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Sustainable Water Management in Iraq (Kurdistan) as a Challenge for Governmental Responsibility

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Abstract: During the last few decades, a critical scarcity of water has occurred in the Middle East due to climate change and the mismanagement of water resources. The situation is complicated by the absence of an effective legislative framework at the local level as well as by the incapability and disrepute of the local water authorities. Most Iraqi citizens depend on the surface waters of the Tigris and Euphrates rivers, which have their sources in upstream neighbouring countries. Water crises concerning the shared waters urgently require a solution at the international level. Unfortunately, Iraq has faced several wars in a row (1980–2003), which has prevented the country from establishing its institutions. The rapid increase in the population of the transboundary countries on the Tigris and Euphrates rivers, and the high demands on agriculture, are accelerating water exploitation. In this paper, the present state of water management in Iraq from the viewpoint of the legislative framework, water balance, and transboundary issues will be discussed, with special attention to Kurdistan. Many legislative documents have been established or amended by the Iraqi and Kurdistan parliaments since 2003. In 2015, the Kurdistan Government Ministry of Agriculture and Water Resources, in cooperation with the EU, issued a guide for environmental legislation related to all environmental components such as air, water, and soil. The recommendations on actions needed in the water management in Kurdistan will be presented; they are inspired by the Water Framework Directive (WFD) (2000/60/EC) implemented in EU member states.

Keywords: water management; transboundary river basin; Kurdistan

1. Introduction

The problem of the insufficient availability of freshwater resources under the threat of climate change, pollution, and natural hazards is becoming urgent worldwide, not only in arid and semi-arid regions [1]. Iraq relies mainly on surface water represented by two rivers (the Tigris and Euphrates) and its accumulation in reservoir dams. Only a small part of water resources (14%) comes from groundwater resources, either shallow unconfined or deep confined groundwater aquifers. Fifty percent of the available surface water in Iraq originates from upstream rivers in the neighbouring countries of Turkey and Iran through the Kurdistan Region, which directly affects the downstream rivers. Therefore, an integrated water resource management (IWRM) approach is required for these transboundary rivers. The locations of the transboundary river basins in Iraq throughout the Kurdistan region, and the water balance (inflow and outflow) are shown in the map in Figure 1.

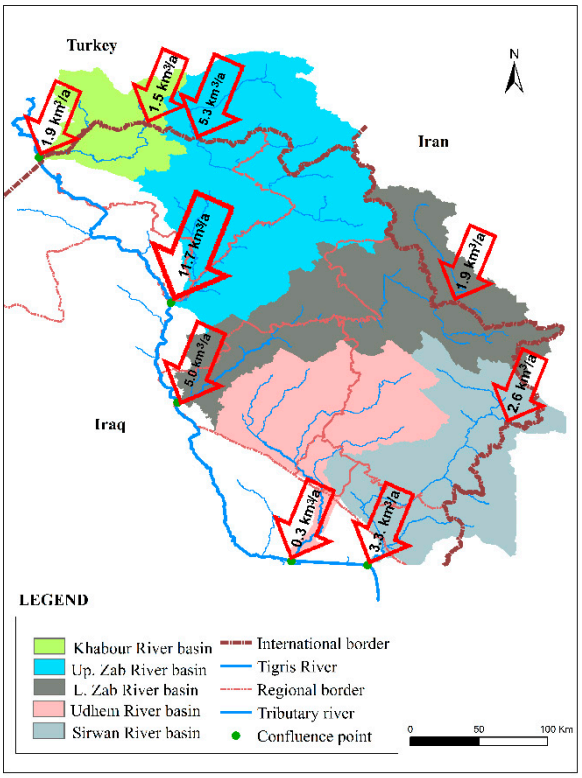

Figure 1. Location of river basins in Kurdistan (Iraq), and the inflow and outflow water balance of the Kurdistan Region.

Iraq shares the Tigris and Euphrates river basins with Turkey, while the Euphrates Basin is also shared with Syria. Iraq and Syria consider the Euphrates to be an international river and initiated an immediate sharing agreement based on the needs declared by each country. Turkey regarded both the Tigris and Euphrates basins as single cross-border river basins [2,3], which has a legislative implication. The international water basins convention for non-navigational uses [4] emphasizes several principles that have been established by international legislations and rules. The principle of the equitable and reasonable utilization of shared water resources represents the key element to be respected by all sharing countries [5].

Iraq did not have any problem with the sharing of the waters of the Tigris and the Euphrates rivers until new factors emerged in Turkey's water consumption rates and its water policy. Additionally, Turkish-Iraqi relations have been influenced by many factors, with the most important ones being security, and strategic economic and cultural aspects.

During recent decades, many water projects have been ongoing in Iraq´s neighbouring countries. One important project was the Turkish GAP project (Güneydoğu Anadolu Proje), whose name means "South-eastern Anatolia Project". The GAP is a major and comprehensive water management project in the southern part of Turkey set by the Regional Development Administration (RDA). It was completed in the period 1975–2017 with a total cost of $32 billion. The project was composed of 13 individual projects, including the construction of 22 dams and 19 hydropower plants producing 27 gigawatts (GW) of electricity. The irrigated area is estimated at 1.8 million hectares, representing 9.7% of Turkish land [3,6].

This project has created a new era of long-term collaboration between the riparian countries of transboundary rivers. The lack of water resources generates conflict of interest between sharing countries. It is apparent that a long-term sustainable solution requires the acceptance of all concerned countries. Due to internal political instabilities, Iraq possesses less political influence in the region [6]. As the headwaters of both the Tigris and Euphrates rivers are in Turkey, Turkey has become the main power steering the water policy in the region. Accordingly, having such a large quantity of water

allows Turkey to negotiate with Israel, Iraq, and Syria in defining the division of this precious resource and obtaining privileges from all these countries [7].

The potential water crisis in Iraq is deepened by the fact that it does not put sufficient financial investments into its national water resources due to internal political conflict. It should have been compulsory for the governments of Iraq to encourage measures ensuring water security. This need is urgent, especially in the situation of the absence of effective international law relating to long-term planning and strategies of transboundary water body management [8].

Based on analysing the list of legislation documents in force in Iraq concerning water resource management, it can be recognized that legislators have demonstrated a degree of awareness related to the legal perspective of water resources in the country in various sectors. This fact demonstrates the goodwill of the Iraqi Government in developing a legal framework for its national water resources [9].

Notwithstanding, Iraqi legislation concerning the efficiency of the water distribution network must be reviewed and improved by stakeholders cooperating with the private sector, non-governmental organizations (NGOs), academic staff in universities, and international organizations. Iraq must have a strategic water directive vision that includes a long-term integrated national water plan [10]. It is regrettable that during the last 50 years, Iraq has not given priority or sufficient attention to the water management framework [11].

2. Objectives of Study

Sustainable water management in Iraq is becoming an urgent and inevitable task, despite the political instability in the region. This article will summarize the key aspects of water management in Iraq, with special attention to the Kurdistan region, and discuss possible changes to the legislative framework. Undoubtedly, the best model for a holistic approach to water management is management by river basin, the natural geographical and hydrological unit, instead of by administrative or political boundaries. This model requires wide collaboration of water sharing countries, overcoming their political differences and potential conflicts. Water management by river basin was successfully implemented in the European Union (EU) by EU Water Framework Directive 2000/60/EC (WFD), which could be considered as good international practice. The recommendations presented in this paper were inspired by analysing national water management framework and practices in Iraq (Kurdistan) in a light of EU legislation. In 2015, the project titled "Environment Legislation Guides in Kurdistan as first step toward WFD", supported by the EU and the Kurdistan Regional Government, created ground for analysing the present state, key problems, and potential improvements in Iraqi water management.

The main objective behind this study is to describe the background and analyse the major problems of water management in Kurdistan Region (part of Iraq), with special emphasis on water balance. The description of recent state and its critical analysis represent the introductory steps needed for establishing a specific framework for Iraq regarding the protection of surface waters and groundwater including transboundary aquifers, in terms of quality and quantity management.

