Desertification and political onstability in the Tigris and Euphrates River Basins

Kanar Hamza
James Madison University

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Desertification and Political Instability in the Tigris and Euphrates River Basins

Kanar Hamza

A thesis submitted to the Graduate Faculty of

JAMES MADISON UNIVERSITY

In

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for the degree of

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Dedication

To Mom & Dad
Acknowledgement

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The Tigris and Euphrates river basin is located in arid and semi-arid regions of the Middle East. Five countries share this basin, with Turkey, Syria, and Iraq being the main nations concerned. The water resources of the basin are unable to meet the entire current and future water demands of all of these nations. Water scarcity in this basin is caused by one-sided, unilateral development projects and complicated by natural conditions, such as reduced annual rainfall. Shared freshwater resources are complicated matters that cause tensions between nations sharing river basins, especially in arid and semi-arid regions. The shared fresh water problem in the Tigris and Euphrates River Basins nations is further complicated since it exacerbates desertification and environmental instability in Iraq because of its downstream location. The problem of environmental instability in Iraq further complicates the shared fresh water problem because it raises current tensions among Iraq’s ethnic groups causing more conflicts over resources, which in turn threatens the regional security in the Tigris and Euphrates River Basins. To this day, these three nations do not have an agreement for sharing the water resources to ensure sustainable water management in the basin. This thesis provides: (1) insights on how to manage water resources in the Tigris and Euphrates basin to prevent regional conflicts between the nations sharing this fresh water resource, and (2) suggests water conservation methods targeted specifically to Iraq. These methods include rainwater harvesting, managing vegetative cover through forestry systems to slow desertification, and using available water resources as efficiently as possible, particularly in northern Iraq.
Chapter 1

Introduction

This thesis is about the causes, consequences and mitigation of desertification in the Tigris and Euphrates River basins in Iraq. The problem of desertification in Iraq is significant because it threatens the livelihood of the Iraqis, specifically in central and southern Iraq. The problem is further complicated as desertification will force people in south and central Iraq to move to the north of Iraq and the Kurdistan Region. The north of Iraq and specifically the Kurdistan Region is the richest region in Iraq by its ground and surface water resources in addition to fertile lands when compared with the other parts of Iraq. The north part of Iraq already suffers from ethnic problems as a result of different Iraqi regimes specifically Saddam’s administration policies, which brought Arabs from south and central Iraq to replace Kurds and other ethnic groups and changed demographics in the Kurdistan Region. Therefore, any further population movement from south toward north of Iraq, for whatever reason, will cause tensions among ethnic groups, Kurds and Arabs, in Iraq and it is strongly possible that this conflict will move to all of the Tigris and Euphrates River basins nations. The key recommendations in this thesis to prevent such conflicts are: (1) regional cooperation to identify a fair water management strategy to share the Tigris and Euphrates River in a way that would be accepted by downstream and upstream nations, and (2) the effective use of

Figure 1: Shows the Tigris and Euphrates River Basins (Encyclopedia 2008).
available resources in Iraq through implementing rainwater harvesting techniques and forestry systems to combat desertification, specifically north of Iraq.

Shared freshwater resources are complicated matters that cause tensions among/between nations sharing river basins, especially in arid and semi-arid regions. The Tigris and Euphrates River Basins are located in arid and semi-arid regions of the Middle East. Five countries share the Tigris and Euphrates Basins, with Turkey, Syria, and Iraq being the major nations concerned. The water resources of the Tigris and Euphrates Basin are unable to meet the entire current and future water demands for all of these nations. Water scarcity in this basin is caused by one-sided, unilateral development projects within nations in the basin, and is complicated by natural conditions, such as reduced annual rainfall. To this day, these three nations do not have a regional, multilateral agreement to share the water resources to ensure sustainable water management in the Tigris and Euphrates River basins (Kaya 1998) (table 1 – page 17).

The problem of fresh water availability in the Tigris and Euphrates River basins is complicated by climate change, population growth, and increasing demand for economic development in the region. Downstream water shortages in the Tigris and Euphrates River basins have the potential to be geopolitically destabilizing in the Turkey-Iraq-Iran-Syria region. Indeed, water shortage could be highly threatening and the root cause of future armed conflict among these nations. The major challenge to any regional solution is how to bring Turkey—because of its upstream position and military power—to negotiate water rights that are acceptable to its downstream neighbors. The Tigris and Euphrates Rivers have significant value to Iraq for potable water, irrigation, hydropower and environmental values. Iraq is the most vulnerable country regarding water shortage because of its downstream location. The water shortage in Iraq results in acceleration of land degradation and desertification, which in turn threatens the livelihood and food security of the Iraqis.
International Law and Transboundary Water Resources

This section addresses the terminology and state-level approach of each riparian nation about the legal case of the Tigris and Euphrates River. The reasons that each nation insists on its opinion of these two rivers legal case is identified. The Tigris and Euphrates River Basins case is analyzed regarding to the each riparian nation opinion and details is provided regarding the Tigris and Euphrates River case according to international fresh water treaties and guidelines.

The UN Convention on the Law of the Non-navigational Uses of International Watercourses 1997 (Article 2 – a) defined “Watercourse” as “a system of surface waters and groundwaters constituting by virtue of their physical relationship a unitary whole and normally flowing into a common terminus,” and (Article 2 – b) defined “International watercourse” as “a watercourse, parts of which are situated in different States.” The trans-boundary term is used by Turkish authorities. Turkey defines International Watercourses as a river that follows the political border between two countries or more while the watercourse that intersects the political border between the two countries or more considers trans-boundary river. Therefore each country has complete sovereignty to use a trans-boundary river until it leaves its border without taking into consideration the other riparian nations’ needs for water (Asmahel 2004). Therefore Turkey is using the Tigris and Euphrates River according to its statement that both of the rivers are Turkish rivers and ignores the UN Convention on the Law of the Non-navigational Uses of International Watercourses 1997 based on equitable and reasonable use of International watercourses.

The “Tigris and Euphrates Rivers as a single basin” approach is used by Turkey. Turkey stated that the Tigris and the Euphrates are two tributaries of the Shatt el Arab River. Therefore Turkey allows diverting water from the Tigris River to the Euphrates River and vice versa since they are tributaries of the same river, Shatt el Arab River. The reason behind Turkey’s insisting
on this approach is to divert water from the Tigris to the Euphrates because of the topographic condition of the Tigris basin in Turkey is not suitable for big agricultural projects and population densities is low unlike the Euphrates basin. Therefore by diverting water from the Tigris River to the Euphrates River Turkey can cover any water shortages in its projects on the Euphrates basin (Asmahel 2004).

The “Tigris and Euphrates Rivers as separate basins” approach is used by Iraq. Iraq stated that the Tigris and the Euphrates have separate basins and the fact that the Tigris and Euphrates meet at Shat Al Arab River do not make them a single basin as stated by Turkey. Therefore, Iraq stated that its share from the Tigris River is different from the Euphrates. In short, Iraq demands a separate agreement for the Euphrates River and the Tigris River (Asmahel 2004).

On one hand, according to topographic, hydrologic, meteorological, and geological characteristics, the Tigris and Euphrates are separate watersheds but Turkey has chosen to regard them as part of the greater Shatt al Arab basin in order to get more water from both rivers. On the other hand, since both the Tigris and Euphrates River are meets in south of Iraq and discharge their water on Shatt Al Arab River, technically Turkish approach is correct too.

To date, there is no a single enforceable international law dealing with the problems confronted in the Tigris-Euphrates Basins. Codifying international law regarding International Watercourses traces back to the beginning of the twentieth century and the most significant efforts started recently. The International Law Association’s (ILA) 1966 Helsinki Rules identified that the international drainage basin have to be shared equitably and reasonably. An international drainage basin as defined by the Helsinki Rules on the Uses of the Waters of International Rivers in 1966 is “a geographical area extending over two or more States determined by the watershed limits of the system of waters, including surface and underground
waters, flowing into a common terminus.” In 1970 the International Law Commission (ILC) was asked by the United Nations General Assembly to codify and develop a law regarding “non navigation use of international watercourses.” The ILC efforts resulted in the UN Watercourse Convention on the law of the Non-Navigational Uses of International Watercourses, opened for signature in 1997, and provided the same factors to identify fair management of international watercourses as Helsinki Rules which are reasonable and equitable use of international drainage basin (Kaya 1998). In 2004, the Helsinki Rules were replaced by Berlin Rules, according to Berlin Conference in 2004; “An “international drainage basin” is a drainage basin extending over two or more States.” Generally Berlin Rules identified that basin nations have the right to participate in the management of waters of an international drainage basin in an equitable, reasonable, and sustainable manner.

The reasonable and equitable depends on these factors: geography, hydrology, climate, past and present utilization, economic and social needs of the riparian nations, population, costs of alternative measures, other resources, practicability of compensation in instance of dispute, and how the needs of one riparian nation may be fulfilled without substantial injury to another riparian nation (Kaya 1998). With respect to the Tigris-Euphrates watersheds, the major challenges are: (1) the UN Watercourse Convention on the law of the Non-Navigational Uses of International Watercourses is not recognized by Turkey (Kent State University’s Research Center for Educational Technology 2008), and (2) Turkey does not consider the Tigris and the Euphrates to be International Watercourses.

According to the definition of International Watercourses that identified by the UN Watercourse Convention on the law of the Non-Navigational Uses of International Watercourses, both the Tigris and Euphrates Rivers should be considered International Watercourses and therefore the theory of equitable and reasonable use apply to both of them, but Turkey disputes this classification. Also, according to Helsinki and Berlin Rules both the Tigris and Euphrates
Rivers should be considered to be part of international drainage basins and the approach of equitable and reasonable applied to them. None of the mentioned laws and treaties are enforced international laws.

However, even by Turkey’s own definitions, both the Tigris and Euphrates are International watercourses. For example, Turkey defines International watercourses as a river that follows the borders of two or more countries. In this case the Tigris River is considered International River because it follows Turkey – Syria borders for about 50 km and Syria – Iraq borders for about 7 km. The same approach applied for both Khabour and Greater Zab (two of the Tigris River tributaries), because both of them follow 55 km and 50 km Iraq- Turkey borders respectively. Since Turkey considers both the Tigris and Euphrates a single river basin, then both of them are International watercourses (Asmahel 2004). Therefore, the reasons that Turkey is not accepting to share these two rivers with other riparian nations are: (1) It is in Turkey’s national self-interest to maintain total sovereign control over these rivers while they are within Turkish borders, (2) there is no enforceable international legal regime dealing with transboundary freshwater flows, and (3) Turkey is stronger than both Syria and Iraq regarding military, economic, and political power.

Nonetheless, even if the Tigris and Euphrates are recognized as International Watercourses by Turkey, problems will persist until the following questions are resolved: (1) how does each riparian nation defines equitable and reasonable uses and can they agree on these? (2) who will identify the economic and social needs of each riparian nation and according to what criteria? (3) if the social and economic needs are identified by riparian nations themselves, how reliable will this information be? (4) if International Organizations such as the UN identified the riparian nations’ social and economic needs, would the riparian nations accept the results? (5) who will identify and verify population data in each country? and (6) which populations will be
considered key to regulating access amounts -- only those who are living in the Tigris and Euphrates Basins or the overall population of each country?

The purpose of this thesis is to identify the causes, consequences, and mitigation of desertification in the Tigris and Euphrates River Basins in Iraq. The impact of desertification problems in Iraq on the other riparian nations is analyzed. This thesis provides insights to solve desertification issues in Iraq regionally, through proposing a regional cooperation among riparian nations regarding fair management of shared fresh water resources, and locally, through implementing rainwater harvesting techniques and forestry systems in order to use available resources in Iraq, specifically north of Iraq, as efficiently as possible. This thesis is organized as follows: (1) Salient physical, economic and social characteristic of the Tigris and Euphrates River Basins, (2) Iraq’s land characteristics, (3) Factors that lead to desertification, (4) The social, economic and political consequences of desertification on the Tigris and Euphrates River Basins Nations, (5) Managing the Tigris and Euphrates River water resources, (6) Strategies to combat desertification in Iraq and the Kurdistan Region, and (7) Conclusions.

Water Shortage

Identifying the average annual flow of the Tigris and Euphrates River is very hard because of the large yearly fluctuation. Records for from 1938 to 1980 show that there has been yearly flows of (Tigris – Euphrates together) of 68 km$^3$ and 84 km$^3$ recorded in the mid – 1960s and the mid – 1970s respectively. Also, there have been years during severe drought periods where the flow of both rivers were below 30 km$^3$. Therefore, it is difficult to have a constant adequate water allocation plan managing these two rivers in a way that ensures a fair share of water among riparian nations (FAO 2009). According to Congressional Research Service 2004, the Euphrates River has an average flow of 30 km$^3$ and the Tigris River a bit more than 21 km$^3$ (Congressional Research Service 2004). However, the estimated value varies depending on the
observation time. For instance, Asmael 2004 identified that the Tigris flow is about 48 km$^3$ and Beaumont 1997 estimated it about 51 km$^3$.

The water crisis in Iraq is getting worse over time; the 450 – 500 m$^3$/sec of water that released from the Euphrates River at the point where it enters Syria is not enough to help Iraqis who are struggling from the severe drought years. For instance in September 2009, 2000 people abounded their homes in a fishing village around Shatt el Arab river because the decline of Shatt el Arab River and steadily encroaching sea water toward Shatt el Arab, and in August 3000 people moved out (UPI 2009).

Upon completion of its dams early in the 21st century in Turkey, the storage capacity of these dams on the Euphrates River will be equal to 1.38 times the annual flow of the River. Turkey has less control of the Tigris River. In 1997, it was expected that the Turkey’s demand for irrigation water in the Euphrates Basin to be 10 km$^3$ (1 km$^3$ = 1,000,000,000 m$^3$) and the demand to be about 16 km$^3$ for Syria and Iraq together. However, the average annual flow of the Euphrates River has fallen below 20 km$^3$ on a few occasions. Therefore, the water deficit is about 6 km$^3$ in this case. The major concern is that Syria as its upstream neighbor, Turkey, started developing projects in the 1960s, therefore the mentioned rates of water use is just a beginning of a larger use of water through expanding irrigated lands (Beaumont 1998).

It is expected that Syria irrigates about 475,000 ha in early years of 21st century, which consumes about 4.75 km$^3$/year of water. Sources of Syrian government have suggested that the area of irrigated lands in the Euphrates basin in Syria may rise to 1,000,000 ha, which in turn increase water consumption to 10 km$^3$/year. Therefore, in the case of irrigating 475,000 ha of land in Syria, Iraq receives about 10 km$^3$/year form the Euphrates River. But in the case of 1,000,000 ha, Iraq only receive 5 km$^3$/year. Both case based on a flow of 500 m$^3$/sec that released from Turkey when the Euphrates enter Syria (Beaumont 1998).
In the case if both Turkey and Syria extracted the maximum amount of water for expected needs for irrigation, Iraq will only receive 5 km³/year from the Euphrates River while Iraq in the 1960s was receiving about 16,368 km³ and the demand is expected to be about 25 – 28 km³/year in a period after 2020. Generally, Beaumont 1997 based on estimation of three scholars regarding future needs of water in Syria, Turkey and Iraq in a period after 2020 estimates (taking into consideration water resources in both the Tigris and Euphrates River) the possibility of water defect of 2.233 km³ as minimum and 38.641 km³/year (greater than the Euphrates annual flow) as maximum depending on the areas of irrigated lands in each country (Beaumont 1998).
Chapter 2

Salient Physical, Social, and Economic Characteristics of the Tigris and Euphrates River Basins

This chapter focuses on analyzing: (1) the legal case of the Tigris and Euphrates River and providing the bilateral agreement between riparian nations, (2) the distribution of water resources in the Tigris and Euphrates Basins, (3) population growth in the basin nations, (4) annual precipitation and water balance in these basins, (5) Turkish economic exploitation of basin water resources, and (6) land degradation and desertification in Iraq.

