacity of this dam is (300) million m3 [16].

3:2:7 Zewih Dam: It is located (26 km) away from Kamiaran city. The dam's storage capacity is (17) million cubic meters, used to irrigate more than (10,000) du of agricultural lands [17].

3:2:8 Zhawe Dam: It is a concrete cylindrical dam and was chosen as one of the best concrete dams in the world. The storage capacity of this dam is (172) million m3 used for drinking purposes, supplying

the factories with water, and irrigating more than (68,000) du of agricultural lands by modern irrigation systems [18].

3:2:9 Azadi Dam: This dam was constructed on one of the Sirwan River tributaries which is called Azad tributary, and it is located between Sinna and Marivan cities. The storage capacity of the dam is (70) million m3 used for drinking purposes, supplying factories with water and irrigating more than (16,800) du of agricultural lands [19].

3:2:10 Sulaiman Shah Dam: It has a storage capacity of (48) million m3 of water to irrigate more than (10,800) du of farmland in Sanqar-Kermanshah [20] .

3:2:11 Ameerabad Dam: This dam was built in the Kamyaran region, and has a storage capacity of (6) million m3, to irrigate and convert (3420) du of rain fed agricultural lands to irrigated lands in order to increase agricultural production [21].

3:2:12 Ramshat Dam: This dam was also constructed in the Kamyaran region, with a storage capacity of (6) million m3 to irrigate and covert (1420) du of rain fed agricultural lands to irrigated lands [22].

3:2:13 Azgala Dam: The storage capacity of this dam is (30) million m3. It is the last dam within the first section of the tropical water project TWP, in which water is collected and transported from other dams to this dam through the (Nosud) water tunnel, and from Azgala dam the second part of the tropical water project begins [23].

Table (1) The properties of TWP dams

No.	Dam	N	E	Capacity Million m3
1	Azadi	34°32'55.6"N	46°21'12.3"E	70000000
2	Gawshan	34°57'49.0"N	46°59'38.5"E	550000000
3	Daryan Bawa	35°09'08.3"N	46°18'25.3"E	338000000
4	Sulaimanshah	34°53'32.4"N	47°31'51.6"E	48000000
5	Zimkan	34°19'10.7"N	46°22'04.0"E	23000000
6	Azgala	34°47'30.1"N	45°50'57.2"E	30000000
7	Garan	35°36'03.6"N	46°19'10.1"E	110000000
8	Herwi	35°07'19.8"N	46°14'43.3"E	30000000

9	Zhawe	35°04'09.0"N	46°50'01.2"E	172000000
10	Azad Banir	35°20'08.6"N	46°32'58.5"E	300000000
11	Zewih	34°55'38" N	46°42'36.9" E	17000000
12	Ameerabad	35°04'05.7"N	47°15'37.1"E	6000000
13	Ramshat	35°04'58.1"N	47°11'51.4"E	6000000
Total Capacity				1700000000

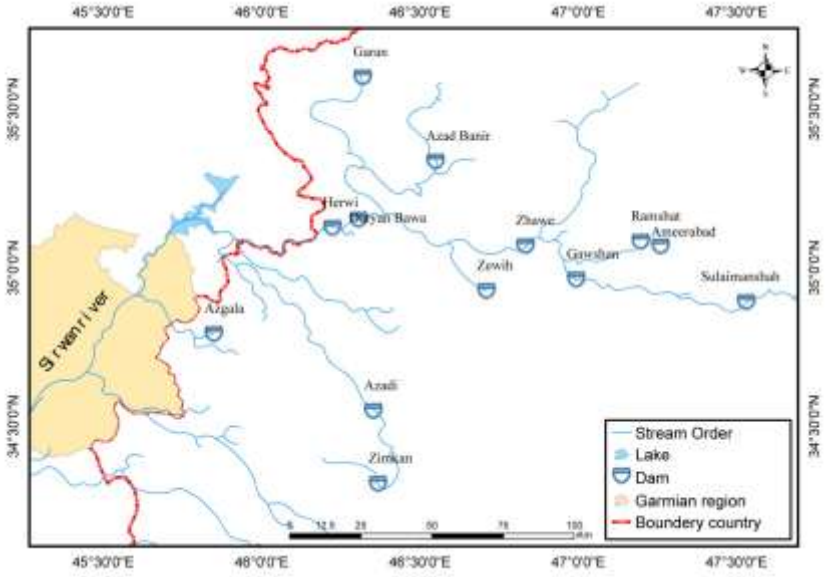

Figure (2) The TWP dams

3:2:14 Deviation channels

The aim of deviation channels is to change the course of the Sirwan River tributaries. These channels collect and convert water to the (Nousod water tunnel) and thus prevent water from entering Iraq [4]. These deviation channels include: Merakhil, Lella, Gerdi Qasman and Zimkan which all diverting water into the Nousod tunnel; while, Imam Hassan channel converts water from the (Imam Hassan) tributary into Azgela Dam, figure (3) [4].