The implementation of a proper water management strategy must be based on the establishment of a clear legislative framework at the national and regional levels. In the recent unstable political situation in Iraq, this task seems to be extremely challenging. The future actions in the establishing water management framework for Iraq include (but are not limited to):

- Stopping the further deterioration of the qualitative and quantitative status of water bodies;
- Creating a clear and unambiguous legislative framework for the protection and management of water resources at the river basin scale;
- Introducing water management plans and updating periods through strategic planning to mitigate the impacts of floods and droughts;
- Clarifying the responsibilities of the water authorities at the national and regional levels and all legislative procedures.

3. EU Water Legislative Framework—Key Principles and Objectives

The awareness of the need to protect water resources in individual European countries can be determined as having started in the 1970s (e.g., Water Act 1973 c. 37, United Kingdom Public General Acts or Water Act 138/1973 Sb., former Czechoslovak Socialist Republic). Its main emission control element was the Dangerous Substances Directive Council Directive 76/464/EEC [12]. However, not much later at the end of the 1980s, gaps were identified in addressing pollution from urban wastewater and agriculture. In response, the Urban Waste Water Treatment Directive [13] and the Nitrates Directive [14] were adopted. Those directives were followed by a new Drinking Water Directive [15], and a Directive for Integrated Pollution and Prevention Control (IPPC) [16]. An Industrial Emissions Directive—IED 2010/75/EU [17]—repealed the IPPC Directive and the sectoral directives.

From the abovementioned list, it is apparent that water policy was very fragmented in terms of both objectives and means. In response to the need for a single piece of framework legislation, the EU Water Framework Directive (WFD) was adopted in 2000 [18]. The consequences of this were a shift from sectoral environmental protection to a more integrated form, as well as the establishment of compulsory environmental standards and status [19]. The WFD introduced the ambitious objective that all groundwater, surface and coastal waters in the EU should achieve a "good status" (good ecological quality) by 2015. "Good ecological status" can be understood to mean that water can be used by humans as long as the ecological function of the water body (surface and groundwater) is not significantly damaged. This modern piece of EU legislation establishes clear objectives, and is based on achieving milestones such as the risk evaluation of anthropogenic pressures and impacts, monitoring programs, development of river basin management plans, and the design and operation of programs of measures [20]. The WFD imposed a new and revolutionary form of responsibility on the EU member states [19]. Teodosiu et al. [21] summarized the principal objectives of the WFD as follows:

- Expansion of the scope of water protection to all waters, including surface waters, groundwater, and coastal and transitional waters;
- Water management based on river basins;
- A "combined approach" of emission limit values and quality standards;
- Setting of the right prices;
- Encouragement of closer citizen involvement;
- Streamlining of legislation.

Concerning surface waters, the objective is to reach a "good ecological status" and a "good chemical status". Groundwater protection, however, requires specific approaches. Groundwater should not be viewed only as a drinking water resource or resource of water for industry or agriculture. The WFD [18] established for the first time that groundwater should be protected for its environmental value; whereas the aim for surface waters was to reach a good ecological and good chemical status, the WFD focuses on both quantitative and qualitative status objectives for groundwater. Chemical criteria are more complex and are dependent on local geological and hydrogeological background conditions. Thus, the Groundwater Directive 2006/118/EC [22] was adopted clarifying the criteria for a "good chemical status" and specifications related to the identification and reversal of pollution trends.

The WFD introduced a revolutionary approach to water governance, offering more flexibility than previous directives and an opportunity for continuous policy adjustments [23–25]. The WFD is not target-based legislation. It is, however, explicitly stated that no water bodies are to experience deterioration in status from one class to another [26,27].

Fifteen years after the WFD was introduced, achieving its objectives remains a challenge. Voulvoulis et al. [28] reviewed the WFD implementation efforts, focusing on the interpretation of its key principles in the process. The objective of their study was to understand why the great expectations that came with the WFD have not yet been fully fulfilled. Additionally, Voulvoulis et al. [28] commented that 47% of EU surface waters did not reach the good ecological status by 2015, which was a principal

objective of the WFD [29]. This study emphasized the need to review or revise current implementation efforts, which would allow the directive to deliver its systemic intent to reach its full potential.

The WFD introduced integrated water management by river basins. Integrated and traditional water management differ in terms of objectives and target areas [21]: traditional management focuses on a specific and a single domain of water use (water supply, irrigation, wastewater treatment, pollution control, etc.), whereas integrated management tries to gather all these sectors into a unified framework with each sector having individual importance. The principles of integrated water management in the context of the WFD are discussed, e.g., by Reference [30].

4. Water Management in Kurdistan

A successful water management policy basically relies on and revolves around factors such as awareness, socio-economic status, well suited supply costs, data availability and reliability, and a schematic assessment of population growth. There are two main kinds of challenges related to water crises in the Kurdistan Region: external challenges represented by climate change, international agreements, and the GAP project; and internal challenges represented by inadequate water management, political instability, lack of local policies, and an insufficient legal framework [6].

The population of Kurdistan rapidly increased to an unbelievable extent from 2009–2017. The main factors influencing population growth were flash waves of Syrian refugees in 2010 and a high rate of incoming Iraqi internally displaced persons (IDPs) under the impact of unstable security due to ISIS attack in 2014. These events increased the population by 28%. Moreover, there was migration from rural areas to urban regions driven by the search for increased chances of employment [31,32].

Many state and local administration authorities are responsible for various water subsectors; thus, the system is complicated, with possibly overlapping rights and responsibilities. The current state of responsibilities of the Iraqi water authorities is shown in Table 1. It could be compared to the situation in Turkey, where the implementation of the EU's WFD was planned [33].

Table 1. Responsibilities of Iraqi water authorities.

Organization	Main Tasks and Responsibilities
Ministry of Agriculture and Water Resources (MAWR)	• Sharing hydraulic and operational information about transboundary rivers (Tigris and Euphrates). • Applying the principle of integrated water resource management (IWRM), similarly to that which is applied in Turkey and EU countries. • Coordinating between water resources and water demand sectors. • Monitoring the surface and groundwater status. • Legislating acts related to protect groundwater bodies. • Planning the application of rational irrigation techniques. • Reclaiming marshlands. • Developing fishery projects through supporting the private sector. • Managing river basins based on the scope of legal exploitation of water supply and the organization of sand/gravel quarry works.
Ministry of Municipalities (MoM)	• Providing and supplying domestic water for both urban and rural areas. • Protecting the water supply networks from leaks and damages. • Legislating the recovery cost instructions of supplied water.

Table 1. *Cont.*

Organization	Main Tasks and Responsibilities
Ministry of Environment (MoE)	• Protecting and improving water quality. • Developing and improving wastewater management. • Employing integrated management of hazardous chemicals. • Performing necessary surveys to specify environmental impacts resulting from the use of internationally prohibited weapons. • Implementing the standard limits of contamination allowed in water resources used for different purposes.
General Directorate of Meteorology and Seismology (GDMS)	• Continuously recording and monitoring meteorological and seismological events. • Forecasting natural hazards such as floods, drought, and earthquakes.
Central Agency for Standardization and Quality Control (CASQC)	• Creating and controlling the physical and chemical standards of water quality for multiple purposes. • Specifying general requirements for non-bottled drinking water, including water produced from water intakes and dam reservoirs, transported through distribution networks and special conveyance vehicles according to Iraqi standards relating to water quality: IQS/417/2001, ICS:13.060.20
Ministry of Electricity (MoEl)	• Planning and constructing hydropower plants.

4.1. The Influence of Transboundary River Conflicts on River Basin Management

The first definition of the international watercourse was created in the Geneva Convention of 1815. In 1997, the United Nations Convention on the "Law of the Non-Navigational Uses of International Watercourses" GA RES 51/229 (21 May 1997) was adopted [4].