The major concerns indicated in this chapter are the increased demand of fresh water and the situation complicated by climate change. Also, the fast growth of population size has significant impacts on managing the two rivers. The most important problem is, at least according to downstream nation views, the majority of water resources of the Tigris and specifically the Euphrates is originated in Turkey, which makes Turkey to have a control on any negotiations regarding water management in the Tigris and Euphrates River. In addition to unequal geographic distribution of the Tigris and Euphrates water resources problems, each riparian nation insists on its inflexible opinion regarding managing the Tigris and Euphrates River.
The legal case of the Tigris and Euphrates River basins has changed from Internal (National) River to International River after dissolving of the Ottoman Empire by the end of the World War I. The Tigris and Euphrates River Basins is now divided between the relatively newly created nations of Turkey (1923), Iraq (1921), Syria (1946), and Saudi Arabia (1932), in addition to Iran. Therefore, the legal case changed from internal (national) river to International River because they pass through different nations (Asmahel 2004) (Figure 2).

Multinational efforts to manage water resources regarding water quantity, infrastructure development, and technical cooperation began in the 1920s in the Tigris and Euphrates River Basins (Table 1 – page 17).

The following table shows the treaties and agreements between the riparian nations regarding management of Tigris and Euphrates water resources. The importance of the treaties and agreements that are listed in table 1 are highlighting the major concerns in the Tigris and Euphrates River basins between/among basins nations as following (Oregon State University 2007):
1- **Franco - Britain Convention on certain points connected with Syria, the Lebanon, Palestine and Mesopotamia (1920):** The objective of this agreement was establishing a commission to observe and to examine the impact of the irrigation plan in the French controlled region on water flow to the British controlled region of Mesopotamia.

2- **Iraq and Turkey Treaty of friendship and neighborly relationships (1946):** The following were the main objective of this treaty: each country respect the drawn border between them according to 1926 agreement, each country has to observe a policy of absolute non – intervention to the other country domestic affairs, peaceful solution for any disputes between them and refer to UN in case of any disputes, each country support the other one regarding to international affairs especially those having regional character affecting themselves in the United Nations, cooperation regarding water management in Turkey and exchanging information, cooperation regarding security issue, cooperation regarding educational institutional and cultural matter, cooperation regarding establishing postal, telegraphic and telephonic communication between each other, cooperation regarding economic development, and cooperation to ensure the security in frontier area between the two countries,

3- **Treaty concerning the state frontier and neighborly relations between Iran and Iraq and protocol (1975):** The major objective of this treaty were border and water pollution issues mainly demarcation of rivers, specifically Shut el Arab River.

4- **Agreement between Iraq and Iran concerning the use of frontier watercourse (1975):** The major objectives of this agreement were agreeing on dividing water quantity of the watercourses that follow the frontier line between the two countries and successive watercourses which intersect the frontier line between the two countries in a way satisfy both sides with secondary discussion about border issue.

5- **Law No.14 of 1990 between Iraq and Syria, ratifying the Joint Minutes concerning the provisional division of the waters of the Euphrates River:** The major objectives of
this law were dividing a fixed annual total percentage (water year) of the water of Euphrates River allowed to pass in Syria through the border with Turkey between Iraq, 58%, and Syria, 42%, and establishing joint committee to implement this agreement.

6- **Minutes between Syria and Turkey on cooperation in fighting terrorism, signed at Adana, including Annex 2 (1998):** Agreement between Syria and Turkey to combat Kurdistan labor Party (PKK). Syria will stop supporting PKK in order to normalize its relation with Turkey and prevent armed conflicts between them.

7- **Joint communiqué between Republic of Turkey Prime Ministry Southeastern Anatolia Project Regional Development Administration (GAP) and Arab Republic of Syria Ministry of Irrigation General Organization for Land Development (GOLD) (2001):** The purpose of this agreement was technical cooperation between Turkey’s Southeastern Anatolia Project Regional Development Administration (GAP) and Syria’s General Organization for Land Development (GOLD) regarding training programs, joint projects, and exchange programs.

The problem is the majority of these agreements have never been implemented on the ground. The main evidences for that are frequent changes in the Euphrates River water flow, 30 days shut off of flow in the 1990s during filling of Ataturk dam in Turkey, while according to Protocol on matters pertaining to economic cooperation between Syrian Arab Republic and Turkey, signed at Damascus on 17 July 1987 mentioned that Turkey is responsible to release 500 m$^3$/sec of water at the point where Euphrates enter Syria. Iraq – Iran war as a result of border disputes is another example of failure to implement agreements on the ground, even though Iraq and Iran had an agreement, treaty concerning the state frontier and neighborly relations between Iran and Iraq and protocol in 1975, regarding border issue, specifically in Shut el Arab River area, but they went through 8 years war.
The major problem is that the three concerned riparian nations (Syria, Turkey and Iraq) do not have an agreement or treaty together; they only have bilateral treaties and agreements, refer to table 1 (page 17). Also, the 1987 protocol that appointed responsibility to Turkey to release 500 m$^3$/sec of water at the point where Euphrates enters Syria was signed between Syria and Turkey without taking into consideration Iraq, which is another riparian nation located downstream. Therefore, Syria has a separate agreement to share the Euphrates River with Iraq, Law No.14 of 1990 between Iraq and Syria, ratifying the Joint Minutes concerning the provisional division of the waters of the Euphrates River. Since there are two separate agreements to manage the Euphrates River, Turkey – Syria and Syria – Iraq, between the riparian nations, it means that Iraq is not required to respect the Turkey – Syria agreement nor is Turkey required to respect the Syria – Iraq agreement. On one hand, Iraq is demanding 700 m$^3$/sec (Aaron T. Wolf 2007) of water to enter Syria from the point where Euphrates enters Syria’s borders and Iraq said that it is not a part of the 1987 protocol and therefore Iraq did not agree on 500 m$^3$/sec. On the other hand, any disruption of 500 m$^3$/sec of the Syria – Turkey agreement will automatically change the quantity of water that Iraq receives, which creates problems between Iraq and Syria. Therefore, any treaty and agreement in order to be valid must be based on tripartite agreement.

The legal and ownership issues of the Tigris and Euphrates Rivers are very complicated. Iraq and Syria consider the Tigris and Euphrates Rivers as international Watercourses. Therefore, both Iraq and Syria request a fair share from the Tigris and Euphrates water resources. Turkey does not consider the Tigris and Euphrates Rivers to be international rivers, instead Turkey calls them transboundary rivers, which means each one is a Turkish river until it leaves Turkey’s borders. Several formal letters were sent to both Syria’s and Iraq’s government from Turkey’s government stating that Turkey will not agree to share Turkish water resources with Iraq and Syria. Suleyman Demirel (President of Turkey) at the 1992 dedication of the Ataturk Dam:
Neither Syria nor Iraq can lay claim to Turkey’s rivers any more than Ankara could claim their oil... The water resources are Turkey’s, the oil resources are theirs. We don’t say we share their oil resources, and they can’t say they share our water resources (Kent State University’s Research Center for Educational Technology 2008).

One of the Turkish government men, Kamaran Inan, said, “If Syria and Iraq are requesting a share of Turkish water, then Turkey has a right to request a share of their petroleum.” Turkey always mentioned through its leaders that it is ready to negotiate the use of water in a way that all of the riparian nations receive benefits from available water resources, but Turkey reserves the right to withdraw water for its domestic needs as internal demand dictates. In effect, then Turkey will use as much water as it needs without taking in consideration the downstream nations water demands (Asmahel 2004) (Ünal Öziş, Yalçın Özdemir 2009).

Turkey’s authorities are not motivated to sign a specific agreement about water resource management with the downstream nations. But Turkish authorities are more interested in a multi-purpose agreement related to the security situation, economic cooperation, and energy with the Syria and Iraq. In addition to redrawing a political border with Syria, the security and economic issue are the major concerns of Turkey. For example, according to Iraq news paper, Alsabaah, Turkey is trying to get subsidies oil from Iraq in exchange for water (Mhna 2006). For security case, in 1978, Syria supported the Kurds who are living in Turkey to establish an armed party, Kurdistan Labor Party (PKK), in order to use them against Turkey and force Turkey to provide Syria a fair share of the Euphrates River. Therefore, security is Turkey’s priority for any agreements with Syria or Iraq (Asmahel 2004). In 1999, Syria’s government stopped supporting

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1 Kurdish/Turkish politician, member of Turkish parliament at various times, Turkish UN Ambassador at various time, permanent UN representative, Minister of Energy and Natural Resources and Minister of state.

2 The majority of the GAP region and the Tigris and Euphrates River Basin in Turkey are populated by Kurds.
Kurdistan Labor Party as a result of Turkey’s threatens to declare war against Syria if Syria did not stop supporting PKK, see Minutes between Syria and Turkey on cooperation in fighting terrorism, signed at Adana, including Annex 2 (1998) above. After PKK rebels were forced to leave Syria in 1999, to date the PKK rebels are located in northern Iraq, which has created a significant obstacle for any efforts for water management agreements between Iraq and Turkey. Because of PKK rebels attacking Turkish army between time and time, therefore Turkey stated that it will not cooperate with Iraq regarding water issue unless Iraq take actions against existing PKK members in its Land. But Iraq cannot take any actions against PKK because: (1) PKK rebels settled in the mountainous region which is very hard to take military actions against them, and (2) The areas that the PKK rebels settled in are dominated by Iraqi – Kurds and Kurds, generally, are strongly supporting PKK. In 2009, Syria and Turkey assigned a strategic agreement including 30 sectors, one of which focused on the fresh water issue which finished decades of tensions between these two neighbors (Aljazeera A 2009).
Table 1: Shows the treaties and agreements between Tigris and Euphrates riparian nations (Oregon State University 2007).

<table>
<thead>
<tr>
<th>Name</th>
<th>Parties</th>
<th>Principal Issue area</th>
<th>Treaty Basin</th>
<th>TFDD Basin</th>
<th>Date</th>
<th>Signatories</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minutes between Syria and Turkey on cooperation in fighting terrorism, signed at Adana, including Annex 2</td>
<td>Bilateral</td>
<td>Water Quantity</td>
<td>Not specified</td>
<td>Tigris-Euphrates-Shatt al Arab</td>
<td>October 20, 1998</td>
<td>Syria Turkey</td>
<td><a href="http://ocid.nacse.org/tfdd/treaties.php">http://ocid.nacse.org/tfdd/treaties.php</a></td>
</tr>
<tr>
<td>Joint comminique between Republic of Turkey Prime Ministry Southeastern Anatolia Project Regional Development Administration (GAP) and Arab Republic of Syria Ministry of Irrigation General Organization for Land Development (GOLD)</td>
<td>Bilateral</td>
<td>Technical Cooperation/Assistance</td>
<td>Frontier or shared waters</td>
<td>Tigris-Euphrates-Shatt al Arab</td>
<td>August 23, 2001</td>
<td>Syria Turkey</td>
<td><a href="http://ocid.nacse.org/tfdd/treaties.php">http://ocid.nacse.org/tfdd/treaties.php</a></td>
</tr>
</tbody>
</table>
Political Jurisdictions and Water Resources

There are four riparian nations sharing these two rivers: Turkey, Syria, Iraq, and Iran. Saudi Arabia contributes only episodically to the Euphrates River Basin. Iran does not contribute to the Euphrates River, but serves as headwaters for tributaries of the Tigris River, and a large tributary of the Shatt el Arab waterway, outside the scope of this study. The Tigris and Euphrates Rivers are very close to each other, though they have separate watersheds (Asmahel 2004).

The Tigris River basin is within the boundaries of Turkey, Iraq, Iran, and Syria. The area of the Tigris River Basin in each of the riparian countries is the following: 185,550 km$^2$ in Iraq, 57,614 km$^2$ in Turkey, 45,000 km$^2$ in Iran, and 836 km$^2$ in Syria. The overall area of the Tigris river basin is 289,000 km$^2$, which it means that Iraq controls 64.2%, Turkey 20%, Iran 15.75%, and Syria 0.3% of the Tigris River Basin. But this area does not reflect the amount of water that each of these countries contributes to the Tigris River. The area of feeding basin$^3$ is different than the area of virtual basin$^4$. Although only 19.93% of the River basin is within Turkey’s boundary, the region provides 54.62% of the Tigris River’s water. Iraq contains 64.2% of the Tigris River Basin, but Iraq only contributes 33.45% of the Tigris River’s water. Iran’s 15.57% of the Tigris River Basin supplies 11.78% of the Tigris River’s water. Meanwhile, Syria claims only 0.3% of the Tigris River Basin and makes no significant contribution to the water that flows in the Tigris River water (Asmahel 2004).

---

$^3$ A feeding basin is the geographic location that supplies the river with its water. For example, the areas within the basin boundaries that have rainfall and/or snowfall and/or ground water that are contribute to the river water.

$^4$ A virtual basin is a geographic location within the river basin but does not directly feed the river with water.
Table 2: Shows the Tigris River Basin information in each of the riparian nations (Asmahel 2004).

<table>
<thead>
<tr>
<th>Country</th>
<th>% Area (km$^2$) of the River Basin</th>
<th>% Contribution to the River water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iraq</td>
<td>64.2</td>
<td>33.45</td>
</tr>
<tr>
<td>Turkey</td>
<td>20</td>
<td>54.62</td>
</tr>
<tr>
<td>Iran</td>
<td>15.75</td>
<td>11.78</td>
</tr>
<tr>
<td>Syria</td>
<td>0.3</td>
<td>0.15</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

The main characteristic of the Tigris River is the geographic distribution of its tributaries and water resources. In addition to the tributaries that enter in Turkey, there are four more tributaries in Iraq and Iran that feed Tigris by water: Great Zab, Lesser Zab, Adhaim and Diyala feed the Tigris in the middle portion of its course. It is difficult to control flow of the Tigris from a single country because it requires a lot of dams in order to control output because of the topographic characteristics of its basin is not as suitable as the Euphrates Basin for building dams and geographic variety of the Tigris water resources (Beaumont 1998).

The Euphrates River Basin is within the boundary of Turkey, Syria, Iraq, and Saudi Arabia. The Euphrates River Basin is bigger than the Tigris River basin by 35%. The overall area of the Euphrates River Basin is 444,000 km$^2$. The following are the Euphrates basin areas in each of the riparian countries: 177,000 km$^2$ in Iraq, which is 40% of the Basin area; 125,000 km$^2$ in Turkey, or 28% of the Basin area; 76,000 km$^2$ in Syria accounting for 17% of the Basin area; and 66,000 km$^2$ in Saudi Arabia, or 15% of the Basin area. The mentioned area represent the virtual area of Euphrates River Basin, while the actual area of Euphrates feeding basin is about 110,000 km$^2$ which represents 25.2% of the overall Euphrates River Basin area, mostly located in Turkey and Syria (Asmahel 2004).
Table 3: Shows the Euphrates River Basin information in each of the riparian nations (Asmahel 2004).