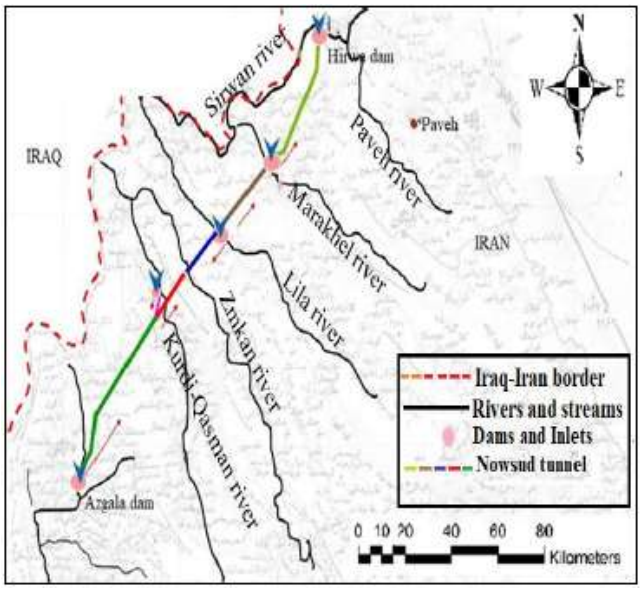

Figure (3) Deviation channels within TWP project

3:2:15 Nousod Water Tunnel

This tunnel is considered as one of the largest tunnels dedicated for water converting around the world. As it reaches (48.7) km in length and (6.125) m in diameter and in some areas its diameter reaches (9) m to convert more than (70) m3/sec of water from dams and tributaries including (Daryanbawa, Herwe, Zimkan, Lella, Merakhil and Gerdi Qasman) into Azgala Dam [4] [24]. This tunnel has ability to convert (1-1.6) billion cubic meters annually from Sirwan Basin to Ilam Governorate in order to develop agricultural and industrial projects.

4 Results and Discussion

The entire capacity of all the TWP dams is more than (1.7) Milliard m3. Also, about (1-1.6) Milliard m3 of water annually will be transferred through Nousod tunnel to Ilam Provinces. This tunnel has ability to convert (70) m3/sec [24] [25]. A study conducted in Darbandikhan, revealed that the Darbandikhan dam's catchment area before the TWP project was (16.685) km2; while, the catchment area after the completion of TWP has been reduced to (3.837) km2 [24]. According to some calculations, TWP will withdraw more than (3) milliard cubic meters from the Sirwan River basin. Therefore, TWP dams will reduce the current of the Sirwan/Diyala River by more than (70%) [4].

Thus, the capacity of the Darbandikhan Dam supplying irrigation water will be limited to a great extent; this means that less water will be released from Darbandikhan Dam which ultimately affects Garmian Region. The impacts of TWP on Garmian Region include the followings:

4:1 Agricultural lands Declining

Geographically, Garmian Region is located within the arid and semi-arid region, which is regarded as unassured rainfall area. As mentioned before, about 80% of the agricultural lands in this area are rain fed lands, table (2). However an area of (213185) du which is about (20%) are irrigated by Sirwan River, as large proportion of agricultural products comes from these lands [6]. Therefore, the agricultural map of Garmian Region will be completely changed. The impacts of TWP in the coming years will be visible due to decrease in Sirwan water levels which ultimately lead to social unrest; also, the agricultural lands will be totally destroyed, and food security in the study area will be threatening.

Table (2) Projects and channels that feed from the Sirwan River in Garmian Regiom [6]

No.	District	Projects/Channels	Area (du)
	Kalar	Pebaz	134
		Kalar	6555
		Maydan	713
	Kifri	Kokiz	19777
		Shekh Langer	34000
		Qrablagh	7010
	Khanaqeen	Balajoo	145000
Total Area			213189

4:2 Water Balance

The study area suffers from water imbalance, as the annual rate of precipitation is slight compared to evapotranspiration rate which has been rising significantly recently [26]. It is noticed that there is a large gap between the amount of water input and the amount of output, table (3). As a result of decreasing the level of Sirwan River, the gap will increase further, causing major environmental issues. Water balance is calculated as:

$$P - Ep = \pm$$

Where, P is actual precipitation, and PE is actual evapotranspiration

Table (3) water balance in the study area (2001-2021) [26]

District	Precipitation (mm)	Evapotranspiration (mm)	Water Deficit
Kalar	317	2957	-2640
Kifri	296.7	3021	-2724.3

4:3 Groundwater

Groundwater should not be considered as a drinking, industry or agriculture water resource. It has to be protected for its environmental value. Water resources requires long term sustainable management for equilibrium of all water resources including surface and groundwater (inflows, precipitation) with sinks (evapotranspiration, runoff) as well as water exploitation [3]. As a result of declining Sirwan River's inflows, people will be forced to exploit groundwater, which will pose a great danger to the groundwater level.

4:4 Water quality

Construction of TWP has led to cause ecological changes in the Sirwan River flow rate which resulted in water quality declining. The (TWP) project upstream the Sirwan River has caused return irrigation flow water quality to deteriorate. Water quality of Sirwan River in Garmian (as downstream region) has become under threating of the pollutants (municipal and commercial wastewater from other towns) which are directly discharged into the river without treatment.