Globally, approximately 270 international rivers exist within international river basins around the world, yet the riparian countries of only 40% of these international water basins have signed a formal agreement to secure their fair shares of the water resources [34–37]. International law, international court judgements, and all international norms have settled on two main points with regard to the international sharing of waters. First, any surface water body belonging to one drainage basin should be treated as a whole and not a separate unit. Second, each country located on one transboundary river basin has the right to a reasonable and equal share in the beneficial use of water, unless there are bilateral agreements or binding conventions [36,38]. The Helsinki agreement of 1966 (Articles 4 and 5) indicates the share of water for every riparian country according to basin hydrogeology, the economic and social needs of each country, climate change impact on the basin, the population relying on the basin water for each riparian country, the availability of alternative resources, and the extent to which one or more basin countries can be compensated as a means of controlling conflicts between water users [36,39]. The fast-rising water demand inevitably leads to conflicts among riparian countries, particularly when utilities are considered as non-essential, to benefit only a few people, etc. [40]. "The balance between the public nature of the resource and private rights to it will continue to be the subject of political contestation as will entitlements to waters in shared rivers and the obligations of riparian states to each other" [41].

Iraq is a country that mainly depends on the two international transboundary rivers of the Tigris and Euphrates. Syria, on the other hand, mainly depends only on the Euphrates. The headwaters of both rivers originate in Turkey, and both countries have had conflicts with Turkey since their independence. Since the 1960s, the demand for water resources within these countries has surprisingly increased as their populations have doubled in size [6]. Although Iraq, Syria, and Turkey have negotiated sporadically, with diplomatic and technical discussions concerning the waters of the

Euphrates River occurring for decades, they have still not been able to agree on a permanent tripartite treaty. The issue of setting the right terminology to be used for this transboundary river persists, with "sharing" suggested by Iraq and Syria, while Turkey insists on the term "allocating" [42]. The Turkish position regarding the water issue in Iraq illustrates that Iraqi officials should establish a strategy on how to connect the Tigris and Euphrates through the Tharthar channel to compensate the shortage in the Euphrates. Turkey still believes that the Tigris and Euphrates represent one basin, and claims that neither river is international but that they are merely transboundary. In contrast, Turkey listed the Tigris and Euphrates as separate basins in the hydrogeological studies done by the Turkish General Directorate of State Hydraulic Works (abbreviation DSI in Turkish), naming the Euphrates basin No. 21 and the Tigris basin No. 26 [36].

The drainage pattern system of the Kurdistan Region is governed by four major, roughly parallel rivers, with a flow direction from the northeast to the southwest. The confluence of each tributary, i.e., Khabour, Great Zab, Little Zab, and Sirwan, with the Tigris River from north to south, respectively, is either outside or just at the border of the Kurdistan Region. The headwaters of the Khabour and Greater Zab tributaries originate in Turkey, while the Little Zab and Sirwan headwaters are in Iran. Although the Udhem basin is completely within Iraq, it has very limited resources, as it drains only the dry lowland Garmian area (Table 2).

Table 2. River basins in Northern Iraq, data source [43].

River Basin		**1 Tigris (Direct)**	**2 Khabour**	**3 Greater Zab**	**4 Little Zab**	**5 Udhem**	**6 Sirwan**
Origin		Turkey	Turkey	Turkey	Iran	Iraq	Iran
Catchment area (km^2)	Upstream of Iraq border	40,600	1303 [1]	9414	4883	-	17,423 [2]
	Within Kurdistan Region	2770	2627	16,696	12,229	5774	9286
	Total at mouth	n/a [3]	6027	26,331	19,593	n/a [3]	n/a
Existing large dam		Mosul	-	Bekhme (planned)	Dokan	-	Derbendikhan
Governorates		Duhok		Erbil	Suleiymaniya		
					Garmian		

[1] In addition, the border section of the lower Khabour drains another 2097 km^2 of Turkish territory; [2] Of which 13,431 km^2 upstream of Derbendikhan Reservoir; [3] No data.

Although Iraq has a relatively large share of the river basins, approximately 50% of the surface water resources originate upstream, i.e., outside the border of Iraq, while 50% of the Tigris and 90% of the Euphrates originate from Turkey [44]. Three major dams have been constructed on the Tigris and its tributaries, namely the Mosul, Dokan, and Derbendikhan dams on the Tigris, Little Zab, and Sirwan, respectively. There is a plan to build the Bekhme Dam on the Greater Zab River, which is estimated to become the largest dam in Iraq. Table 3 provides an overview of the constructed dams.

Regarding sharing waters with Iran, both of the Tigris tributaries, Little Zab (also named Lesser or Lower Zab) and Sirwan, originate in Iran. The impact of upstream country water management in Iran was manifested when Iranian officials started to utilize the shared water resources through the construction of dams on these two tributaries. In 2009, the Iranian government started the construction of Daryan Dam on the Sirwan River, 28.5 km from the Iraqi border. When the Daryan Dam was about to be completed (in 2015), the measured inflow (2.4 m^3/s) was not sufficient to prevent the river from being contaminated due to insufficient dilution rates; this rate represents only 40% of the original discharge [45].

In 2011, Iran continued its strategy to tackle water scarcity through the construction of the Sardasht Dam on the Little Zab river, 9 km from the Iraqi border. Its operation (from June 2017) resulted in a shortage of drinking and irrigation water in most of the regions of Suleiymaniya Province in Kurdistan. Its negative impact could also be seen on the annual capacity of Dokan Dam (1954–1975) [37]. Accordingly, the absence of effective understanding between Iraq and Iran left Iraq suffering from the lack of water resources, while there is no legal paper to be used in the UN General Assembly to instigate upstream countries to regulate the transboundary waters among riparian countries [37,46]. The conflict remains a pending issue between Iraq and Iran. The reason for this is that Iran is positioned as the owner of its natural resources, and supposes that under "the theory of absolute territorial sovereignty" it has the authority to utilize its water resources fully according to its need without restrictions [37,47].

Table 3. The dams built on the Tigris and Euphrates rivers in riparian countries, data sources [44,48].

Dam	Country	Operational Year	River	Capacity (BCM) *	Purpose	Hydro-Power (MW) *	Irrigated Area (ha) *
Keban	Turkey	1974	Euphrates	30.6	Hydro-power, irrigation, flood control	1330	63,872
Karakaya	Turkey	1987	Euphrates	9.5	Hydro-power	1800	-
Ataturk	Turkey	1992	Euphrates	48.7	Hydro-power, irrigation, fishery, recreation and sport	2400	882,000
Birecik	Turkey	2000	Euphrates	1.22	Hydro-power, irrigation	672	95,000
Ilisu	Turkey	2018	Tigris	10.41	Hydro-power, flood control	1200	-
Tabqa	Syria	1975	Euphrates	11.7	Hydro-power, irrigation	800	124,000
Sardasht	Iran	2017	Tigris-L.Zab *	0.38	Hydro-power, irrigation	421	80,500
Daryan	Iran	2018	Tigris-Sirwan	0.36	Hydro-power, flood control	230	-
Derbendi-khan	Iraq	1965	Tigris-Sirwan	3	Hydro-power, water supply	249	-
Dokan	Iraq	1975	Tigris-L.Zab	6.97	Hydro-power, irrigation	400	35,500
Mosul	Iraq	1986	Tigris	11	Hydro-power, irrigation, flood control	1052	750,000

* BCM: Billion Cubic Meters, MW: Megawatt, ha: hectare, L. Zab: Little Zab.

Thus, the negative impact of the completion of all of Turkey's and Iran's projects on the Tigris and Euphrates, including the tributaries of the Tigris, will directly influence the lives of seven million Iraqis who live on the banks of the rivers, and also 1.9 million hectares of agriculture lands [45]. Despite the many existing dams, artificial lakes, and regulating connection channels in Iraq, such structures are not sufficient to manage the surface water requirements. A list of the dams constructed on the Tigris and Euphrates rivers in all riparian countries with influence on the transboundary water management is provided in Table 3 and shown in Figure 2.