<table>
<thead>
<tr>
<th>Country</th>
<th>% Area of the River Basin</th>
<th>% Contribution to the River water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turkey</td>
<td>28</td>
<td>98%</td>
</tr>
<tr>
<td>Syria</td>
<td>17</td>
<td>2%</td>
</tr>
<tr>
<td>Iraq</td>
<td>40</td>
<td>No significant contribution</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>15</td>
<td>No significant contribution</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

The geography of tributaries and water resources of the Euphrates River Basin is unlike the Tigris River Basin. 54.8% of the Euphrates River Basin is within Iraq and Saudi Arabia’s boundary, but neither of them contribute to the Euphrates River water because almost all of the actual area of the Euphrates feeding basin is within Turkey and Syria’s boundaries: 98% and 2% respectively (Asmahel 2004). The concentration of the water resources of the Euphrates River Basin in Turkey means that any single dam will have a significant impact on the proportion of water released toward downstream countries (Beaumont 1998).

**Population Pressures Within the Basins**

According to the United Nations estimates, the overall population in the Tigris and Euphrates River basins nations in 2050 will be 295.3 million. While in 2010 the overall population is 204.8 million. The rate of growth from 2010 to 2050 is about 44.2%. With this fast growing population, it is normal that people will move where the resources are available. In case of Turkey, according to Asmahel 2004, the Tigris and Euphrates River Basins are the richest regions in Turkey by its water resources. Therefore, the possibility of implementing more effective strategies to meet the population demands of water is very high. The same approach is applied for both Syria and Iran and therefore Iraq as a downstream nation will be severely damaged for two reasons: (1) growth of its population will stimulate demand for more water, and
(2) Turkey, Syria, and Iran population growth will lead to further decline of released water from the watercourses that originated in these countries toward Iraq.

According to United Nations’ estimates of population size and density, each of the Tigris and Euphrates riparian nations is experiencing population growth. Iraq will experience a dramatic population growth in the next forty years (figure 3), from 31,467,000 in 2010 to 63,995,000 in 2050. A 100% of the Iraqi populations are living in the Tigris and Euphrates River Basin (see figure 7 – page 23). Therefore, the Tigris and Euphrates River have a critical influence on Iraqis’ livelihoods and their futures. The Tigris and Euphrates River in Iraq is estimated to irrigate about 4,900,000 hectares of land (Asmahel 2004).

Table 4: Shows the population growth from 2010 to 2050 in each of the Tigris and Euphrates riparian nations (UN 2008).

<table>
<thead>
<tr>
<th>Year</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
<th>2040</th>
<th>2045</th>
<th>2050</th>
<th>Net Change from 2010 to 2050 (Thousand)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Population of Iraq (Thousand)</td>
<td>31467</td>
<td>35884</td>
<td>40228</td>
<td>44692</td>
<td>48909</td>
<td>53017</td>
<td>56926</td>
<td>60595</td>
<td>63995</td>
<td>32528</td>
</tr>
<tr>
<td>Population Density/km² (Iraq)</td>
<td>72</td>
<td>82</td>
<td>92</td>
<td>102</td>
<td>112</td>
<td>121</td>
<td>130</td>
<td>138</td>
<td>146</td>
<td></td>
</tr>
<tr>
<td>Total Population of Syria (Thousand)</td>
<td>22505</td>
<td>24494</td>
<td>26475</td>
<td>28592</td>
<td>30560</td>
<td>32418</td>
<td>34111</td>
<td>35628</td>
<td>36911</td>
<td>14406</td>
</tr>
<tr>
<td>Population Density/km² (Syria)</td>
<td>122</td>
<td>132</td>
<td>143</td>
<td>154</td>
<td>165</td>
<td>175</td>
<td>184</td>
<td>192</td>
<td>199</td>
<td></td>
</tr>
<tr>
<td>Total Population of Turkey (Thousand)</td>
<td>75705</td>
<td>79966</td>
<td>83873</td>
<td>87364</td>
<td>90375</td>
<td>92917</td>
<td>94939</td>
<td>96434</td>
<td>97389</td>
<td>21684</td>
</tr>
<tr>
<td>Population Density/km² (Turkey)</td>
<td>97</td>
<td>102</td>
<td>107</td>
<td>111</td>
<td>115</td>
<td>119</td>
<td>121</td>
<td>123</td>
<td>124</td>
<td></td>
</tr>
<tr>
<td>Total Population of Iran (Thousand)</td>
<td>75078</td>
<td>79454</td>
<td>83740</td>
<td>87134</td>
<td>89936</td>
<td>92441</td>
<td>94622</td>
<td>96209</td>
<td>96975</td>
<td>21897</td>
</tr>
<tr>
<td>Population Density/km² (Iran)</td>
<td>46</td>
<td>48</td>
<td>51</td>
<td>53</td>
<td>55</td>
<td>56</td>
<td>57</td>
<td>58</td>
<td>59</td>
<td></td>
</tr>
</tbody>
</table>
As in Iraq, there will be a significant increase in Syria’s population size over the next 40 years (figure 4); net change of population in Syria from 2010 to 2050 is 14,406,000. The Euphrates River is one of the major resources that support Syria’s economy. The Euphrates River has a significant value for Syria because considerable portion of Syria’s populations are living in this River Basin (See figure 6 – page 23) and it is estimated to irrigate 760500 hectares of land (University of California 2006).

The population growth rate in Turkey is shown in figure 5. As shown in the figure, the growth rate is slower than the growth rate in Iraq and Syria. But by 2050, Turkey’s population
will almost reach a hundred million. Even if a small portion of Turkey’s populations are living in these River Basins (Figure 7), the overall population increase will lead to more significant water management issues. It is estimated that Turkey is planning to use the Tigris and Euphrates water resources to irrigate 1,700,000 hectares of land in Anatolian drylands (Asmahel 2004).

Iran’s population in the next half century will increase to almost a hundred million, as shown in figure 6. Iran is experiencing the slowest growth rate in the region. Iran does not contribute to the Euphrates River basin. But, there are a few big and small tributaries within Iranian borders that contribute to the Tigris River. A significant portion of Iranian populations

Figure 7: Show the population densities in the Tigris and Euphrates River basins in each riparian nation (UNDP 2008).
are living in the Tigris River basin (Figure 7). Therefore, these water resources are significant regarding supporting the livelihood of Iranian and it is estimated to irrigate 93900 hectares of land (University of California 2006).

**Annual Precipitation, Water Balance, and Expected Climate Change**

Generally, the water balance in the Tigris and Euphrates River basins is negative, -1150 - -1000 mm in the southern regions of the basins and gradually increase to 1 – 150 mm in the top northern region in the basins. Generally, over 95% of the basins area has a negative water balance. The annual evapotranspiration decreases gradually from the northern region of the basins, 401 – 716 mm, toward the southern region, 1 – 120 mm (UNDP 2008).

Annual precipitation rates for the basin areas include both rainfall and snowfall. Generally, the rain precipitation occurs in most of the Tigris and Euphrates River basins but the amount varies from very low in southern regions and increasing toward northern regions. The average rain precipitation rate in Turkey is 700mm in the Euphrates Basin and 850mm in the Tigris basin. In Syria, the average rain precipitation rate is 100 – 200 mm in the southern region of the Euphrates basin, 200 – 300 mm in the northern region, and 400 – 600 mm in a small portion in the top northeastern region. In Iraq, the average rain precipitation is 815 mm in the mountainous region of northeast of Iraq, 315 mm in the semi mountainous region, located below mountainous region, and 145 mm in the sedimentary plain, located in the middle and south of Iraq in between the Tigris and Euphrates rivers, and 100 mm or less in the southwestern portions of Iraq and northeastern areas of Saudi Arabia. In Iran, the rainfall rate decreases from north toward southern region of the Tigris basin (Figure 8) (Asmahel 2004).

Snowfall and subsequent snow melt is one of the major sources that feed both the Tigris and Euphrates Rivers. Snowfall distribution differs from the rain precipitation distribution. Almost all of the snow precipitation that feeds the Euphrates River comes from the basin area in
Turkey. Snowmelt contributes 48% of the Euphrates River’s annual water resources. The snowmelt contributes 28.8% of the Tigris River’s annual water resources mostly located in the basin in Turkey and the mountainous region in the north and northeastern Iraq, and northwestern Iran. The rest of the Tigris and Euphrates River Basins area does not have any significant snow precipitation (Asmahel 2004).

The groundwater resources in the northern part of the Tigris and Euphrates River Basins contribute significantly to both Tigris and Euphrates River annual water resources. Specifically during the summer season when precipitation rates are very small these groundwater sources keep the rivers flowing. Groundwater contributes an average of 35.7% to the Euphrates River annually.
and 22.7% to the Tigris River. The groundwater contribution varies according to the season. For example, during drought years the groundwater contribution is higher and vice versa (Asmahel 2004).

According to the Tigris and Euphrates Basins’ population density map in figure 7 (page 23) and the annual precipitation map in figure 8, the Tigris and Euphrates Rivers have significant economic, environmental, and social impacts on all of the riparian nations. But the impacts on Iraq are much greater than the other riparian nations because the majority of the Iraqis depend on the water of these two rivers and their tributaries (Figure 7). The greatest direct impact of the water shortage issues will be felt in south Iraq because of the dependency on irrigation for agricultural purposes, about 8,000,000 out of 12,000,000 hectares of Iraqi arable lands depends on these two rivers, specifically in south Iraq (Asmahel 2004), and higher dependence on the Euphrates River, the source of which is completely under the control of Turkey. The situation in north Iraq and the Kurdistan Region is different, because they depend on rain for agricultural purposes and depend on the Tigris River which is partially within the boundary of Iraq and not controlled completely by another nation like the Euphrates River (see Figure 9). The northern part of Iraq and the Kurdistan Region will be impacted indirectly as a result of environmental changes and water shortage in southern Iraq and immigration from the damaged regions in the southern regions of Iraq.

Figure 9: Shows the Iraqi agricultural land (USDA 2008).
The United Nations Development Program (UNDP) mentioned that Iraq has passed through frequent and severe drought seasons for the past three years and has experienced a decline of rainfall over the past 5 to 10 years. Precipitation reached only 25 to 65 percent of normal levels as a result of global climate changes (UNDP 2009) and natural factors such as El Nino/La Nina cycles off the Pacific coast of South America.

According to the Intergovernmental Panel on Climate Change (IPCC) report, in the middle of the twenty-first century, the Mediterranean basin will suffer a decrease of water resources as a result of global climate change.

The effect of climate change on streamflow and groundwater recharge varies regionally and between climate scenarios, largely following projected changes in precipitation. A consistent projection across most climate change scenarios is for increases in annual mean streamflow in high latitudes and Southeast Asia, and decreases in central Asia, the area around the Mediterranean, southern Africa, and Australia (IPCC 2003).

The Tigris and Euphrates Rivers are located in the same latitude as the Mediterranean Basin; therefore it will experience water shortage that will complicate the relationships between the riparian nations (Kucukmehmetoglu 2009). Almost all of the Middle Eastern Countries are struggling from the shortage of fresh water availability. The Middle Eastern Countries including the Tigris and Euphrates Riparian Nations are among the most stressed areas in the world regarding fresh water availability according to different scenarios of climate change. The following is the fresh water availability per capita (m$^3$/capita) in Turkey and Syria: In 1955 fresh water availability in m$^3$/capita in Syria and Turkey was 6,501 and 8,508 m$^3$/capita, respectively. These values were changed to 2,089 and 3,619 m$^3$/capita in 1990, and the estimated values for 2025 and 2050 are 770 and 2,232 m$^3$/capita and 546 and 1,910 m$^3$/capita, respectively (K. Haktanir 2002).
Obviously, the land degradation and water scarcity status in both Syria and Turkey is damaging Iraq and the situation will get worse over time. As much as 92% of Iraq’s cultivated land is subject to desertification and 71% of irrigated lands are already desertified (K. Haktanir 2002). Specific data about scenarios of climate change in Iraq are not available, but according to the United Nation Development Program (2009), Iraq is already impacted by climate changes due to frequent prolong drought years.

The data about scenarios of climate change in Turkey can be used to predict these changes in Iraq. Also, these data about Turkey are important because most of the sources of Iraqi water are located in Turkey. The impacts of climate change in Turkey on temperature, precipitation, runoff, crop yield, and water stress are predicted according to scenarios of climate change, numerical data’s is provided in table 5.

Table 5: Shows the impacts of climate change on Turkey’s natural resources (K. Haktanir 2002).

<table>
<thead>
<tr>
<th>Element</th>
<th>Changes with unmitigated emission scenario</th>
<th>Changes with stabilizing Co₂ concentration at 750 ppm</th>
<th>Changes with stabilizing Co₂ concentration at 550 ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Projected Temperature Change</strong></td>
<td>3-4 °C increase in the annual average temperature of Turkey from the present day (average of the period 1961-1990) to the 2080s</td>
<td>2-3 °C increase in the annual average temperature by the 2080s</td>
<td>-3 °C increase in the annual average temperature by the 2080s</td>
</tr>
<tr>
<td><strong>Projected Precipitation Change</strong></td>
<td>0 to -1 mm/day change in the annual average precipitation by the 2080s</td>
<td>0 to -0.5 mm/day change in the annual average precipitation by the 2080s</td>
<td>0 to -0.5 mm/day change in the annual average precipitation by the 2080s</td>
</tr>
<tr>
<td><strong>Projected Vegetation Biomass Change</strong></td>
<td>No considerable change in the vegetation biomass (kg/m²) by the 2080s in response to climate change</td>
<td>No considerable change in the vegetation biomass (kg/m²) by the 2080s in response to climate change</td>
<td>No considerable change in the vegetation biomass (kg/m²) by the 2080s in response to climate change</td>
</tr>
<tr>
<td><strong>Projected % change in annual runoff by major river basins relative to 1961-1990</strong></td>
<td>20 to 50% decrease in annual runoff by the 2080s</td>
<td>5% to 25% decrease in the annual runoff by the 2080s</td>
<td>5% to 25% decrease in the annual runoff by the 2080s</td>
</tr>
<tr>
<td><strong>Projected % change in crop yield</strong></td>
<td>0 to 2.5% change (a decrease) in the crop yield</td>
<td>0 to 2.5% change (a decrease) in the crop yield</td>
<td>0 to 2.5% change (a decrease) in the crop yield</td>
</tr>
</tbody>
</table>
Iraq will be impacted by climate changes and with greater consequences than Turkey because of two reasons. First, direct impacts of climate change in Iraq on temperature, precipitation, vegetation cover change, annual runoff, crop yield production, and other numeric data are not available about Iraq can be predicted from table 5 because Iraq and Turkey are located in the same region. Second, these changes (table 5) will prompt Turkey to intensify the use of the Tigris and Euphrates Rivers’ already scarce water resources, which results in decreased water availability in Iraq.