The results of some water quality assessment show that the pollutants in the Sirwan River increased during summer 2021 due to the lack of water flow [27]. The results were compared to a study conducted in summer 2018 in the same stations. As shown in table (4), turbidity, Ec and NO3 were increased in 2021compared to 2018; however, DO were decreased in all the stations. This is clear

evidence that the decrease in water flows due to the TWP project has led to an increase in the proportion of pollutants in the Sirwan River.

Table (4) Comparison between some results of the physicochemical parameter in 2018 and 2021

Sample	Turbidity (NUT) 2018	Turbidity (NUT) 2021	EC (µS/cm) 2018	EC (µS/cm) 2021	D.O (mg/l) 2018	D.O (mg/l) 2021	NO3- (mg/l) 2018	NO3- (mg/l) 2021
Darbandixan	1.47	4.6	371	409	7.71	5.6	1.51	10.24
Maydan	5.40	5.5	455	510	7.73	5.33	4.56	9.21
Bawanur	2.80	5.82	481	521	7.13	5.9	3.34	10.1
Isayi	2.99	4.73	500	567	7.92	6.6	2.62	8.43
Qulasutyaw	2.88	4.36	485	510	7.45	6.56	3.66	8.33
Kalar	1.63	5.33	468	528	7.99	6.31	2.96	7.18
Shexlangar	1.72	4.45	788	795	6.70	6.10	3.37	7.34
Ave.	2.70	4.97	506.86	548.6	7.52	6	3.15	8.7
WHO	5		400-800		5		45.0	

4:5 Drought and Desertification

As mentioned before, water levels of Sirwan River may fall further in the coming years due to declining precipitation which will gradually causing desertification phenomena. As a result of TWP the rapid and high rates of losing arable fields are alarming and could drive this region to the verge of a crisis. Mismanagement of water, inefficient farming practices, and already dry climate makes it vulnerable to desertification and climate change.

In this study, the percent of normal precipitation index PNPI were used in order to determine drought situation in last 20 years in Garmian based on data collected from Kifri and Kalar weather stations [26]. The PNPI categories are grouped in terms of drought as indicated in table (5), it is calculated as:

$$PNPI= (Pi/P)*100$$

Where: Pi is actual precipitation and P is normal average precipitation [28].

Table (5) PNPI group in terms of drought [29]

No.	Category	Index (%)
1	Normal	> 80

2	Weak drought	70-80
3	Moderate drought	50-70
4	Severe drought	40-50
5	Extreme drought	< 40

Results in table (6) indicate that Kifri district were exposed to drought (eight) times during the past twenty years; while, Kalar district were exposed to drought (five) times during the same period. The recurrence of drought phenomena is a great indicator of the region's vulnerability to desertification in the coming years. The situation will gradually deteriorate as the water flows of the Sirwan River in Garmian decrease due to the TWP project.

Table (6) results of drought index (PNPI)

Year	Kifri	PNPI	Index	Kalar		Index
2001-2002	278	93.7		395.5	124.8	
2002-2003	213.75	72	Weak drought	305.55	96.4	
2003-2004	191	64.4	Moderate drought	274.05	86.4	
2004-2005	297.65	100.3		348.07	109.8	
2005-2006	242.5	81.7		321	101.3	
2006-2007	231	77.86	Weak drought	272.5	85.96	
2007-2008	103.5	34.89	Extreme drought	106.5	33.6	Extreme drought
2008-2009	238	80.22		214	67.5	Weak drought
2009-2010	474	159.77		385.8	121.7	
2010-2011	222.5	74.99	Weak drought	245.8	77.5	Weak drought
2011-2012	135	45.5	Severe drought	134.7	42.5	Severe drought
2012-2013	265.4	89.46		401.8	126.7	
2013-2014	362.6	122.22		340.3	107.3	
2014-2015	273.3	92.1		292	92.1	
2015-2016	868.8	292.8		558.9	176.3	
2016-2017	236.4	79.68	Weak drought	271.3	85.6	
2017-2018	279	94		299.3	94.41	
2018-2019	608.4	205		688.8	217.3	
2019-2020	298.4	100.6		367.1	115.8	
2020-2021	114.5	38.6	Extreme drought	117.5	37	Extreme drought

5 Conclusion & recommendations

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 Sirwan River flow. Therefore, Garmian Region is facing a serious water shortage problem now and in the future. The TWP project consists of (13) dams and a number of diversion tunnels which are constructed on Sirwan River. The total storage capacity of the TWP dams is (1.7) billion m3. The Nousod diversion tunnel is designed to divert a (1-1.6) billion m3/year of water to outside the Sirwan River basin. Ultimately, the flow rates of Sirwan River will be affected and the water level in Darbandikhan dam will be significantly declined. As a result of TWP construction, Garmian area will suffer major crises; thus, the issue of water shortage and quality will appear and negatively affect the agricultural sector.

It is preferable to expedite the application of modern irrigation systems and cultivate crops that are resistant to drought and high temperatures. Also, it is urgent to prevent wastewater discharging into the Sirwan River directly; wastewater should be treated and reused in Agricultural and industrial sectors.

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