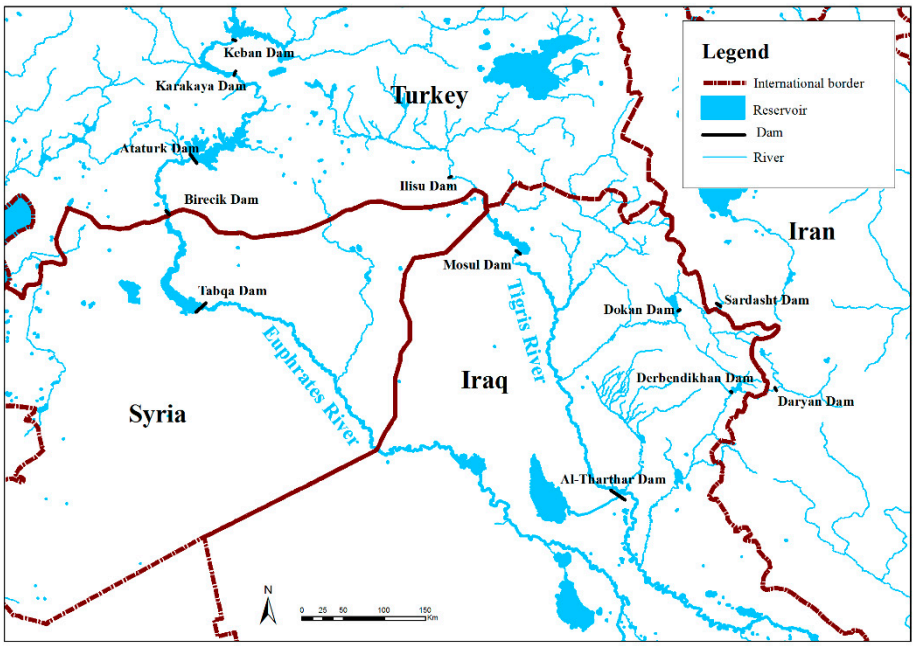

Figure 2. Dams with the greatest impact in upstream countries (Turkey and Iran) and the most affected dams in downstream countries (Syria and Iraq).

4.1.1. Historical Agreements on Transboundary River Basins

The historical conflict regarding the regional water basin—namely, the Tigris-Euphrates basin—dates back to the early 1920s. After the collapse of the Ottoman Empire in 1922, Turkey, Syria, and Iraq became independent countries sharing the Euphrates and Tigris waters. The tension among these riparian countries increased after Turkey started its long-term strategic water management planning. This change forced both Syria and Iraq together to proceed against Turkey's water policy concerning the incoming water through the Tigris and Euphrates rivers [6,42].

Accordingly, numerous agreements and protocols have been signed among or between the transboundary countries, but unfortunately none of them have gone into force, on account of the powerful positions of both Turkey and Iran compared to Iraq and Syria. Turkey dominates the Tigris and Euphrates against Iraq and Syria, while Iran has control of most of the tributaries of the Tigris [5].

4.1.2. Iraqi–Turkish Agreements

In 1923, Iraq signed its first treaty with Turkey called the Lausanne agreement (24/7/1923). Its Article 109 indicates that both countries must preserve their rights when a water management system (canal opening, flood dams, irrigation, drainage system, etc.) is built in the territory of another state or when water is used in the territory of one of the countries [36,49]. The first tension started in 1926 after the collapse of the Ottoman Empire, when Turkey wanted to change the amounts of discharged waters for downstream countries despite the claims submitted by Syria and Iraq. Turkey did not pay attention to their claims, under the pretext that the agreement was irrelevant due to the existing Turkish political and economic situation. In March 1946, a treaty of friendship and good neighbourly relations was signed between Iraq and Turkey in Ankara. Protocol 1 of this treaty focused on regulating the waters of the Tigris and Euphrates rivers, while Protocol 3, Article 3 focused on economic and technical cooperation between Iraq and Turkey.

By the early 1960s, the population of the downstream countries had doubled; thus, the demand on water resources increased dramatically. The downstream countries started to request larger amounts of water, while Turkey did not pay attention under the pretext of non-rationalizing the consumption of water [6]. The validity of the 1946 treaty lasted until 1964, when Turkey started to build the Keban Dam and an electricity power plant on the Euphrates. Despite this step, Turkey promised Syria and

Iraq (through negotiation with their technical expert teams) to pass 350 m^3/s in the Euphrates river. According to experts from the downstream countries, this amount of water was not sufficient even for agriculture. In Baghdad in 1965, extensive negotiations took place about the Tigris-Euphrates basin. Syria opposed Turkey's proposal, which considered the Tigris-Euphrates as one basin—i.e., in case the Euphrates could not satisfy the needs of the territory at that time, the Tigris could solve the problem [42].

In the beginning of the 1970s, Turkey initiated plans for the construction of dams on the shared rivers. Though Iraq was aware of the need for action, nothing happened until 1975, when Turkey started the biggest water project in the region, namely the GAP project. At this time, Syria also started construction of the Tabqa Dam, which angered Iraq further. At the same time, the Turkish government continued its negotiations with the World Bank to obtain funding for the construction of the Karakaya Dam on the Euphrates. The World Bank experts laid conditions for Turkish officials to let 500 m^3/s of water pass downstream, while the negotiations continued between Turkey and the World Bank to inform the downstream countries about the conducted agreement. Both Syria and Iraq raised claims, which led the World Bank to stop providing funding. This forced Turkey to finance the project in conjunction with the Ataturk Dam project from its own budget [42]. The Iraqi-Turkish Joint Committee for Economic and Technical Cooperation was established, and in a meeting, held in Ankara on 5/12/1980 (Article 5), the following points were approved:

1. The two sides agreed to cooperate in the field of pollution control of the shared water in the region;
2. The two sides agreed to form a joint technical committee within two months to study regional water issues (particularly around the Tigris and Euphrates rivers) and submit their report to the governments of the three countries (Turkey, Syria, and Iraq) within a period of two years.

In 1987, Turkey and Syria issued the Protocol of Joint Economic Cooperation Committee regarding the sharing of 500 m^3/s of water resources without Iraq, under the pretext that Turkey supported their Kurdish Revolution in Iraq. For this reason, Iraq did not join the meeting. In 1989, Iraq and Syria organized their bilateral meetings to sign the agreement on 17 March 1989, and it came into force on 16 April 1990. The two countries agreed that Iraq´s share would be 58% of the Euphrates waters running out from the Turkish-Syrian border until a tripartite agreement was reached.

The topic of "transboundary rivers" was placed on the table for discussion during a technical tripartite joint meeting in Ankara in April 1990, as well as during the 16th tripartite meeting in Damascus in September 1992 [36].

In 1992, Iraq and Turkey initiated negotiations concerning the conflict over the Euphrates shared waters. When the Ataturk Dam was completed, Turkey cut off the Euphrates waters to fill the dam, not considering that Iraq had asked for the share of 700 m^3/s. The former Prime Minister Suleyman Demirel announced that "we do not say we share their oil resources. They cannot say they share our water resources. This is a right of sovereignty. We have the right to do anything we like" [6,50].

At the same time, Turkey received diplomatic notes from Iraq and Syria regarding the negative impacts of the dam. When the dam temporarily started to cut off 75% of the Euphrates waters, Iraq declared its preparedness to use force to stop the action, and Turkey mobilized its military for an emergency and declared that it was ready to cut off the river completely [6].

In 1996, Iraq and Syria sent their protests to Turkey about the construction of the Birecik Dam, as the Euphrates water level dropped, and the river water was polluted. In 2009, Iraq sent two protest memoranda to UNESCO and the League of Arab States about the negative impact of the GAP project on the environmental state of the Shatt Al-Arab River. Iraq indicated the increasing rate of river water salinization in connection with the decreasing water discharge and lowering river water stages of the Tigris and Euphrates in response to the ongoing GAP project.

In 2012, Iraq faced the problem of the desertification of marshlands in the southern part of the country. This forced the government to protest about the risk of the low production of domestic crops. The Ilisu Dam was finalized in 2015, which worsened the situation by cutting the rate of incoming

water in the Tigris River to Iraq by half. At the end of 2017, the GAP project came close to its final stages. It is expected that the outflow of Euphrates water passing the Turkish-Syrian border will be reduced by 70–80%. This could be a real disaster, so downstream countries are turning to the international community to address the issue [6].