**Land Degradation and Desertification in Iraq**

Land degradation and desertification is not a recent phenomenon in Iraq. Since ancient history, the southern plains in Iraq experienced soil salinity as a result of irrigation and desert expansion. The northern part of Iraq specifically the Kurdistan Region was totally covered by forest once, but the region is experiencing deforestation. The appearance of several civilizations and subsequent rapid population growth in Iraq caused depletion of Iraq’s natural forests during the middle ages. During the eras of the Assyrian, Babylonian, Abbasi, and Umayyad empires, the northern Iraq forests were damaged severely. Timbers harvested from the forests were used to build huge palaces for Kings and sultans and thousands of army vehicles especially during Assyrian and Babylonian era. During the Islamic conquests, vast areas of Iraqi forests were harvested to provide Islamic armies wood for cooking and heating purposes (Hussien Kariem, Abdulmahdi Jbr 2008).

In 1492, the Ottoman Empire practiced a mass harvesting of the existing forests in order to build the warships as a result of the wars that the empire were involved in and to build merchant fleets. The remaining forests in northern Iraq were damaged severely by unsustainable harvesting by individuals because the regional authorities were too weak to enforce laws until

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5 100% of Iraq’s remaining forests are located in the northern part of the country.
1734 when the first legislation stated by the Ottoman authorities. More legislation and actions had been taken in order to improve the forests during the Ottoman Empire because of the Empire were done with its wars in European side of the Empire and it started controlling its territory again. In 1900 the law of reforestation was enacted, and in 1913 the forestry police department was established. But a few years later, when the Ottoman Empire was defeated in World War I, the Iraqi region was controlled by British and French armies. Therefore, the forests were damaged as a result of unsustainable harvesting by individuals because there were not strong regional authorities to enforce laws until 1936 when the Department of Forestry was established as a part of the agricultural ministry. In 1957 the Iraqi forestry police department was established (Hussien Kariem, Abdulmahdi Jbr 2008).

The previous damage to Iraqi forests was significant. The majority of Iraqi forests were depleted as a result of the human actions through the previous centuries. To date, the situation in the forest areas is very critical. From the mid-1930s up to 1991, the very small remaining forest areas in the mountains were the main battlefields between Kurds and Iraqi governments because Kurds were refused to be a part of Iraq and demanded autonomous region in Iraq or an independent nation of Kurdistan. From 1994 to 1998, the forested areas were the battlefield of the Kurds civil war between Kurdistan Democratic Party and Patriotic Union of Kurdistan in order to control power in the autonomous region of Kurdistan after Saddam was defeated in the First Gulf War. In recent days, the northern region of Iraq, where most of the remaining Iraqi forests are located is bombarded frequently by Turkey’s and Iran’s armies because the Kurdistan Labor Party (PKK) Guerillas are sheltering there. As a result of these actions, the mountainous and hilly regions in northern Iraq are severely damaged by erosion and forest fires as a result of military actions, having lost their ability to regenerate naturally especially in the regions that are close to the Iraqi drylands where the precipitation rate is low.
The continuing drought that is affecting Middle Eastern countries, as well as the water scarcity in the southern part of Iraq resulting from the impeded flow of the Tigris and Euphrates Rivers due to upstream countries, complicates the availability of arable land and environmental condition in the northern part of Iraq. The green covers in southern Iraq have significantly decreased, especially with the palm farms and marshlands. Therefore, the desert expansion process has accelerated and moves toward the northern part of the country. Recent dust storms further demonstrate this acceleration, as they have affected the region in a manner that never happened in the past. Figures 9 and 10 show the characteristics of land use in whole Iraq and the northern part of Iraq (Kurdistan Region) respectively.

![Land Use Map](F:\iraqfig1.gif)

**Figure 10:** Shows the Iraq’s Land Use map. Source: (Global Security 2010)

![Land Use Pie Chart](F:\iraqfig1.gif)

**Figure 11:** Shows the North Iraq’s (Kurdistan Region) Land Use (F:\iraqfig1.gif)
**Turkish Economic Exploitation of Basin Water Resources**

The Tigris and Euphrates Rivers have significant economic value for the riparian nations because of the high dependency on these two rivers for irrigation, hydropower plants and the population density in these two river basins. In case of Iraq the value of these two rivers are extremely significant, without these two rivers almost all of the central and southern Iraq are not suitable for living. As a result of population growth and water scarcity the riparian nations developed different strategies in order to meet their population demands regarding power and food. Turkey’s exploitation of the Tigris and Euphrates is of special concern because of its upstream control of these rivers (Kucukmehmetoglu 2009).

Since 1970 Turkish authorities started to develop the southeastern Anatolian region where the Tigris & Euphrates Basins are located. The need to increase agricultural lands and provide energy for expanding urban areas in the last fifteen years has led to increasing the number of dams and reservoirs through the Southeastern Anatolia project (GAP). Regional concern started when Turkish authorities began implementing the GAP project for two reasons: (1) intensified water use in the upstream parts of the basin, and (2) the majority of precipitation that feed both the Tigris and Euphrates Rivers fall in Turkey.

GAP is one of the biggest regional and world projects located in southeastern Turkey. This is a multi-sector project including: agriculture, industry, transportation, telecommunication, education, urban and rural infrastructure, housing, tourism and environment. The purpose of GAP is to develop the overall economy in the GAP region and the rest of Turkey. The GAP project includes thirteen regional projects; seven of them in the Euphrates River Basin and six in the Tigris River Basin. The main component of these projects is dams. The overall numbers of dams and hydropower plants that are completed, under construction, and planned are 22 dams and 19 hydro power plants, in addition to expanding agricultural or irrigated areas in both of the
Tigris and Euphrates Basins. The GAP project area is 75,358 Sq. km, which is 9.63% of Turkey’s area, bigger than the area of Holland and Belgium together (Balat 2003) (Asmahel 2004).

The main outputs of the GAP project are increasing the irrigated agricultural area to about 1.7 million hectares in Anatolia dry lands, producing more than 7.5 GW of electric power, and storing 128 billion m$^3$ of water in reservoirs. The agricultural purpose is the major objective of this project. Turkey wants this project to:

1- Stop immigration from rural areas to urban areas.
2- Improve the people’s income in the region.
3- Increase employment opportunities in both agricultural fields and agro industries.
4- Make Anatolia flat land a food basket for all of the Middle Eastern and former Soviet Union nations.
5- Develop attractive socio-economic conditions in the GAP region and in the rest of the country.

But the agricultural development efforts lead to some negative impacts on environmental conditions in the GAP region regarding the loss of some native species and losses of biodiversity through implementing monoculture systems (Balat 2003) (Asmahel 2004).

The reasons that forced Turkey, recently, to put more efforts to manage its water resources is the increase of grain (wheat and barley) prices as a result of drought seasons that damaged different regions in the world, specifically the Middle East. Downstream countries complain that Turkey, through implementation of the GAP project, does not provide them a fair share of the Tigris and Euphrates Rivers, while Turkey stated that the GAP project provides free benefits regarding flood control to the downstream nations (Syria and Iraq) (Ünal Öziş, Yalçın Özdemir 2009).
The precipitation in Turkey is not equally distributed throughout the year. The amount of precipitation varies during seasons and from year to year. Therefore, Turkish authorities stated that the GAP project is not damaging Syria and Iraq but rather will assist all the basin nations regarding sediment retention, flood mitigation and temporary low flow augmentation during drought seasons through using stored water (Ünal Öziş, Yalçın Özdemir 2009).

The expected/projected/anticipated natural water shortage as a result of global climate change and the increased demand for fresh water in order to meet the economic and population growth in Turkey is expected to lead to decreased water availability downstream, especially for irrigation, in Syria and Iraq. The Iraqi ministry of water resources, in the last meeting with the Turkey’s authority in 2009, stated that his country is experiencing a massive emigration from rural areas to big cities as a result of water scarcity (Aljazeera B 2009).

**Conclusion**

The change of legal case of the Tigris and Euphrates River from internal to international watercourses by the end of the World War I stimulated a need for agreements between/among riparian nations. To date, the core problem among the Tigris and Euphrates riparian nations is the lack of tripartite agreement. However, several bilateral treaties and agreements exit between riparian nations but these bilateral treaties and agreements are not effective because these rivers are shared by more than two nations. Since there is no enforce international law to be implemented to share the Tigris and Euphrates River among riparian nations and no effective tripartite agreements exist among riparian nations, each nation defines these rivers differently. For example, Turkey insists that these two rivers are Turkish river, Iraq and Syria both stated that these two rivers are international watercourses in addition to debating among riparian nations either the Tigris and Euphrates are a single basin or separate basins.
However, the issue of making a tripartite agreement among riparian nations is further complicated by non fresh water related problems (regarding political and security problems), rapid growth of population and water decline as projected by climatic change scenarios. The majority of the Tigris and Euphrates basins area are located in arid and semi arid region and therefore the water balance is negative in over 95% of the basins area. Therefore, further effective uses of water resources in upstream nations are expected. The implementation of Southeastern Anatolian Project (GAP) in Turkey is the main evidence of such effective use of water in Turkey. The use of water resources in upstream nations specifically Turkey is a big problem for downstream nations, specifically Iraq, because Turkey has a control of these two river water resources, specifically the Euphrates, as a result of its upstream position. The fact that the majority of Iraqi arable lands, over 70%, depends on these two rivers make Iraq extremely vulnerable to desertification and land degradation as a result of fluctuation and shortage of water and therefore will further damage already damaged Iraqi environment.
Chapter 3  

Land Cover, Land Use, and Soil Erosion in Iraq  

This chapter provides details about geographic, climatic, land use and land degradation in Iraq, specifically north Iraq. Details are provided to visualize the region and the land degradation problems in different parts of Iraq, specifically north Iraq. The provided details are significant to identify the type of land degradation, such as salinazation and erosion, in Iraq and to visualize vulnerable regions to desertification. Also, climatic details, such as temperature and rainfall, and topographic details, such as slopes and elevation, that are provided in this chapter assist in selecting appropriate solutions in chapter seven (Strategies to Combat Desertification in Iraq and the Kurdistan Region) for each region in Iraq.

Generally, this chapter identifies a few major details about Iraq as follows: (1) precipitation in Iraq varies from northern region, up to 1000 mm, toward southern region, below 100 mm, (2) gap of elevation is significant, ranging from over 2000 m in north to below zero in south, and annual temperature, 0 - -4 C in top north (over 2000 m above sea level) to 25 – 30 C in south, and (3) north of Iraq is chiefly damaged by water erosion as a result of rainfall erosivity and soil erodibility factors and south of Iraq by salinazation.

Iraq is divided into three different natural zones: mountains, desert, and the great Mesopotamia plains (upper plain and lower plain). The mountain region is located in the north and east, while the desert areas are located in the south and west. The great Mesopotamia plain is surrounded by desert area on the south and west, and mountains in the north and east. The upper Mesopotamian plain is comprised mostly of non-irrigated, rain fed farms while the lower Mesopotamian plain is primarily dominated by irrigated fields (Figure 9 - page 26). The climate in Iraq is generally divided into three types: (1) Mediterranean, in the north and northeastern
regions, (2) continental, and (3) sub-tropical semi-arid. The average rainfall is 216 mm but the range varies from northern toward southern regions. The rainfall range is about 1200 mm in the northeastern region while it is about 100 mm in the southern region, which includes approximately 60% of Iraq. The rainy season occurs in north and northeastern regions in the winter from November to April, while in the other parts of the country the rainy season occurs from December to February (FAO 2009).

The land uses in Iraq vary according to the topography and climatic conditions. As shown in figure 10 (page 31), forests and pastures cover the mountainous region in the north and some parts of the east. The northern Iraqi hilly plains and flat land are located below the mountainous region, indicated by brown color, and include most of the Iraqi rain fed, non-irrigated, arable lands, which provide the main source of grains, primarily wheat and barley. The lower Mesopotamian plains are located in between the Tigris and Euphrates Rivers in the central and south of Iraq. These plains include most of Iraq’s irrigated lands, which produce different types of agricultural products such as wheat, barley, rice, vegetables, and dates. The rest of the south-western and the western regions are dominated by desert (Figures 9 – page 26 & 10 – page 31).

The elevation level in Iraq varies from north to south, from up to 3000 meters above sea level at the top northern mountainous region to zero meters in the southern region. Generally, the altitude decreases gradually from the northern regions toward the southern regions (Figure 13). The temperature patterns also vary from the northern regions toward the southern regions. In the northern mountainous regions in the areas where the elevation averages over 2000 m, the average annual temperature ranges between -4 and 0 Celsius degrees. While in most of the middle and southern Iraq is ranged between 20.5 and 30 Celsius degrees. Generally, the temperature increases gradually from the northern regions toward the southern regions (Figure 12).
Iraq has about 48,000,000 dounums or 12,000,000 hectares of agricultural land. Of that, 8,000,000 hectares are located in the Southern Region and 4,000,000 hectares in the Northern Region. Only about 21%, or 2,517,000 hectares, of Iraq’s agricultural lands are located in non-irrigated areas. Only 20% or 497,000 hectares are located in the areas likely to receive enough

Figure 12: Shows the average annual temperature in Iraq (FAO 2010).

Figure 13: Shows the elevation of Iraq (FAO 2010).
rain for growing crops, and the rest of it is located in the marginal areas or semi likely to receive enough rain for growing crops, 610, 000 hectares, and the areas unlikely to receive enough rainfall for growing crops, 1,410,000. The variation of rainfall is +30% or -30% of the overall precipitation in the marginal areas and unlikely areas to receive enough rain for growing crops therefore some of these lands are supported by supplementary irrigation systems in order to be agriculturally viable (Asmahel 2004) (Nhma 2009).

**Land Characteristics in Northern Iraq**

The area of northern Iraq and Kurdistan Region is about 12,000,000 hectares including forest, pasture, waste and dry crop lands. The region is divided into three different zones according to the mean rainfall amounts: (1) high rainfall zones (above 600 mm), (2) medium rainfall zones (between 400 mm and 600 mm), and (3) low rainfall zones (below 400 mm). Generally, the northern Iraq region has a semi-arid Mediterranean climate. The temperature pattern varies from summer to winter by about 20 Celsius degrees. During winter months, minimum daily temperature drops below the freezing point, while in summer the maximum daily temperature is above 35°C and sometimes reach 45 °C or above especially in the southern region of North Iraq (Hussein, Water erosion assessment and control in Northern Iraq 1998).

Figure 14: Shows the nature of land uses in North Iraq and Kurdistan Region (Hussein, Water erosion assessment and control in Northern Iraq 1998).
Figure 14 shows more specific details about land uses in the Kurdistan Region and North Iraq. As shown in figure 14, almost all of the Iraqi degraded forest areas, about 1,500,000 hectares, are located in the north and northeastern regions characterized by high mean annual rainfall with hilly and steep topography. The area of dryland farming in North Iraq is about 2,000,000 hectares, with 60% located in the low rainfall zones. Dryland farming (crop land) as indicated in figure 14 is practiced within the boundary of likely and unlikely areas to receive enough rain for growing crops. The topography in the dry land farm area is level to rolling. The grazing areas exist in all the rainfall zones; it covers about 2,000,000 hectares of the land (Hussein 1998).