4.1.3. Iraqi-Syrian Protocols

The first meeting, organized in 1962, emphasized the requirement that both sides shall exchange information on Euphrates waters and recognize the rights of existing water projects in both countries. The formation of a permanent body coordinating water management projects on the Euphrates River was agreed upon [49]. However, later political events prevented the body from being convened. It should be noted that the functions of this permanent body, which was to be formed in 1962, were the same as those of the Joint Technical Committee, which the Syrian and Iraqi sides agreed to sign in 1980, 18 years after the first proposal. Both countries overcame their political differences, while they did not harm their supreme national rights. The Turkish side joined the agreement later, in 1984, and dared to impose a fait accompli on the sharing of the Euphrates watershed.

The second meeting between the two parties was held in late 1965 in Baghdad (the meeting was attended by a delegate from the Turkish side). The sharing of the Euphrates River and the preparation of a timetable for filling the water reservoirs in the basin countries were discussed. The parties did not reach any concrete results, and considered the meeting to be without positive outcomes because of the endeavour of each party to give priority to its own interests over the interests of the other basin states. Syria suggested that Euphrates water was not enough to meet the needs of irrigation for the three riparian countries. For this reason, Syria proposed to convert some of the Tigris waters to the Euphrates; Iraq stood against the proposal and kept discussing only the Euphrates [42].

The third meeting was organized in April 1990. In this meeting, Iraq agreed to share the Euphrates water discharges with Syria, at 42% for Syria and 58% for Iraq.

4.1.4. Iraqi-Iran Protocols

The first important agreement was signed in Constantinople (now Istanbul) in 1913, and was called the Istana Protocol. In line with this agreement, the demarcation of the river border in the Shatt al-Arab area was carried out in 1914 by a special boundary commission. The boundary was demarcated at the low water level line on the eastern side of the Shatt al-Arab, except for the area opposite to Abadan city, where the 7 km-long border line, the Thalowge line, was the deep course of the line. The agreement allowed Iranian merchant ships to move freely in front of the port city [5]. The protocol of 1937 claimed that the two countries affirmed the recognition of the water border as laid out in the "1914 water demarcation protocol" without changes [51]. "Protocol Algiers 1975" was signed in Algiers on 6 March 1975, when the President of Iraq Saddam Hussein gave up Iraq's sovereignty over the other half of the Shatt al-Arab to Iran under the condition that Iran would stop supporting the Kurdish Revolution in Northern Iraq (recently named the Kurdistan region). The signed agreement confirmed the new international border line of the Shatt al-Arab as the deep course of the river line.

Despite all mentioned agreements and protocols signed among Iraq and its neighbours concerning the sharing of transboundary water bodies, unfortunately, none are any longer in force due to political conflicts. After the invasion of Iraq by coalition forces in 2003, the Iraqi institutions totally fell apart, and Iranian interference and dominance over political decisions in later stages of the conflict consequently kept Iraq from securing its water rights.

4.2. Water Balance

Sustainable water management requires reaching a long-term equilibrium of surface and groundwater resources (inflows, precipitation) with sinks (evapotranspiration, runoff from watershed) and water exploitation. Despite the poor policies of the Kurdistan Region and the negative impacts of drought and climate change, the current status of the water bodies of the Kurdistan Region is

still preserved. According to Reference [44], Iraq annually receives 70.92 billion m^3 of water and consumes 60.43 billion m^3. The annual decreases in the Tigris and Euphrates waters are 0.1335 and 0.245 billion m^3, respectively. Accordingly, the average annual demand on incoming water through the Tigris and Euphrates rivers in 2020 is predicted to increase to 42.884 billion m^3 and 29.225 billion m^3, respectively, representing a total of 72.069 billion m^3; this indicates that the shortage amount will be approximately 8.609 billion m^3. Furthermore, groundwater is also affected in the Tigris and Euphrates basin; studies have indicated that the overall loss of groundwater in the basin was nearly 144 billion m^3 from 2003–2009 [52].

Based on the water management report of the Ministry of Agriculture and Water Resources (MAWR), the average annual inflow of surface water from the upstream neighbouring countries, Turkey and Iran, amounts to approximately 11.3 billion m^3. This is equivalent to a discharge of 537 m^3/s as a mean annual inflow of surface water into the Kurdistan Region through the Tigris River tributaries of Khabour, Greater Zab, Little Zab, and Sirwan [43].

The mean annual flow of the surface water from the Kurdistan Region into Iraqi territories is estimated at 22.4 billion m^3, which is equivalent to 1064 m^3/s. From the difference between the inflow and outflow measurements, it could be concluded that the Kurdistan Region feeds Iraq with surface water through the rivers mentioned above with approximately 50% of the total amount of surface water inflow into Kurdistan [48].

The groundwater conditions are also affected by the same factors mentioned in the previous paragraphs. Research carried out in Duhok governorate emphasized that the drawdown of static groundwater levels in Duhok city was approximately 3.79 m in confined aquifers and 7.09 m in unconfined aquifers in 2010 [53], while the same deterioration could be found in the Aqra-Bardarash basin (the wealthiest basin in Iraq), where the decline of groundwater table is approximately 4.78 m in the eastern part and 4.13 m in the western part of the Khazir River [54]. Moreover, Qurtas [55] indicated that the groundwater level in the Erbil plain had decreased by approximately 30 m in some areas. Meanwhile, the reports of the MAWR indicate a decrease of groundwater levels in some regions in Suleiymaniya governorate of up to 50 m. Unfortunately, officials in the Kurdistan Region failed to carry out comprehensive annual surveys concerning the water balance for both surface and groundwater resources.

Springs are the traditional source of water supply for both domestic use and irrigation in most of the mountainous regions of Kurdistan. The current records of the Ministry of Irrigation and Water Resources indicate the number of registered springs in Duhok governorate to be approximately 2860, while the total number in the Kurdistan Region is estimated at 10,000. From 2008–2016, many springs dried up due to the low rate of precipitation, especially in distant mountainous areas, because the saturated thickness did not meet the current yearly recharge according to the General Directorate of Meteorology and Seismology [56].

Water resources are mainly used in Kurdistan in two sectors: for domestic use as drinking water sources and for agricultural irrigation purposes. Potable water requirements cover about one third of total water demands. The MAWR adopted a master plan to decrease the current two thirds of consumption for agriculture by 15% (see Table 4). Additionally, the Ministry of Municipality, as a relevant institution for water supply, planned to separate the domestic water resources from the agricultural resources.

Table 4. Water demand—potable water vs. water for agriculture, data source [43].

	Domestic Water Supply Mio. m^3/year (ADD)		Irrigation Mio. m^3/year	
	2010	2030	Current	After Implementation of the Strategic Plan
Erbil	178	328	439	2.199
Duhok	129	240	186	999
Erbil + Duhok	307	568	625	3.198
% of total demand	33	15	67	85
% of today's demand	100	187	100	511

ADD: Average Daily Demand.

The over-exploitation of water resources is considered to be one of the great challenges in Iraq. To overcome this problem, officials must dispute this strategy on the local level to motivate the involvement of NGOs in public policy debates and to establish a program to set up a specific database regarding the qualitative and quantitative status of water bodies (according to EU WFD), particularly for groundwater resources [53,57]. Accordingly, the Kurdistan Regional Government issued some laws, legislative documents, and regulations related to the protection of groundwater bodies. According to the authority given by the MAWR, Act No. 6 (2015), Item No. 5, Clause No. 3, specifies the following rules and measures focused on the improvement of the quantitative status of groundwater bodies [58].

Item 1: Identification of the related institutions that have the right of supervision of these regulations;

Item 2: The distance between drilled wells specified in different geographical regions as follows: In mountainous areas, not less than 250 m, while in plains, from 400–500 m as specified for each governorate;

Item 3: The distance of a well site from springs and seepage sites should be at least 500 m;

Item 4: The licensing of drilled wells for irrigation should require the confirmation of related institutions;

Item 5: Instructions for the drilling of drinking water wells for public use should pass through some specific steps in coordination with the related officials (desk and field actions needed);

Item 6: Instructions for the drilling of wells for the private sector. The owner must apply for a license according to the conditions issued for this purpose by related institutions (desk and field actions needed).