Different types of soil exist in North Iraq and the Kurdistan Region. The low rainfall zone is dominated by Aridisols. Vertisols, Mollisols, and Aridisols are found in the high and medium rainfall zones. These two zones are usually used for dryland farming. Entisols exist in the more sloped regions. Generally soil depth is less than 1 meter for both Aridisols and Entisols, while it reaches 1.5 meters for both Vertisols and Mollisols (Hussein, Water erosion assessment and control in Northern Iraq 1998). Aridisols are a dry soil with low organic matter components, covered sparsely by salt or drought tolerant plants. In order to be agriculturally viable it needs supplementary irrigation. Vertisols are a clay rich soil best suited for pasture lands and plants that thrive in standing surface water. Vertisols are characterized by low water permeability. Mollisols are characterized by high concentration of humus in it and are highly arable and suitable for cereals and grains. Entisols are formed from the recent geological actions and are resistant to weather characteristic, usually found in areas of active erosion (Encyclopedia Britannica 2010).

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6 Please refer to figure 9 (page 26) for a complete map of Iraq
The nature of slopes in Northern Iraq and Kurdistan Region, as shown in figure 15, varies from region to region. Generally the north and northeastern regions are dominated by steep slopes, while the middle and southern regions of North Iraq have variable slopes from nearly level, gently rolling to rolling, hilly, hilly to steep, and steep, though not mountainous (Figure 15).

Table 6: shows the meaning of the symbols that are used in figure 15 (Hussein 1998).

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Class</th>
<th>Range of Slope (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Nearly Level</td>
<td>0 - 5</td>
</tr>
<tr>
<td>AB</td>
<td>Level</td>
<td>0 – 10</td>
</tr>
<tr>
<td>B</td>
<td>Rolling to rolling</td>
<td>5 - 10</td>
</tr>
<tr>
<td>C</td>
<td>Hilly</td>
<td>10 - 30</td>
</tr>
<tr>
<td>CD</td>
<td>Hilly to steep</td>
<td>Greater than 10</td>
</tr>
<tr>
<td>D</td>
<td>Steep</td>
<td>Greater than 30</td>
</tr>
</tbody>
</table>
The rainfall erosivity in North Iraq and Kurdistan Region varies from north to south. As shown in figure 16, units are the potential erosive force of runoff as determined by the average slope and intensity of the rainfall. The higher the number, the greater the erosive force of the rainfall and runoff. Generally, the rainfall erosivity decreases gradually from the northern regions toward the southern regions (Figure 16). The erosivity depends on the season and the topographic characteristic of the land. For example, the rainfall erosivity decreases in dry seasons. Also the force of rainfall erosivity depends on the land’s slope classes and rain intensity (Hussein 1996). The season, especially in croplands, has significant impacts on the rainfall erosivity. For example, during spring season the rainfall erosivity is higher because the vegetation cover is minimal, soils are saturated, and snow is melting (C.S. Baldwin 2003).

The soil erodibility in North Iraq and the Kurdistan Region is different from region to region depending on the regional characteristics such as topography, soil type, rainfall, and land use activities. The map of soil erodibility in North Iraq and Kurdistan Region is shown in figure 17 (Figure 17). The degree of soil erodibility depends on the soil type and properties such as infiltration rate, organic matter continent, and structure. For example, soil is more resistant to erosion if it has a faster rate of infiltration, high level of organic matter, and good structure. Also, some types of soil such as silt, very fine sand, and certain clays, are more erodible than other types such as sand, sandy loam and loam. Agricultural practices also have impacts on soil
erodibility through lowering organic matter in soil and decreasing the quality of soil structure, which leads to compact land surface and increasing erodibility (C.S. Baldwin 2003).

Figure 17: Shows soil erodibility map for Northern Iraq (Hussein 1998).

Table 7: Shows water erosion classification used in Northern Iraq (Hussein 1998). This table is used as a guideline for both figures 17 above & 18 below

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Typical Annual Soil Loss (ton/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>None to slight</td>
<td>0 – 5</td>
</tr>
<tr>
<td>2</td>
<td>Slight to moderate</td>
<td>5 – 10</td>
</tr>
<tr>
<td>3</td>
<td>Moderate to severe</td>
<td>10 – 50</td>
</tr>
<tr>
<td>4</td>
<td>Severe</td>
<td>50 – 100</td>
</tr>
<tr>
<td>5</td>
<td>Very severe</td>
<td>Greater than 100</td>
</tr>
</tbody>
</table>
Figure 18 shows the water erosion and land conditions in North Iraq and the Kurdistan Region. It is clear from the description of each unit in the map that the erosion exists all over the region. The southern region of North Iraq is more vulnerable to desertification because: (1) as indicated previously, the southern region of North Iraq is located in the low rainfall zones, (2) land use is dominated by dryland farming and grazing areas, which are prone to overuse problems, and (3) geographically, it is located next to the Iraqi desert. But, as shown in figure 18,
erosion and land degradation exist all over the region. Therefore, the northern region might be less impacted by desertification in the short term but it will be impacted severely in the long term unless appropriate policies and techniques are followed to manage the lands in a sustainable way. Current dust storms, figures 22 & 23 (page 60), are the main evidence for acceleration of desert expansion from the southern region of Iraq toward the north.

**Conclusion**

The land degradation in northern Iraq, specifically the Kurdistan Region, is chiefly caused by water erosion because steep slopes, nature of the land and intense rainfall along with lack of vegetative cover increases rainfall erosivity and soil erodibility. The degree of rainfall erosivity decreases from northern region toward southern region of north Iraq. The southern part of north Iraq is dominated by marginal lands that are characterized by low annual rainfall (200 – 400 mm) and therefore are prone to overgrazing and overuse problems, which in turn results to increase the vulnerability of land to erosion. It can be concluded in this chapter that the most important driving cause of land degradation in north Iraq are water erosion, overgrazing and overuse of marginal lands. Therefore any efforts to solve land degradation and desertification problems should pay particular attention to these problems, specifically erosion problems.
Chapter 4

Factors that Lead to Desertification

This chapter provides details about driving factors of desertification including demographic, economic, technological, government policy, climatic and deforestation. Also, details are provided about unique local factors contributing to land degradation and desertification in Iraq and the Kurdistan Region, including armed conflict, deliberate destruction of natural resources, and UN economic sanctions against Iraq. Studying the role of these factors assists to identify the major critical causes of desertification in Iraq.

The major findings in this chapter are the consequences of population growth and economic development to accelerate land degradation. For example, the population growth in Iraq leads to intensify use of available lands and move toward utilizing ecologically unsustainable low productive lands to meet the needs of agricultural products. Also, economic growth results in urban expansion onto fertilizer lands, which in turn encourages utilizing marginal lands for crop production through using irrigation systems and chemical fertilizers to compensate the loss of fertile lands around urban centers. However, the marginal lands are ecologically unsustainable for growing crops, which in turn results in degrading these lands in the future. The upstream nations, specifically Turkey, water management policy through building dams and expanding irrigated areas declined the amount of water that Iraq receives. Therefore, these upstream nations policy further damage Iraqi degraded environment and worsen Iraqi land condition. 61% of Iraqi arable lands are subject to salinity problems and 92% of Iraqi lands are subject to desertification.

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7 “The UN Security Council imposed comprehensive economic sanctions against Iraq on August 6, 1990, just after the Iraqi invasion of Kuwait. When the coalition war had ousted Iraq from Kuwait the following year, the Council did not lift the sanctions, keeping them in place as leverage to press for Iraqi disarmament and other goals (Global Policy Forum n.d.).”
(K. Haktanir 2002). The overall condition is further complicated by the climatic problems such as drought and its consequences. The economic growth in the Kurdistan Region stimulated efforts to develop agricultural sector through implementing a plan to meet food self sufficiency and be a net exporter of agricultural products may stimulate establishing advanced monoculture systems, which contribute to land degradation and desertification in long term.

- **Demographic Factors**

The growth of human population is leading to increasing population in urban areas, accelerating cropland expansion, and rising livestock populations. Cropland expansion causes a loss of the natural green cover that protect the land from erosion. The ongoing conversion of range and forest lands to monoculture cropland decreases land productivity in short term and land degradation in long term. The increase of livestock populations has caused overgrazing, which accelerates soil erosion and land degradation (Houérou 2002) (Helmut J. Geist, Eric F. Lambin 2004).

The demographic factor is leading to “desertization or human made desert” (Houérou 2002). Desertization as defined by Le Houérou is the present irreversible degradation of arid lands, turned into man-made deserts. The increase of human and livestock population, along with the mismanagement of the soil and water resources, results in desertization especially in arid and semi-arid regions. The

Figure 19: Shows the role of demographic changes to promote desertification (Houérou 2002) (Helmut J. Geist, Eric F. Lambin 2004).
demographic related problems are increasing in many parts of the world as a result of rapid population growth, which puts more pressure on using lands. Figure 19 shows the consequences of demographic factors on desertification processes (Houérou 2002).

As shown in figure 19, the growth of human and livestock populations will lead to increased fuelwood collection, medicinal plant collection, overgrazing, and inappropriate use of resources or poor resource management. These in turn result in declining natural green cover. The poor resource management causes increased soil salinity, soil alkalinity, and reducing soil productivity, which leads to changes in soil structure. The destruction of natural green cover leads to accelerated erosion, soil compaction, and a change in soil structure and salinity. The change in soil structure and salinity leads to increased sedimentation and water logging alkalization. Almost all of the mentioned consequences of the human and livestock population growth are leading to accelerated land degradation and desertification.

The reinforcing or positive feedbacks loops (R)⁸ imply that the land condition will worsen over time. R1 shows the decline of natural green cover causes acceleration of the change in soil structure and salinity, which leads to more declines in natural green covers in a positive feedback loop. R2 shows the decline of natural green cover causes accelerated erosion, land degradation and desertification which lead to more decline in natural green covers in a positive feedback loop. R3, R4, and R5 have the same impacts on land degradation and desertification as R1 has through accelerating soil compaction, sedimentation, and water logging alkalization respectively (Figure 19).

⁸ There are two types of feedback loops, reinforcing and balancing feedback loop. Reinforcing feedback loop (R) “tend to reinforce or amplify whatever is happening in the system, for example, the more nuclear weapon NATO deployed during the cold war, the more the Soviet Union built, leading NATO to build still more (Sterman 2000).” Balancing feedback loop (B) “is a feedback loop in which changes anywhere in the loop propagate around the loop to “UNDO” original change (Deaton 2009),” for example, “the more attractive a neighborhood or city, the greater the in migration from surrounding areas will be, increasing unemployment, housing prices, crowding in the schools, and traffic congestion until it is no more attractive than other places people might live (Sterman 2000).”
The human pressure on the arable lands in Iraq is noticeable through intensifying uses of arable lands as a result of population growth. The following are data’s about land availability per capita overtime in Iraq: between 1981 and 1983, the available arable land per capita was 0.4 hectare, between 1991 and 1993 this area decreased to 0.3 hectares (UNEP 1997). In 2005 and 2007 the arable land availability per capita further declined to 0.19 and 0.17 hectare respectively (The World Bank 2010). The major losses of arable lands caused by the following consequences of population growth: (1) Large agricultural areas close to the urban centers have been lost because of urbanization, industrialization, and transportation infrastructure, (2) To provide more land for agricultural purposes in order to compensate the lands that has been lost regarding urbanization, marginal lands has been reclaimed for agricultural purposes, (3) The land of low productivity is being overused as herds overgraze rangelands, (4) Irrigated lands is being used all year round through using more water, chemical fertilizers and pesticides, and (5) The increased population and agricultural activities resulted in increasing demand for water and caused overusing ground water, which in turn resulted in soil salinazation and destruction of plant and animal habitats (UNEP 1997).

- Economic Factors

Economic factors are some of the major causes of desertification in different parts of the world. Urbanization, commercialization, industrialization, and market growth are creating a perfect atmosphere prompting the farmers to overuse the land by using different types of technologies such as irrigation systems and chemical fertilizers. For example,
external high demands for strategic agricultural commodities, such as grains, beef and cotton, along with the lack of labor, land scarcity, and low investment potential are leading the farmers to overuse their lands (Helmut J. Geist, Eric F. Lambin 2004).

In other cases, when the demand for agricultural products increases, farmers will move to adapt range and forest lands to agricultural fields in order to increase food production and to harvest more wood from the forest in order to export it. Nepal nationalized forest lands in 1957 in order to increase food production through adapting forest land to agricultural fields and improve its economy through exporting harvested wood (A.P. Gautam 2004); this serves as a perfect example of this case because it led to increased agricultural production in the short term but resource depletion and land degradation or desertification in the long term (Figure 20 above).

Turkey’s economic ambitions are a good example of such a case in the Tigris and Euphrates River basin. As a result of increasing demands for food and agricultural products all over the world, Turkish authorities wish to be the major producer of food and agricultural products for both the Middle East and the Central Asian region through increasing irrigated lands in the Tigris and Euphrates River Basin (Asmahel 2004) (Ünal Öziş, Yalçın Özdemir 2009).

The Kurdistan Regional Government is following a five-year plan (2010 – 2014) to develop the agricultural sector in the region. It is worth mentioning that until the 1970s agricultural products were being exported from the Kurdistan Region to the rest of Iraq and neighboring countries, but this situation severely changed as a result of wars and conflicts. Currently the Kurdistan Regional Government through taking advantages from economic development and security stability, compared with the other parts of Iraq, in the region is implementing a five-year plan from 2010 to 2014 to redevelop the agricultural sector. The goals are meeting food self sufficiency within five years and being a net exporter of agricultural products in the future. Generally, the total numbers of agricultural projects that should be
implemented or established are 1865 projects with a total investment of $10,221,297,000 within five years (2010 – 2014). However, the plan includes moving from small agricultural farms to larger farms through tapping water from aquifers, providing subsidized irrigation systems and chemical fertilizers (Kurdistan Regional Government - Ministry of Planning 2009). Generally, these governmental subsidies are leading to overusing of agricultural lands and developing monoculture systems. The fact that the Kurdistan Region is suffering from the lack of enough agricultural expertise and skilled farmers will further increase the vulnerability of land degradation due to misuse of the provided irrigation systems and land resources. Since ancient history, the urban centers were built on the fertile lands. Therefore any expansion of urban centers will be onto the fertile lands (UNEP 1997). Currently in the Kurdistan Region, the capital city, Arbil, is expanding rapidly as a result of economic growth. Of course, this expansion will take fertile arable lands around the city. The concern is with the 2010 to 2014 plan; the need for lands to be used for agricultural purposes is increasing. Therefore, more use of marginal lands and overuse of available agricultural lands are expected.

- **Technology Factors**

  The use of modernization theory and Misuse of heavy agricultural technologies in managing water and land is one of the major causal factors of desertification. These technological innovations include the development of the land and water resource management through small projects at the village level such as motor pumps and boreholes, or through larger projects such as dams, reservoirs, canals, collectors and artificial drainage networks. The lack of maintenance on these systems is causing major losses of the water in addition to causing drastic changes in the natural hydrographic network through altering the direction of water flows. The Aral Sea disaster is one of the best examples of the role of misusing technologies that accelerates land degradation through altering natural systems. The former USSR implemented very extreme policies in the Aral Sea Basin to increase agricultural production through withdrawing water from
the two rivers that discharge in the Aral Sea in order to irrigate more lands. The results were disastrous changes that happened in both hydrological and environmental systems all over the basin. Overtime the Aral Sea almost disappeared and now only a very small part of it remains (Saiko 2000).

The current implementation of water resource management technologies through impounding water and diverting water courses to irrigate Anatolian drylands by Turkey’s government is the best equivalent example of the Aral Sea case in the Tigris and Euphrates Rivers Basin. Turkey is following the same strategies, diverting river courses to increase irrigated lands, that the former Soviet Union followed in the Aral Sea Basin in order to increase irrigated land and agriculture production. The details about Turkey’s water management strategies were provided in chapter one – GAP section. Also, the withdrawal of water from Mesopotamia’s marshlands in southern Iraq by Saddam Hussein’s regime to promote agricultural production in the same region is another equivalent example of the Aral Sea case in the Tigris and Euphrates Rivers Basin. Through intensifying irrigation in southern Iraq, Hussein’s regime drained the Mesopotamian marshlands. Even as recently 1970s the Mesopotamian marshlands covered 20,000 km² in Southern Iraq. In addition to expanding irrigation lands, Hussein intentionally dried the marshlands to force those who were living there to move and to relocate them because of their political views⁹. Also, the building of dams in Turkey, Syria, Iran and Iraq itself has a significant impact on the shrinking of the Mesopotamian marshlands through decreasing the amount of water that discharges in theses marshlands. The marshlands were a very special ecosystem in the southern part of Iraq but now only 10 – 15% of these marshlands remain. Figure 21(page 58) shows the change of Mesopotamian marshland condition since 1973. The dark red color represents the density of vegetation cover (Middleton 2005) (Figure 21 – page 58).

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⁹ The Marsh Arabs are Shiite while Hussein’s regime was dominated by Sunnis (Middleton 2005).
The technological development in Iraq has contributed to changing land use and land degradation. For example, in south-central irrigation zone investment in water storage and flood control projects along with adoption of irrigation pumps resulted in expanding irrigated area rather than productivity. Due to mismanagement and lack of maintaining irrigation projects, soil salinization damaged large areas. In northern Iraq, the arrival of tractors rapidly expanded cultivated areas to marginal lands. Such expansion of agricultural fields were ecological unsustainable because the majority of marginal lands are not getting sufficient rain for growing agricultural crops and they are serving as grazing and rangelands (Congressional Research Service 2004).

- **Policy Factor**

Iraq’s government policies regarding land management have significant impacts on the change of land cover and land surface. The purpose of government policies are to improve agricultural production through agricultural intensification methods, and converting forest and rangelands to agricultural fields in response to national economic development and globalization (Elsevier Science Ltd 2001) (Helmut J. Geist, Eric F. Lambin 2004). These policies include agricultural reforms, methods of agricultural intensification per unit area, market liberalization, developing big agricultural projects and changing the land tenure policies. These policies are considered a significant factor that has driven desertification all over the world (Helmut J. Geist, Eric F. Lambin 2004) including Iraq and Kurdistan Region.

Both the deforestation case in Nepal and the Aral Sea disaster are extreme examples of the policies that have inadvertently promoted desertification and land degradation. The Aral Sea details were provided in above. In Nepal the government implemented policies to extract more timber from the woodlands and to adapt range and woodlands to farm fields. The results were
increased timber exports and agricultural products in the short term but deforestation and land degradation in the longer term (A.P. Gautam 2004).

The situation in the Tigris and Euphrates River basin differs from the Nepal deforestation case but it is closer to the Aral Sea case. In the Tigris and Euphrates River Basin, the policy in any country, especially upstream countries, will influence those downstream. For example, any policies to manage water and lands in Turkey, Syria and Iran will have negative impacts on Iraq’s hydrological and environmental system. In addition to the impacts of the upstream country’s policies on Iraq’s land structure, building of dams in Turkey, Syria, Iran and Iraq itself has a significant impact on the shrinking of the Mesopotamian marshlands through decreasing the amount of water that discharges in theses marshlands (Middleton 2005), some of the other internal policies in both of the woodlands in the northern portion of Iraq and Mesopotamia’s marshland in southern Iraq during Saddam’s administration have significant roles in causing expansion of deserts and accelerating land degradation all over Iraq.

- **Climatic Factors**

  The increase of greenhouse gas emissions and aerosols in the atmosphere result from different human activities since the beginning of industrial age. Burning fossil fuels and changes in land cover are major causes that contribute to the greater concentration of atmospheric properties that absorb radiant energy. These changes in atmospheric properties are causing significant alteration in the factors on which human systems and natural environments depend, such as precipitation and temperature. These changes also induce extreme climate events, sea level rise, and desertification especially in arid and semi-arid regions (Sivakumar 2006). Iraq’s atmosphere is severely polluted as a result of burning fossil fuels and other problems such as wars and destruction of marshlands (Al-Attar 2004). The following are major sources of pollution in Iraq: (1) Carbon monoxide (Co), (2) Carbon dioxide (CO₂), (3) Chlorofluorocarbon, (4) Lead
(Pb), (5) Ozone, (6) Nitrogen oxide (Nox), (7) Suspended particulate matter (SPM), and (8) Sulfur dioxide (SO₂). Therefore, the identified consequences of changing atmospheric properties above are applicable to Iraq and the Kurdistan Region too.

Decreasing rainfall is one of the significant factors that simultaneously marks and intensifies desertification in different parts of the world. Also, climate change exacerbates desertification through changing of the spatial and temporal patterns of rainfall in different parts of the globe (Sivakumar 2006). The variation of rainfall amounts causes changes in land cover through both lengthening number of dry years or seasons, resulting in very long drought periods, such as a drought that damaged Sudan from 1960s to 1990s (Helmut J. Geist, Eric F. Lambin 2004).

The increase of global temperatures as a result of climate change results in changing: (1) soil properties and processes, such as organic matter decomposition, greater leaching losses, and decreased soil water, (2) soil erosion and degradation through reducing soil moisture, and (3) erosion in some regions because of heavy rainfall and increased windspeed (IPCC 2003). Also, climate change accelerates desertification through changing the regional water resources and wetland systems this occurs by disrupting the balance between water outflow and inflow because of the variation of rainfall amounts and increasing temperature, which enhances evaporation. These changes will lead to decreasing lake and reservoir sizes, to drying wetlands and to changing regional environments (Sivakumar 2006).

The United Nations Development Program (UNDP) mentioned that Iraq has passed through frequent and severe drought seasons for the past three years and has experienced a decline of rainfall over the past 5 to 10 years. Precipitation reached only 25 to 65 percent of normal levels as a result of global climate changes and natural factors such as El Nino/La Nina cycles off the Pacific coast of South America. These changes shrink the southern marshlands and
increase the likelihood of massive dust storms as a result of losing soil moisture and vegetation cover. The impacts of climate change are expected to become more severe as time passes, which will lead to more destruction of physical and chemical characteristic of soil in Iraq’s arable and non-arable lands (UNDP 2009).

In the past drought issues and dust storms were very rare in the Kurdistan Region. The problem of drought started roughly in the last 10 to 15 years as a result of global climate change. Currently, the Kurdistan Region faces an unpredictable climate due to changes in rainfall amounts, changes in rainfall times, dust storms, and rising average temperatures. Climate change has significant impact on land use, land cover, and water resources in this region. For example the change in rainfall amounts and the distribution of rainfall times forced the farmers to depend more on irrigation systems, which led to reduced ground water levels, increasing soil erosion and salinity, changing soil structure, and decreasing soil moisture. For example, in 1996 under the UN – Iraq “oil for food” program, the number of wells increased in the Kurdistan Region through FAO efforts to solve water scarcity and drought problems. The increased number of wells led to sharp decline in ground water in some parts of the Kurdistan Region. This in turn resulted in drying some natural springs in areas sharing the same aquifer with the newly established wells which forced those who depend on these natural springs to leave and a reduction of vegetative cover occurred. These changes of the soil and natural properties in the Kurdistan Region made the region more vulnerable to dust storms and climate change (Hamza 2009) (UNDP 2009).

- **Deforestation and Rangeland Modification factors**

Multiple factors lead to deforestation, including population growth, poverty (A. S. MATHER 2000), economic development, national policy, agricultural expansion, international trade growth, technological development (Rudel 1993), private property regimes, access rights, policy deficiencies, and weak political institutions (Hecht 2004). The same basic factors promote
rangeland destruction along with other factors such as overgrazing (Sivakumar 2006). This thesis does not provide a deep explanation about causal factors of deforestation and rangeland destruction, but pays particular attention to the roles of deforestation and rangeland destruction (land cover change) to promote desertification.

The estimate of land cover change worldwide since 1850 through deforestation, rangeland modification, and agricultural expansion suggests that about 6 million km$^2$ of forest and woodlands and 4.7 million km$^2$ of savanna and grasslands have been converted to cropland (N. Ramankutty and J.A. Foley 1999). The change in land cover through adapting forest and rangelands to croplands is one of the major driving factors of lands degradation (Sivakumar 2006). Also, adapting forest and rangelands to cropland depletes the soil organic carbon pool (Lal 2004).

The change in land cover through forest and rangeland depletion and adapting them to agricultural fields makes soils more vulnerable to erosion (FAO 2003). Soil erosion leads to decline of the soil organic carbon content (Sivakumar 2006). The depletion of a soil’s organic carbon causes a decline in soil quality, decreases biomass, and contributes to global warming through emitting carbon to the atmosphere (Lal 2004). All these consequences of land cover changes will lead to desertification in the long term if appropriate management techniques are not implemented.

Pielke (2007) described the impacts of land cover change specifically converting grass and forest land to agricultural fields and pastures on regional precipitation. Pielke (2007) conducted case studies in different parts of the world including North and South America, South East Asia, China and Africa. In most of the cases, the land cover changes caused a change in regional climate and rainfall patterns. In very limited cases the land cover changes caused an
increase in rainfall as in South East Asia in wet seasons while it declined in dry seasons (Pielke 2007).

In Iraq, especially the northern part of it, deforestation and rangeland degradation have caused massive soil erosion and loss of soil quality especially in hilly and mountainous regions as a result of the lost vegetation cover (Hussien Kariem, Abdulmahdi Jbr 2008). Similarly, deforestation and change in the Kurdistan Region’s land cover over the previous decades have significant impacts on the regional rainfall pattern, which lead to accelerated losses of soil productivity, erosion and land degradation (see chapter two – page 29).

**Desertification and Conditions Unique to Iraq**

The above described causal factors are very general and occur in most of the dry lands in the world. In this section, specific details will be described about causal factors of desertification specific to Iraq, such as deliberate depletion of lands or resources by Saddam’s regime, wars, and UN economic sanction against Iraq.

![Figure 21: Shows the shrinkage of the Mesopotamian Marshland from 1973 (left image) to 2000 (right image) (EDRO 2009).](image)
Abbas Alsakb, an Iraqi water resource expert, mentioned that the wars in Iraq from 1980s until the Second Gulf War in 2003 had significant impacts, including increasing desertification. Alsakb said that these wars should be examined according to the following criteria: (1) impacts of military actions on the land surface and its consequences, (2) lack of government strategies to manage resources because the priority was for wars, and (3) inappropriate use of water resources. All of these issues caused losses in productivity and quality of Iraq’s fertile soil (Aljazeera.net 2009).

In addition to wars and conflicts, UN sanctions against Iraq in 1991 significantly contributed to speeding land degradation in Iraq (Aljazeera.net 2009). As a result of UN economic sanctions, the Iraqi government moved toward expanding agricultural lands through implementing intensive irrigation systems. The intensification of irrigation caused changes to the hydrology of the Tigris and Euphrates Rivers. Following the 1990s, the Iraqi government implemented a massive drainage network in order to increase agricultural lands in Southern Iraq. As a result, the ecosystem was changed, soil fertility declined because of sedimentation and salinity, and a huge shrinkage of vegetation cover occurred in the Mesopotamian marshlands (see figure 21 above) and palm tree forests (Middleton 2005).

These changes are one of the most important causes of land degradation and desertification all over Iraq. Even the Kurdistan Region, which is located in the north of Iraq, is not protected from the negative consequences of changing the marshland ecosystem. These marshlands provided a greenbelt that protected the Southern Mesopotamian plains and the Kurdistan Region from desert expansion. As shown in figure 21, theses marshlands are almost gone. Figure 22 and 23 show the severity of dust storms that are attacking most of Iraq’s lands. The decrease in the amount of water that discharges into the marshlands is considered the main challenge today. There is no solution in sight for the near future, as the situation is expected to worsen as a result of frequent drought seasons and the inability of the Iraqi government to
implement appropriate policies currently as a result of political and security conditions all over the nation (Aljazeera.net 2009) (Middleton 2005).

Figure 22: Shows the 2009 dust storms the attacked Iraq (EDRO 2009).

Figure 23: Shows a raise of dusts from near the US military position in Baghdad (Al-dabaggh 2009).
Conclusion

Nowadays, the economic growth in the Kurdistan Region along with overall population growth in Iraq motivated the region to develop agriculture sector through 2010 – 2014 plan. This in turn increases pressure on lands and leads to utilizing marginal lands, which is ecologically unsustainable for growing crops. The increased demand of agricultural products as population increases and economic growth lead to developing monoculture system, which results in further decline in arable lands. Also, population growth and efforts to improve economic condition in upstream nations, specifically Turkey damages Iraq through reducing the amount of water that Iraq receives, for instance GAP project in Turkey. In this case, the efforts to solve environmental problems as a result of past wars and its consequences on Iraqi environment will be extremely hard or even will further worsen the situation. Climate changes and its consequences, for instance frequent droughts and dust storms, worsen the environmental and land condition in Iraq and make Iraq more vulnerable to land degradation and desertification.
Chapter 5

The Social, Economic, and Political impacts of Desertification on the Tigris-Euphrates Basin Nations

This chapter provides details about the economic, social and political consequences of desertification in Iraq. The role of environmental instability as a result of desertification and other environmental threats in Iraq to promote and cause violence in the other riparian nations is explained. For instance, details provided about how natural resource problem may transform to military threats. The impacts of desertification on Iraq regarding key elements of national security; food, health and livelihood security are identified. Iraq is extremely vulnerable to desertification and therefore the key elements of national security in Iraq are threatened by environmental instability in its central and southern part as a result of decline of the Tigris and Euphrates water.

The desertification problem in Iraq and its consequences leads to force people to leave their homes (environmental refugee). That 4500 out of 5000 villages in the Kurdistan Region were destroyed by Hussein’s administration and 92% of Iraqi lands are subject to desertification is an indication of the environmental refugees’ problem in Iraq. The current environmental instability threats will further complicate the situation. Quantifying environmental refugees in Iraq is impossible because it is hard to distinguish between those who were displaced because of poor security conditions in Iraq or because of environmental degradation. However, the continuing decline of the Tigris and Euphrates River water in Iraq will cause further deterioration of environmental conditions and might cause environmental instability, creating further regional instability in the Tigris and Euphrates River Basins.
Iraq

Achieving food security in arid and semi-arid regions typical of the Middle East is a very hard goal. The arid and semi-arid regions are extremely vulnerable to climate change and desertification (Brauch 2006). The drought years, in the last 10 – 15 years in Iraq severely undermined Iraqi grain (wheat and barley) production. The United Nations described the 1999/2001 drought in Iraq as the worst in the last 50 years. The levels of the Tigris and Euphrates Rivers were very low, about 20% below of their average flow (WHO 2010) or according to Congressional Research Services the irrigation water in Iraq was down to 43% below normal levels (Congressional Research Service 2004). The decrease in rainfall caused a decline of about 75% in Iraqi grain (wheat and barley) production. Al – Mosul plateau10, which produced 70% of Iraqi grain (wheat and barley) and is considered the breadbasket of Iraq, only received one-fifth of its average rainfall. The UNDP (2009) concludes, “According to Iraqi experts, recurring events -- drought and dust storms -- mark the beginning of the end of the Fertile Crescent, the breadbasket of the Middle East.”