Iraqi officials represented by the Ministry of Water Resources (Iraqi central government) seek to achieve the following objectives based on Act No. 50 [59]:

- Organize water distribution, reduce the risk of flooding, control surface runoff, and conserve a good state of river basins;
- Carry out in-depth studies and research related to irrigation, reclamation, dams, and groundwater, and establish designs and related documents through institutions and other associated authorities;
- Management, operation, and maintenance of dam projects, reclamation, irrigation, drainage, and groundwater;
- Coordinate actions with international, regional, and Arabic organizations and NGOs specialized in water resources and environmental issues;
- Negotiate plans of the MAWR with planning authorities, water consumption sectors, and other relevant sectors in accordance with sustainable development in Iraq;
- Develop modern techniques and a geographic information system (GIS) to improve working methods in the MAWR. Technical staff should be trained to utilize advanced scientific procedures in water management;
- Adopt the principle of awareness to conserve water wealth and protect water from pollution. Officials should request help from NGOs to achieve the objectives.

In spite of the existing simple procedures such as groundwater level monitoring, there are no active strategies to fill the gap that has existed in the deterioration of groundwater levels since the drought periods 1999–2001 and 2007–2009 [53,57].

5. Conclusions and Recommendations

Based on an overview of the water management issues in Iraq (with special attention to the Kurdistan Region) and the legislative framework in force, it can be concluded that environmental objectives in the sustainable water system protection that would ensure a good state of water bodies will not be easy to achieve. The implementation of principles of the EU WFD in Iraq faces not only technical challenges; the region has long been economically and politically unstable, with current waves of immigration from neighbouring regions suffering from war conflicts (e.g., Syria).

Iraq, being a downstream country whose watercourses (the Euphrates, the Tigris, and their tributaries) have their headwaters in Turkey and Iran, still does not have effective agreements relating to the quantity and quality issues of the shared water. This situation coincides with high population growth in all the water-sharing countries, and possible conflict is a critical issue. Politically, Iraq and Syria lack a strong influential position for enforcing their water demands, while they have no long-term strategies related to water resource harvesting through the application of rational techniques on water utilization in different sectors, unlike Turkey and Iran. It is apparent that the conflict issues among the riparian countries will have to be resolved in negotiations mediated by a third party.

According to Article 33 of the Charter of the United Nations, the UN or its agencies provide investigation, mediation, arbitration, and the judiciary to aid committed countries in the resolution of disputes and to reach a peaceful solution to conflicts that might threaten peace and result in water conflicts.

Many disputes have been resolved through the mediation of the UN and its agencies, for example, the disputes over the Al-Sindh waters (India and Pakistan) and the waters of the Kang (India and Bangladesh); through arbitration, such as the dispute concerning the Malando River (Afghanistan and Iran); or through the judiciary, such as the disputes concerning the Banana River (Belgium and the Netherlands) and the Oder River (Poland and the Czech Republic), etc. On the other hand, the whole region is influenced by water resource shortage due to water mismanagement and also climate change. The Kurdistan Regional Government should pay attention to problems related to water pollution as a main hazardous risk in the region. These problems must be addressed as soon as possible through the implementation of water management strategies, inspired, for example, by the EU Water Framework Directive.

The Iraqi water authorities have dedicated a large budget to water supply, while data indicate that the recovery costs did not fill the shortage gap. This indicates that the government should re-evaluate its policies regarding consumption fees to meet the recovery costs. In spite of the existing regulations, excessive pumping with a huge drop in water levels still represents one of the highlighted points that threaten the groundwater situation, coinciding with the effect of climate change as the most influential factor since the drought period of 1999–2009. The water management practices concerning the reuse of wastewater after treatment for irrigation and industrial uses, the decrease of water lost in the drinking water supply systems, artificial recharge, etc., need to be re-assessed.

The analyses of data collected by Iraqi governmental institutions such as the Directorate of Groundwater, Directorate of Water Distribution, and Directorate of Statistics and Hydrometeorological Institute have been performed with a focus on water quantity together with field reconnaissance. Based on the analysis, the first practical steps in water management practices in Kurdistan (Iraq) aiming at improving the ecological status of surface water and quantitative status of groundwater (EU WFD) could be implemented as follows:

- Re-registration of the wells that have been illegally drilled to control the quality and quantity of water resources, and adopting strict authorization conditions for deep wells drilling;

- Installation of measuring gauges on drinking water networks to control the water consumption fees regarding the recovery cost policy;
- Government encouragement of its institutions to decrease the use of groundwater and replace it with the use of surface water as an alternative;
- Support the establishment of surface water projects to construct dams (e.g., completing Bekhma Dam on Greater Zab river, Bakurman Dam on Khazir river, and Barhol Dam on Khabour river);
- Supporting measures aimed at increasing a retention of water in a landscape and preventing fast overland outflow from the river basin during flood events and during wet seasons. We propose establishment of ponds on the seasonal streams (with the capacity of 0.5 to 5 million m^3) to be used for the multisectoral purposes: irrigation, fishery, tourism, environment conservation, etc.;
- Decreasing a full dependence of rural areas on groundwater use by the construction of infrastructure transferring river water to distant areas;
- Intensification of modern irrigation techniques (drop water) to decrease the evaporation lost and water consumption for irrigation purposes;
- Re-use of the discharged wastewater to make up for the gap and relieve the stress on water supply projects;
- Application of artificial recharge as a modern technique to recover the negative impact on groundwater status;
- Construction of treatment stations in transition streams under the monitoring control of environmental experts aimed at the re-use of drainage and wastewater for irrigation, washing, and other daily industrial and domestic uses except drinking;
- Collection of rainwater for, e.g., re-use for irrigation and washing. This measure should be mandatory for newly constructed buildings and building structures (car parking) funded by both the state and the private sector;
- Imposition of taxes on private wells or, rather, installation of measuring gauges;
- Introducing water management planning in a river basin scale with updating in 5 years' planning cycles; improve predictions on water demands in various sectors;
- Preventing overexploitation of aquifers through excessive pumping; perform study on calculation of exploitable groundwater reserves under climate change (hydrogeological survey, rainfall-runoff, and hydrogeological modelling);
- Establishment of a new water directive framework for the Kurdistan Region through effective coordination among the related ministries, including all necessary legislations concerning both surface water and groundwater status;
- Re-activation of related committees in the Kurdistan Parliament to play their effective roles in the monitoring and implementation of water directive legislations.

Proper water management could significantly influence the water consumption (water management practices, setting of the right prices—EU WFD) and loss of water (maintenance of infrastructure). The authorities can promote practices of water re-use, encourage inhabitants, industry, and agriculture to save water and to implement up-to-date water management practices (irrigation), etc. The encouragement of closer citizen involvement (EU WFD objective) is ongoing. However, the majority of these measures are dependent on financial resources which are not currently available from either the state (Iraqi Government), the Kurdistan regional government, and local authorities or private budgets. This is the primary obstacle to the implementation of the proposed measures.

It is essential to clearly define the responsibilities of water authorities at all levels, from the municipal level, to the regional Kurdistan Government, up to the central Iraqi Government. However, in reality the improvements will take decades. The central Iraqi Government is struggling to develop its institutions and implement any water framework directive, including negotiations with upstream countries about the utilization of strategic water facilities (dams). The Kurdistan Region cannot find a

solution to water shortage by the construction new dams, since such projects are under the jurisdiction and responsibility of the federal government in Baghdad.

The local authorities are not able to stop trading on water resources (illegal connections to water networks) and reduce illegal drilling of wells. Based on the information from the MAWR General Directorate of Water Resources, the illegal drilled wells number 11,000 out of the 25,000 in the whole of Kurdistan. A missing legal framework and the absence of effective penalties (enforceability of law) are obstacles to the solution. The streamlining of legislation (EU WFD objective) is a challenge both for regional and central government.