Without any doubt, limited resource farmers and herders and other vulnerable communities are the most affected by these severe environmental events (FAO 2004). Therefore, food, health, and livelihood security in Iraq is extremely vulnerable to environmental events such as drought, soil and water erosion, and desertification.

Since 1991, as a result of the UN economic sanctions11 against Iraq, food security in Iraq was disrupted. As a result of disruption of food security, both health security and livelihood security were disrupted through lack of food and nutrition in addition to other issues related to

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10 It represents almost the entire Northern plateau.

11 “The UN Security Council imposed comprehensive economic sanctions against Iraq on August 6, 1990, just after the Iraqi invasion of Kuwait. When the coalition war had ousted Iraq from Kuwait the following year, the Council did not lift the sanctions, keeping them in place as leverage to press for Iraqi disarmament and other goals (Global Policy Forum n.d.).”
poverty. Therefore, the Iraqi government set up a nationwide rationing system in order to prevent famine. In 1996, the Oil for Food program launched by UN Security Council Resolution 986 (SCR 986) allowed Iraq to sell oil to buy food, medicine, and other necessary non-military materials. But, the FAO (2008) reported that even with SCR 986 contributions to increase food rations, food, health, and livelihood security still was under threat because:

- the monthly food rations were not enough for the whole month
- the rate of child malnutrition did not improve significantly especially in the central and south of Iraq
- the food that existed in the monthly food rations did not provide a nutritionally sufficient and varied diet
- only small portions of the population were able to supplement their diet through buying food from the market at considerable prices.

It is worth mentioning that there is a significant linkage between the UN economic sanctions against Iraq and the deterioration of the Mesopotamian marshlands. In response to the UN economic sanctions, the Iraqi government started expanding agriculture lands all over the country to minimize the influence of economic sanctions and reach food self-sufficiency. The cultivated agricultural lands in Iraq as measured in the 1980s were about 2,185,000 hectares; Iraq was self-sufficient in 1980 in producing wheat, rice, fruits, vegetables, and sheep and poultry products (Williams 2009). The cultivated agricultural lands reached 3,320,000 hectares in the 1990s before economic sanctions, and then in 1992 reached 4,900,000 hectares. In 1992, about 2,575,000 hectares were supported by irrigation projects, the irrigated areas increased to 2,700,000 hectares in 1995 and 3,150,000 hectares in 2000 (Asmahel 2004).

These continuous expansions in agricultural lands, especially irrigated lands, have had a significant impact on Mesopotamian marshlands through decreasing, sharply, the quantity and
quality of water that are discharged in them. The deterioration that occurred in the Mesopotamian marshlands is shown in figure 21 (page 58). This ecological destruction of Mesopotamian marshlands caused a mass displacement, internal and external, of the indigenous people who lived there for thousands of years and destroyed the biodiversity of that special ecological system (Middleton 2005). Between 80,000 and 120,000 people from Central Qurnah Marsh have crossed the Iraqi border to Iran and another 200,000 have been resettled in other parts of Iraq (Brauch 2006). Generally, in the 1950s the overall population of Iraqi marshlands was 400,000 people but in 2005 only about 60,000 people were living there (Middleton 2005).

The environmental refugees influence the environment in the refugee camps, which creates significant challenges for the host countries/regions and the agencies that support the refugees. The refugees are increasing the pressure on natural resources in the areas where they are resettled through harvesting wood for heating and cooking purposes and other activities that deplete vegetation cover. The relationship between the refugees and the host population is critical because both are depending on the available natural resources in the area. Therefore, unsustainable use of resources will threaten the livelihood of the people, in addition to concerns regarding loss of biodiversity, soil erosion and loss of land productivity (Keane 2004).

**Economic and Social impacts of Desertification on Iraq**

The economic impacts of desertification on Iraq are the same as defined by the United Nations to survey the state of the environment in the world for the period 1972-1992: (1) desertification undermines national food production, which contributes to the regional and international food crisis, (2) desertification results in a mass food shortage in the damaged regions, which negatively influences world food availability and global food trade and markets, and (3) desertification is one of the major factors that causes biodiversity decline in arid and semi-arid regions, which lessen any chance to produce food (Nhma 2009).
Desertification is resulting in social instability in communities through promoting emigration from rural areas toward cities as environmental refugees looking for jobs and better lives. The social impact of this emigration is devastating on the community because: (1) it increases the pressure on the cities through abnormal growth and increase of population, (2) the abnormal growth of a city’s population damages the city’s ability to provide healthy services, (3) it creates a lot of social issues such as lowering living quality, increasing unemployment, decreasing health services and education quality, exacerbating housing problems, creating security issues and social conflicts, (4) most of the time refugees are living in unhealthy and poor neighborhoods around cities, which are extremely vulnerable to diseases and natural disasters, and (5) declining rural population increases desertification issues. Generally desertification is one of the main barriers that confronts social and economic development, which increases the economic crises and this will contribute to further environmental degradation in a positive feedback loop (Nhma 2009).

It is very hard to provide specific statistics about environmental emigration in Iraq. It is impossible to distinguish between those who were forced to leave their lands/home as a result of the poor security situation and political instability in the country and those who relocated as a result of environmental degradation. According to Congressional Research Service (CRS), about 2,700,000 people are internally relocated in Iraq in addition to 2,000,000 people who externally relocated pre and post 2003 as a result of the poor security situation (Congressional Research Service 2009). But knowing: (1) 92% of Iraq’s arable lands are subject to desertification, (2) Iraq has lost almost 2/3 of its date palm trees since the Iraq- Iran war (K. Haktanir 2002), and (3) destruction of 4500 out of 5000 villages in the Kurdistan Region by Saddam Hussein’s regime (Middle East Watch 1993) are good indicators of the jobs that have been lost and stimulated farmers’ emigration toward cites looking for a better life (Nhma 2009).
Desertification and environmental degradation is a regional problem in the Tigris and Euphrates River Basin nations and in Middle East. Therefore, significant cause and effect linkages exist between all of the regional countries in regards to the desertification issue. Studying desertification in all of the Middle Eastern Countries is beyond the scope of this thesis. But it is worth mentioning that the issue of desertification affects both Turkey and Syria because of their impacts on Iraq regarding the use of the Tigris and Euphrates water resources.

The drastic increase in desertification rates in the Tigris and Euphrates River basins countries are expected according to scenarios of climate change. Both Turkey and Syria are facing land degradation, water scarcity, and limited agricultural production as a result of climatic variation, misuse of irrigation systems, land cover changes, agricultural expansion, and soil salinization. The area of surface land in Turkey is 77 million hectares, of which 20 million hectares are located in arid and 31 million hectares are located in semi-arid regions. Generally, in Turkey, about 73% of cultivated land and 68% of prime agricultural land are prone to erosion; the central south and central north, Mediterranean, and GAP regions are experiencing salinity problems. In Syria, the rangeland is severely damaged by desertification. The Badia rangeland and the marginal zone between the Badia rangeland and the Agricultural Zones, both fragile ecosystems, are experiencing a misuse of the resources in addition to frequent dry years. The estimated cost of soil degradation in Syria is equivalent to 12% of the country’s agriculture output. Also, 40% of the irrigated area is damaged by salinity at different levels. Generally, the causes of land degradation in the Tigris and Euphrates Basin Nations are soil erosion, alkalinization/salinization, urbanization and soil sealing (K. Haktanir 2002). These problems in Turkey and Syria make them to implement more projects to meet with their agricultural and economic needs on the Tigris and Euphrates Basins and therefore damages Iraq through declining

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12 Soil sealing: “is the covering of the soil surface with an impervious material, or the changing of its nature so that the soil becomes impermeable, so that the soil is no longer able to perform the range of functions associated with it (Burghardt 2006).”
the amount of water resources that Iraq receives. The situation is further complicated according to the climate change scenarios (Table 5 – page 28).

**Conflicts Regarding Control Resources**

The likelihood of conflict regarding control of water resources is high among the Tigris and Euphrates River Basin countries. In the past, such type of conflicts existed. In 1978, Syria supported the Kurds who were living in Turkey to establish an armed party, Kurdistan Labor Party (PKK), in order to force Turkey to provide Syria a fair share of water from the Euphrates River (Asmahel 2004). At that time, water scarcity was not as bad as it is currently or as it is estimated to be in the future. In addition to the possible conflicts among countries that are sharing these two rivers, the likelihood of internal conflicts exists because of the diversity of the ethnic groups that live in the riparian countries and tensions due to internal displacement.

“Kurdish communities are still coping with the aftermath of the displacement of hundreds of thousands of people who fled or were expelled from their villages during the conflict. The construction of the Birecik and Atatürk dams on the Euphrates displaced thousands more. Because residents of the threatened areas often lack legal land rights, they may be unable to secure compensation for lost homes, land and fishing resources. Local opposition to Ilisu dam stems in part from a fear that the Turkish state wants to use infrastructure projects in order to appropriate land, alter local geography, and thereby strengthen its security control over the region (Angell 2009).”

The internal conflicts and displacement as a result of natural resource limitations in Iraq started in the 1930s. Because of the availability of fertile lands and water resources in the Northern part of Iraq and the Kurdistan Region, compared with the central and southern parts of the country, the Iraqi government, through implementing irrigation projects in the Northern part of the country and Kurdistan Region, resettled hundreds of thousands of herders and farmers from
the Southern and Central Arabian tribes in the North of Iraq and Kurdistan Region. The indigenous people of the North of Iraq and the Kurdistan Region are characterized by religious and ethnic diversity as Kurd, Arab, Turkmen, Armenian, Assyrian, Christian, Muslim, Azedian, and more, considered this government initiative as an Arabization process through supporting resettled people, ignoring the indigenous people and forcing indigenous inhabitants to leave their lands. This process began in 1963 as a result of intense government pressures to change the demographic and political make-up in the region through forcing indigenous inhabitants, mostly Kurds, to leave and resettle Arabian tribes in their lands (Asmahel 2004). The displacement processes were implemented by Hussein’s regime like following: the Kurds who were living outside the autonomous region of Kurdistan, labeled as Kurdistan areas under the control of Iraqi government in figure 24, were simply told by Hussein’s regime that they had to leave their lands in a certain period of time. Otherwise the Iraqi government forced them to leave and be resettled in the autonomous region of Kurdistan that protected by alliance forces. Figure 24 provides insights about where the mass displacement occurred.

In 2003 after the US invasion, the United Nations reported:

*Secretary-General Kofi Annan's Representative on Internally Displaced Persons, Francis M. Deng, said the UN should be asked to help in resolving the issue of internal refugees, including 600,000 to 700,000 Kurds in northern Iraq, more than 100,000 Kurds, Turkmen and Assyrians in the Kirkuk area, tens of thousands of Arab Shiites in the centre
and south, and 100,000 to 200,000 Marsh Arabs in the south. At the same time, any solution had to assure fairness for more than 200,000 Arabs brought into the north by Mr. Hussein’s regime to replace the Kurds, Mr. Deng said in a statement in Geneva (UN 2003).

The internal resettlement problem has a significant impact on Iraqi political system even now. Currently a significant dispute exists between the Kurdistan Regional Government and the Iraqi government regarding any solution for the hundreds of thousands of Kurds and other ethnic groups who were forced to leave their lands and hundreds of thousands of Arabs who were brought to the North to replace Kurds. Globally the conflicts in Iraq known mostly as a pure ethnic conflict between Kurds and Arabs, but the core of the dispute centers on controlling resources, while ethnicity becomes politicized with regard to control over those resources. Water and land scarcity exists all over Iraq, but North Iraq generally and the Kurdistan Region especially comprise the richest region in Iraq, based on surface and ground water, as well as precipitation and fertile lands (Asmahel 2004).

**Environmental Instability Threats**

According to the UNCCD, desertification is causing: (1) reduction in land resilience to climate variability, (2) loss of soil productivity, (3) shrinking vegetative cover, (4) indirect impacts, such as health issues, on peoples who are living outside the direct impacted areas, (5) undermining of food production, (6) increased famine, (7) increasing conflicts and people displacement, and (8) a huge drain of economic resources as a result of influx of “environmental refugees” and decreasing national food production in addition to direct impacts on the damaged regions (UNCCD Secretariat A 2008). Therefore, desertification contributes to poverty through reducing land productivity (UNCCD Secretariat B 2008).
There are significant interactions between desertification and other important global systems such as water resources, food security, biodiversity, energy sources, climate change, and socio-economic factors. Desertification exacerbates poverty and political instability:

“It contributes significantly to water scarcity, famine, the internal displacement of people, migration, and social breakdown. This is a recipe for political instability, for tensions between neighboring countries, and even for armed conflict. Evidence is mounting that there is often a strong correlation between civil strife and conflict on the one hand and environmental factors such as desertification on the other (UNCCD Secretariat C 2008).

The consequences of desertification and soil erosion undermine the key elements of human and social security that are identified by international organizations such as food security, health security, livelihood security, and energy security. Also desertification is considered one of several factors that influence, impact, and trigger violent societal outcomes, in addition to famine and drought that exacerbate political instability (Brauch 2006). For example, North Iraq and Kurdistan are suffering from sharp declines of groundwater and its socio-economic consequences. Dale Lightfoot, an Oklahoma State University Geography Professor, stated that the Karezes in northeastern Iraq, some of them 1500 years old, are dry now as a result of lack of maintenance, overuse, and frequent drought. The livelihood of tens of thousands of villagers who depend on these water resources are under threat as a result of drought. Therefore, the relative stability of the Kurdistan region since the 2003 US invasion may suffer harm as a result of a migration underway from these villages (Lightfoot 2009).

Security is the goal of each individual, community, society and nation. The 21st century security challenges may require a new international cooperation based on narrow military

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13 “Karezes, also known as qanats, work using deep wells dug in porous soils near shallow aquifers, allowing groundwater to seep into them. Then, tunnels are dug, by hand and often through bedrock, at a gentle slope connecting the central wells to lower ones dug at strategic points in the area. Maintenance shafts peek out of the ground every 60 feet or so (Lightfoot 2009).”
concepts\textsuperscript{14} in addition to environmental instability issues. Since desertification undermines the key elements of human security such as food, health, energy, livelihood and health security, desertification and other environmental threats are considered among the major factors that threat the survival of humankind. Since the 1990s, the security concept has been broadened by scientists and policy makers to include not only a narrow political and military dimension but also economic and environmental dimensions (Brauch 2006).