- Actions are urgently needed due to the arrival of nearly two million IDPs and Syrian refugees to the region during 2004–2014. Global warming will probably result in repeated periods of drought, and thus further deteriorate the water balance situation.
- The academic and research institutions in Kurdistan are aware of the necessity for deeper scientific studies regarding water balance. Such studies are ongoing in the phase of collecting data and constructing numerical models of groundwater flow and rainfall runoff models at a river basin scale (EU WFD approach). The conclusions of the studies will contribute to the proposal of monitoring network (data gaps) and the description of the present status of surface and groundwater bodies.

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References

1. Al-Qassas, M.A. Draught: Deterioration of land in arid areas. *J. Alim Al-Ma'arifa* **1999**, *242*, 67–74. (In Arabic)
2. Kibaroglu, A. *Water for Sustainable Development in the Euphrates-Tigris River Basin*; Middle East Technical University Department: Ankara, Turkey, 2002.
3. Kibaroglu, A.; Maden, T.E. An analysis of the causes of water crisis in the Euphrates-Tigris river basin. *J. Environ. Stud. Sci.* **2014**, *4*, 347–353. [CrossRef]
4. United Nation. *Convention on the Law of the Non-Navigational Uses of International Watercourse, New York*; General Assembly 51 Session: New York, NY, USA, 1997.
5. AL-Shakir, V.M. The Legal Framework for the Shared Water Resources between Iraq and Iran. Master's Thesis, Institute of Researches and Arabic Studies, League of Arab States, Cairo, Egypt, 2011. (In Arabic)
6. Al-Muqdadi, S.W.; Mohammed, F.O.; Rudy, A.; Naghshineh, A. Dispute over Water Resource Management Iraq and Turkey. *J. Environ. Prot.* **2016**, *7*, 1096–1103. [CrossRef]
7. Grego, S.; Micangeli, A.; Esposto, S. Water purification in the Middle East crisis: A survey on WTP and CU in Basra (Iraq) area within a research and development program. *Desalination* **2004**, *165*, 73–79. [CrossRef]
8. Al-Hussaieny, A.S.; AL-Sandoq, M.I. *The Problems of Water in Iraq, Reasons and Suggested Solutions*; Faculty of Engineering and Physical Sciences, University of Surrey: Guildford, UK, 2009. (In Arabic)
9. Ahmmad, Y.K. Legislations on Water Resources Protection in Iraq: An Overview Report of the Basic Legal Features. Max Planck Institute for Comparative Public Law and International Law. 2012. Available online: http://www.mpfpr.de/fileadmin/media/Water_Law/Nationales_Recht/Treaties_Iraq/Overview_-_Water_Law_in_Iraq__English.pdf (accessed on 6 September 2018).
10. Al-Ansari, N.A. Management of Water Resources in Iraq: Perspectives and Prognoses. *Eng. J.* **2013**, *5*, 667–684. [CrossRef]

11. Al-Lami, A.A.; Gabriel, H.M.; Abdulhamid, H.M.; Mukhtar, E.A.; Hilo, T.A. The National Environmental Strategy for Iraq and Action Plan for Iraq 2013–2017. Publishing of Ministry of Environment collaboration with the United Nations Environment Programme, United Nations Development Programme and the World Health Organization. 2013. Available online: https://wedocs.unep.org/bitstream/handle/20.500.11822/8726/-The%20National%20Environmental%20Strategy%20and%20Action%20Plan%20%20(2013%20%E2%80%93%202017)%20for%20Iraq-2013National_Environmental_Strategy.pdf?sequence=4&isAllowed=y (accessed on 6 September 2018).
12. EEC. Council Directive 76/464/EEC of 4 May 1976 on Pollution Caused by Certain Dangerous Substances Discharged into the Aquatic Environment of the COMMUNITY. 1976. No Longer in Force. Available online: https://www.eea.europa.eu/policy-documents/council-directive-76-464-eec (accessed on 6 September 2018).
13. EEC. Directive 91/271/EEC, Council Directive of 21 May 1991 Concerning Urban Waste Water Treatment. OJ L135. 30 May 1991. Available online: https://www.eea.europa.eu/policy-documents/council-directive-91-271-eec (accessed on 6 September 2018).
14. EEC. Council Directive 91/676/EEC Concerning the Protection of Waters against Pollution Caused by Nitrates from Agricultural Sources. OJ L375. 31 December 1991. Available online: http://wash.earthforever.org/lib/protection%20of%20water%20against%20nitrate%20pollution_en.pdf (accessed on 6 September 2018).
15. European Commission. Council Directive 98/83/EC of 3 November 1998 on the Quality of Water Intended for Human Consumption. 3 November 1998. In Force. Available online: https://www.mattilsynet.no/om_mattilsynet/utkast_til_dwd_annex_iii.11845/binary/Utkast%20til%20DWD_Annex%20III (accessed on 6 September 2018).
16. European Commission. Council Directive 96/61/EC of 24 September 1996 Concerning Integrated Pollution Prevention and Control. 24 September 1996. No Longer in Force. Available online: http://www.voda.hr/sites/default/files/council_directive_96-61-ec.pdf (accessed on 6 September 2018).
17. European Commission. The Industrial Emissions Directive, Summary of Directive 2010/75/EU on Industrial Emissions (Integrated Pollution Prevention and Control. 2010. In Force. Available online: http://ec.europa.eu/environment/industry/stationary/ied/legislation.htm (accessed on 6 September 2018).
18. European Commission. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 Establishing a Framework for Community Action in the Field of Water Policy. 23 October 2000. In Force. Available online: http://eur-lex.europa.eu/resource.html?uri=cellar:5c835afb-2ec6-4577-bdf8-756d3d694eeb.0004.02/DOC_1&format=PDF (accessed on 6 September 2018).
19. Petersen, T.; Klauer, B.; Manstetten, R. The environment as a challenge for governmental responsibility—The case of the European Water Framework Directive. *Ecol. Econ.* **2008**, *6897*, 2058–2065. [CrossRef]
20. European Commission. Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 Concerning Integrated Pollution Prevention and Control. No Longer in Force. 15 January 2008. Available online: https://www.ecolex.org/details/legislation/directive-20081ec-of-the-european-parliament-and-of-the-council-concerning-integrated-pollution-prevention-and-control-lex-faoc076897/ (accessed on 6 September 2018).
21. Teodosiu, C.; Barjoveanu, G.; Teleman, D. Sustainable water resources management 1. River basin management and the EC Water Framework Directive. *Environ. Eng. Manag. J.* **2003**, *2*, 377–394. [CrossRef]
22. European Commission. Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the Protection of Groundwater against Pollution and Deterioration. 12 December 2006. In Force. Available online: http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1520932004884&uri=CELEX:32006L0118 (accessed on 6 September 2018).
23. Behagel, J.H.; Arts, B. Democratic governance and political rationalities in the implementation of the water framework directive in the nether-lands. *Public Adm.* **2014**, *92*, 291–306. [CrossRef]
24. Von Homeyer, I. Emerging experimentalism in EU environmental governance. In *Experimentalist Governance in the European Union*; Oxford University Press Inc.: New York, NY, USA, 2010; Chapter 10; pp. 121–151.
25. Liefferink, D.; Wiering, M.; Uitenboogaart, Y. The EU Water Framework Directive: A multi-dimensional analysis of implementation and domestic impact. *Land Use Policy* **2011**, *28*, 712–722. [CrossRef]
26. Howarth, W. Aspirations and realities under the water framework directive: Proceduralisation, participation and practicalities. *J. Environ. Law* **2009**, *21*, 391–417. [CrossRef]

27. Donauhanse. The EU Water Framework Directive Factsheet. 2013. Available online: http://icp.donauhanse.net/activities/donauhanse-factsheets.html (accessed on 3 June 2016).
28. Voulvoulis, N.; Arpon, K.D.; Giakoumis, T. The EU Water Framework Directive: From great expectations to problems with implementation. *Sci. Total Environ.* **2017**, *575*, 358–366. [CrossRef] [PubMed]
29. European Commission. Commission Staff Working Document, European Overview (1/2) Accompanying the Document: "Report from the Commission to the European Parliament and the Council on the Implementation of the Water Framework Directive (2000/60/EC) River Basin Management Plans". COM (2012) 670 Final. 2012. Available online: http://ec.europa.eu/environment/water/water-framework/pdf/3rd_report/CWD-2012-379_EN-Vol1.pdf (accessed on 6 September 2018).
30. Bundi, U.; Truffer, B. The Perspective of Integrated Water Management, Directorate and Works on Questions of Water Management and Environmental Policy EAWAG News. 2002. Available online: https://www.dora.lib4ri.ch/eawag/islandora/object/eawag%3A9697/datastream/PDF/view (accessed on 6 September 2018).
31. UNHCR. Published reports about refugees and Internal Displacement Persons (IDPs) in Kurdistan. 2014. Available online: http://www.refworld.org/pdfid/544e4b3c4 (accessed on 7 November 2018).
32. KRSO. Official Published Report Issued by Kurdistan Regional Statistics Office. 2016. Available online: http://krso.net/files/articles/061216021759.pdf (accessed on 6 September 2018). (In Arabic)
33. Moroglu, M.; Yazgan, M.S. Implementation of EU Water Framework Directive in Turkey. *Desalination* **2008**, *226*, 271–278. [CrossRef]
34. De Stefano, L.; Duncan, J.; Dinar, S.; Stahl, K.; Strzepk, K.; Wolf, A.T. Mapping the Resilience of International River Basins to Future Climate Change-Induced Water Variability. 2010. Available online: http://www.transboundarywaters.orst.edu/publications/publications/De%20Stefano%20et%20al%202010 (accessed on 6 September 2018).
35. Mohammed, R.H. A new Strategic Planning Approach to Resolve the Conflict over Great-Zab Transboundary River Basin Using Graph Model for Conflict Resolution"GMCR II". Master's Thesis, University of Duhok, Kurdistan Region, Iraq, 2014.
36. Bahri, D. The importance of international law for global rivers in the aspect of international water relations, a study of Tigers and Euphrates Rivers. *J. Al-Mustaqbal Al-Arabi* **2016**, *453*, 118–132. (In Arabic)
37. Abdulrahman, S.A. The drying up of the Lower Zab River and future water disputes between Iran, Kurdistan Region and Iraq. *Int. J. Environ. Stud.* **2017**, *75*, 29–44. [CrossRef]
38. Ridhwan, W. Water Problem between Syria and Turkey, Damascus-Dar Al-Maarifa. 2004, p. 187. Available online: http://www.caus.org.lb/PDF/EmagazineArticles/dalal_bahri_%20Moustaqbal_%20Arabi_%20453%20FINAL.indd.pdf (accessed on 6 September 2018).
39. Hijazi, K.; Mekhemir, S. The water crises in Arabic Region, the reality and possible alternatives. *Alem Al-Maarifa* **1996**, *209*, 40–41. Available online: http://www.caus.org.lb/Home/publication_popup.php?ID=5402&MediaID=2 (accessed on 6 September 2018).
40. Ragab, R.; Prudhomme, C. Climate change and water resources management in arid and semi-arid regions: Prospective and challenges for the 21st century. *Biosyst. Eng.* **2002**, *81*, 3–34. [CrossRef]
41. Woodhouse, P.; Muller, M. Water Governance and Historical Perspectives on Current Debates. *World Dev.* **2017**, *92*, 225–241. [CrossRef]
42. Gruen, G.E. Turkish waters: Source of regional conflict or catalyst for peace? *Water Air Soil Pollut.* **2000**, *123*, 565–579. [CrossRef]
43. SETEC Engineering. Unpublished Master Plan for The Modernization of the Water Distribution Networks of the Cities of Erbil, Duhok and Suleiymaniya-Kurdistan Region-Republic of Iraq. Unpublished work. 2010.
44. Issa, I.E.; Al-Ansari, N.A.; Sherwani, G.; Knutsson, S. Expected Future of Water Resources within Tigris-Euphrates Rivers Basin, Iraq. *J. Water Resour. Prot.* **2014**, *6*, 421–432. [CrossRef]
45. Chomani, K.; Bijnens, T. The impact of the Daryan Dam on the Kurdistan Region of Iraq. Save the Tigris and Iraqi Marches Campaign. 2016. Available online: http://www.savethetigris.org (accessed on 6 September 2018).
46. Salman, S.M.A. Sharing rivers for peace, development, and security. *Water Int.* **2001**, *26*, 283–288. [CrossRef]
47. Rahman, M.M. Principles of international water law: Creating effective transboundary water resources management. *Int. J. Sustain. Soc.* **2009**, *1*, 207–223. [CrossRef]
48. Al-Rubeai, S. The Water Conventions among Iraq and the Countries of Euphrates basin. 2008. Available online: http://www.watersexpert.se/furatlag.htm (accessed on 6 September 2018). (In Arabic)

49. Wilson, R. Water-Shortage Crisis Escalating the Tigris-Euphrates Basin. Strategic Analysis Paper. Tech. Rep., Future Directions International. 2012. Available online: http://futuredirections.org.au/wp-content/uploads/2012/08/FDI_Strategic_Analysis_Paper_-_28_August_2012.pdf (accessed on 6 September 2018).
50. MacDonald, C.G. Iran's strategic interests and the law of the sea. *Middle East J.* **1980**, *34*, 302–322. Available online: http://www.jstor.org/stable/4326057 (accessed on 6 September 2018).
51. Voss, K.A.; Famiglietti, J.S.; Lo, M.; de Linage, C.; Rodell, M.; Swenson, S.C. Groundwater Depletion in the Middle East from GRACE with Implications for Trans Boundary Water Management in the Tigris-Euphrates Western Iran Region. *Water Resour. Res.* **2013**, *49*, 904–914. [CrossRef] [PubMed]
52. MAWR. Unpublished Record of Ministry of Agriculture and Water Resources-Kurdistan Regional Government. Unpublished work, 2015. Unpublished work. 2015.
53. Yousuf, M.A. Groundwater Artificial Recharge: A Strategic Planning for Duhok City. Ph.D. Thesis, School of Planning, College of Engineering and Applied Geosciences, University of Duhok, Duhok, Iraq, Unpublished work. 2012.
54. Yousuf, M.A.; Rapantova, N.; Camfrlova, M.; Younis, J.H. Groundwater Recharge Management in Semi-arid Regions, a Case Study of Khazir-Basin. *Int. Multidiscipl. Sci. GeoConf. SGEM Surv. Geol. Min. Ecol. Manag.* **2016**, *1*, 367–374. [CrossRef]
55. Qurtas, S.S. Groundwater Evaluation and Management Using Mathematical Modelling for Shamamik Basin Erbil-Kurdistan Region-Iraq. Ph.D. Thesis, University of Salahaddin, Erbil, Iraq, 2013.
56. GDMS. *Annual Report Issued by General Directorate of Meteorology and Seismology, Kurdistan Regional Government*; GDMS: Erbil, Iraq, 2012. (In Arabic)
57. Stevanovic, Z.; Iurkiewicz, A. Groundwater management in northern Iraq. *Hydrogeol. J.* **2009**, *17*, 367–378. [CrossRef]
58. Salih, S.A.; Ali, R.A. Environmental Legislation Guides in Kurdistan Region-Iraq Publication of Ministry of Planning via Ministry of Agriculture and Water Resources (MAWR) cooperating with European Union. 1st version. 2015. Available online: http://www.natureiraq.org/uploads/5/2/9/9/52997379/english.pdf (accessed on 6 September 2018).
59. Ministry of Water Resources. Law of Ministry of Water Resources. Iraqi Chronicle. Act No. 50; 2008; Volume 4098, p. 8. Available online: http://wiki.dorar-aliraq.net/iraqilaws/?p=21040 (accessed on 6 September 2018). (In Arabic)