The situation in the Tigris and Euphrates River basin strongly requires taking into consideration economic and environmental dimensions, in addition to narrow military concepts, to achieve regional security. To date, the narrow military concept failed to provide human, health, environment, livelihood, and food security in the nations sharing this basin. But this region of the world is woefully violent as a result of wars\textsuperscript{15} and terrorism problems. Therefore security will remain defined in terms of military and physical defense. However, reducing the environmental instability challenges in the region in the long term is as important as military and physical defense to achieve national security. For example, since the 1980s, Turkey has been involved in a costly conflict with the Kurdistan Labor Party (PKK) and up to now the situation is more critical and complicated than when the conflict started. It is worth mentioning that PKK was created by Syria in 1978 to put pressure on Turkey to provide Syria a fair share of the Euphrates River water. So the PKK case is a good example about how the resource problems can transform to military threats. The reason for the failure of the narrow military concepts to achieve national security is simply the problem is a matter of social issues, religion and ethnic diversity, human rights, natural resource issues, economic situation, political issues, and the right of self determination as a result of existing national boundaries. Acceleration of the desertification process makes the situation even more critical and vulnerable in the basin nations.

\textsuperscript{14} Having more and more power to protect ourselves from outside threats.

\textsuperscript{15} Iran – Iraq war, the First Gulf War, the Second Gulf War, Counterterrorism war, and Arab – Israel problem.
The following is a possible scenario for military threats as a result of resource problems in the Tigris and Euphrates River basins:

The decline of the Tigris and Euphrates water resources in Iraq will motivate people from damaged areas in central and south of Iraq to move toward north of Iraq to use available water resources because the Tigris and specifically Euphrates River are the only sources of water in central and south of Iraq. North of Iraq specifically the Kurdistan Region is the richest region of Iraq as measured by its ground and surface water compared with the other parts of Iraq. But the problem is that Iraq currently faces tensions among its ethnic groups. For example, there is a huge disagreement between the Iraqi Government and the Kurdistan Region Government (KRG) regarding controlling lands and oil resources as a result of internal displacement that occurred during Hussein’s administration as identified above by Secretary-General Kofi Annan's Representative on Internally Displaced Persons, Francis M. Deng.

The majority of rich water areas are located in the Kurdistan Region and therefore it might cause more tensions, perhaps the water issue will be used for political pressure by the KRG to force Baghdad to solve disputes in favor of the Kurdistan Region. It is worth mentioning that Iraq has a newly established army since 2003 and the Kurdistan Regional Government has an army of 200,000 soldiers. Therefore, any mistakes will cause devastating conflicts between both sides. To date the issue of Hussein’s internal displacement of Kurds and bringing about 200,000 Arabs to displace Kurds has not been solved. Therefore, any other movement from the south toward the north, for whatever reasons, will not be accepted by the Kurdistan Regional Government, therefore the probability of confrontation will be extremely high. It is worth mentioning that a few times both sides were at the edge of war but United States Army mediation prevented such conflict and until now US army is mediating between both sides.
On the other side of the issue, about 20 million Kurds are living in southeastern Turkey in addition to several million in Iran and Syria. Therefore, the Turkish government watches the KRG carefully, afraid of its Kurds for asking for the same right. Since 2003, Turkey located its army around Iraqi borders in case of initiation from the KRG to declare an independent Kurdistan or trying to gain more power through controlling disputed territories\textsuperscript{16}. Kurdish leaders from time to time are indirectly warning Turkey that they are able to move Kurds in Turkey against the Turkish government in case of any attacks from Turkey against the Kurdistan Region. Therefore, any problems in Iraq will move easily to its neighbors. In case of political instability in Iraq and Turkey, the other players in the region such as Syria, Saudi Arabia and Iran will automatically be involved because of the Sunni and Shiite issue. Both Syria and Saudi Arabia support Sunni groups while Iran supports Shiite groups, while the Kurdish population in Iran, Syria and Turkey support Kurds in Iraq.

In the case when the decline of the Tigris and specifically Euphrates water reaches a point in Iraq that is not able to sustain the population in central and south of Iraq, there are no options for people except moving toward where resources are available in north of Iraq or other countries. With the tensions that exist in the north, the likelihood of military confrontation is extremely high. If such conflict happens, it will look like a fire that starts from a very small spot in the forest but very soon burns the entire forest.

Therefore, achieving long term national or regional security must take into consideration environmental instability in the Tigris and Euphrates River basins. The consequences of desertification in Iraq as identified above will not remain within the Iraqi borders. Perhaps the short term scenario is the environmental emigration problem in Iraq, but the medium and long

\textsuperscript{16} Disputed Territories are the areas that the Kurdistan Region claims it should be under the KRG control officially because it was dominated by Kurds and Hussein’s regime changed the demographic fact by bringing hundreds of thousands of Arabs to replace Kurds in these regions. But the Iraqi government rejects the KRG demands in this regard. The areas that are labeled in figure 24 as Kurdistan areas under the control of Iraqi government represent the disputed area.
term will be devastating conflicts regarding the control of resources if the appropriate broadening
security concept based on physical defense and environmental instability issues are not
implemented to manage available resources in the Tigris and Euphrates Basins among the
riparian nations and to achieve regional security. Such conflicts will not only threaten the
regional and national security of the basin nations, but also will damage the entire world and
international security. For example, any conflict will disrupt the oil production processes and
supply lines, which will severely damage the global economy, leading to global crises. The
question with current environmental threats to Iraq and the basin in general is ignoring
possibilities of any environmental instability as a result of inflexible strategies regarding
ownership and using of the Tigris and Euphrates River water resources specifically by Turkey
secure any single country?

Conclusion

The Iraqi food, livelihood and health security is extremely vulnerable to climate changes
and desertification. Iraq already struggles from internal displacement by Hussein’s regime and
deliberate destruction of villages in the Kurdistan Regions and Mesopotamian marshes, in
addition to other displacement regarding changing demographics in the north of Iraq. Therefore,
the desertification problem further complicates these problems through stimulating environmental
refugees. Generally, Iraq is the most vulnerable country in the Tigris and Euphrates Basins
regarding consequences of climate change problems and its consequences as a result of its
downstream location.

The likelihood of internal and external conflicts regarding fresh water in Iraq specifically
and the region generally as consequences of Iraqi problems is extremely possible unless
appropriate strategies are followed to implement fair management of both rivers. For instance,
the relative stability of the Kurdistan Region may suffer harm as a result of migration underway
from the rural area as a result of drying karezes. However, any environmental instability in Iraq will lead to threats to all of the Tigris and Euphrates basins’ nations. Therefore, combating regional environmental instability is as important as military and physical defense in term of national and regional security.
Chapter 6

Managing the Tigris and Euphrates River Water Resources

This chapter provides details about the historical development of engineering projects on the Tigris and Euphrates River. Details about the history of negotiations among riparian nations regarding managing these two rivers are addressed. The major points of disputes among the riparian nations are addressed. Also, details about tensions regarding water resources problem that occurred between these nations is provided. This chapter is an important part of this thesis because it identified the points of disputes and type of threats as a result of the fresh water problem among the riparian nations. Knowing the nature of problems among the riparian nations is significant regarding providing recommendation to provide a model to manage water resources in the Tigris and Euphrates River. In the final part of this chapter, the recommendation is provided to find a model to manage the Tigris and Euphrates River.

Historically, Iraq was the first country to develop engineered projects in the Tigris and Euphrates Basin. Iraq started engineering projects in this basin in the first half of the twentieth century, the Hindiya barrage was built in 1913 and Al Ramadi barrage was built in 1950. The main purposes of these two dams were irrigation and flood control. While Syria and Turkey began developing dams in this basin in the second half of the twentieth century. Syria started building Al Tabqa\textsuperscript{17} dam on the Euphrates in 1966, completing work in 1973. Turkey began constructing dams in this basin in 1966; the Keban, Karakaya, and Ataturk dams were built, as a part of GAP project, in this basin in 1966, 1986, and 1992 respectively. The GAP is an interministerial or multi-purpose project in southeastern Turkey to develop the Tigris and

\textsuperscript{17} Rename “Al thawra” later
Euphrates River basins through building 22 dams on these two rivers. Details were provided about the GAP project in chapter one (Kaya 1998).

These projects were developed in each country without taking into consideration the environmental impacts of these projects (mostly dams) on the other riparian nations, the other riparian nations’ needs, and the basin’s capacity. Therefore, the distribution of fresh water in this basin, to date, continues to cause tensions among riparian nations. In the past, a few tensions occurred among the three principals. For example, near the completion of Keban dam, Syria launched a campaign against Turkey, but the situation got better when Turkey assured Syria that the dam will not cause significant harm. Also, during the time of filling Al Tabqa dam tensions rose between Syria and Iraq. Iraq threatened to bomb the dam; both countries were at the edge of conflict in 1975 and both of them moved troops to their common border. The threat of war died after Saudi Arabia and the Soviet Union mediated, and Syria agreed to release more water to Iraq. Iraqi authorities privately stated that Syria agreed to take 40% of the Euphrates water and release the rest of it to Iraq, but this agreement was never made public (Kaya 1998).

The first event among the three nations in this basin rose in 1970s, while the second major tension occurred in the 1990s during the time of filling Ataturk dam. Syria and Iraq complained that Turkey did not inform them about the cut off time, meaning when Turkey would be filling the dam and thus stopping the flow from the Euphrates southward. Turkey stated that it had informed both Syria and Iraq about interruption of the Euphrates water flow for one month according to technical necessities. Turkey even stated that it increased water flow above the 1987s protocol (500 m$^3$/sec) in order to help downstream nations store surplus amounts of water and use it during release interruptions as a result of filling the Euphrates dams in Turkey. At that time, Iraq threatened to bomb Turkey’s dams as a result of interruption of the water flow. Also, both Iraq and Syria tried going through the Arab League to take actions against Turkey and foreign companies that worked on GAP (Kaya 1998).
Negotiation and information exchange efforts began among these nations in the early 1960s. From the beginning of negotiations among Turkey, Syria and Iraq in 1964 until suspension of negotiations in the 1990s, each country adhered to its inflexible strategies concerning shared water resources. Since the early 1960s Iraq showed a strong interest in immediate sharing agreements for managing water resources, joined by Syria in the 1980s. Turkey as a new user stated that its priority is for domestic (Turkey’s) projects and showed interest in making a joint study to identify irrigation needs for each country and make an allocation agreement based on that study (KİBAROĞLU 2003).

In the negotiations held in 1964 between Iraq and Turkey, Turkey proposed to establish a joint technical committee (JTC) to inspect each river to determine the average yearly discharge, to evaluate the water needs of irrigable lands of each nation through joint field studies, and to estimate the current and future needs of water in each country in order to set up a plan sharing the Tigris and Euphrates Rivers. Following the 1964 meeting, a few more secondary meetings were organized in the region. In 1965 the first tri-partite meeting among Syria, Turkey and Iraq was held in Baghdad. The major discussion point in that meeting was exchanging technical information regarding the dams in each country (KİBAROĞLU 2003).

The deep disputes regarding an agreement to share the Tigris and Euphrates Rivers appeared in the 1965 meeting. Iraq’s delegation submitted a proposal to establish a permanent JTC to be responsible for implementation and supervision of any agreements among the nations. But Turkey’s delegation strongly rejected Iraq’s proposed draft and stated that the JTC could only be responsible for sustaining coordination of the current and future projects in the river basin. On the other hand, Syria proposed including the possibility of diverting a fraction of the Tigris water in order to cover the shortages of the Euphrates River among the responsibilities of JTC. But this proposal was strongly rejected by the Iraqi delegation and insisted on holding discussions on each river separately because each river has its separate basin. During the 1970s numerous meetings
were held among the three countries but they did not result in an agreement (KİBAROĞLU 2003).

In the 1980s Iraq took the initiative to establish a new JTC as a result of intense use of the Tigris and Euphrates Rivers in Turkey. A new JTC was established at the end of the joint economic commission between Iraq and Turkey in 1980. Syria joined the new JTC in 1983. The purpose of establishing a new JTC, as paraphrased from Kibaroglu (2003), were to: (1) discuss and finalize the water issues in the Tigris and Euphrates basin, (2) find mechanisms to determine appropriate and reasonable amounts of water that each nation would need from both rivers, (3) share meteorological and hydrological data in each country, (4) share information about dam and irrigation projects in each country, and (5) exchange information about filling reservoirs in Turkey (KİBAROĞLU 2003).

After sixteen meetings from the 1980s until 1993, the nations were not able to accomplish new JTC goals or even agree on an outline of its meetings. The main dispute points paraphrased from Kibaroglu (2003) were: (1) subject and objectives of the negotiations, (2) whether the Tigris and Euphrates should be considered a single system or the discussion should be only about Euphrates, and (3) using terminology for the final JTC objectives: whether using “sharing of international rivers” or “utilization of transboundary water courses.” Both Iraq and Syria consider the Tigris and Euphrates Rivers to be International Watercourses. Both of them insist on immediate river sharing agreements depending on the declared water needs for each country. Meanwhile, Turkey considers the Tigris and Euphrates River a single transboundary river basin and any agreements should be based on objective needs (KİBAROĞLU 2003).

JTC meetings did not reveals any insights for solutions in this basin. The UN Watercourse Convention on the law of the Non-Navigational Uses of International Watercourses, opened for signature in 1997 is not recognized by Turkey. Therefore, in
order to succeed, future efforts to solve water issues in this basin should expand JTC functions to broader scales including economic and security cooperation among them to attract all riparian nations to negotiations table (KİBAROĞLU 2003). Also, providing Turkey with details about probabilities of environmental instability in Iraq and how it might negatively damage Turkey’s national security should be a point to consider to convince Turkey to agree on a fair management of these two rivers. Of course mediation by other countries such as the United States, Saudi Arabia and international organizations such as the United Nations, Arabian League and European Union is possible. But the issue is that each nation considers these two rivers as a part of their national security and therefore it is hard to convince each player to sacrifice and create a flexible atmosphere for successful negotiations.

For example, if the Tigris and Euphrates are considered a single basin, Iraq will be the major loser because in this case the nations can divert water from the Tigris to the Euphrates. But if the Tigris and the Euphrates are considered two separate basins, Iraq will be the major winner because each basin will have its own sharing agreement and Iraq will get a fair share from Euphrates without taking into considering diversion of water from the Tigris River to cover water shortages in the Euphrates River. The reason is that Iraq contributes about 34% to the Tigris River water and therefore does not have significant problem of water shortage in the Tigris unlike the Euphrates, which Iraq does not contribute water (Asmahel 2004).

Because of the topographic characteristics of the Tigris basin, it is very hard to establish big projects in Turkey and Syria on the Tigris River. The topographic conditions in the Euphrates basin, however, are suitable for big irrigation projects in both Syria and Turkey. Therefore both Syria and Turkey are trying to push the point that the Tigris and Euphrates comprise a single basin system to get more water from the Euphrates and convince Iraq to fulfill its water demands from the Euphrates with water diverted from the Tigris. Iraq strongly rejects this idea and insists on dealing with each river as separate basins. Both Iraq and Syria insist that the two rivers are
International Watercourses while Turkey states that these two rivers are Transboundary Rivers (Asmahel 2004). Obviously, each country has a different point of view to solve the water issue in this region.

The negotiations among/between all the basin nations, including Iran, since the early 1960s have yet to produce a single significant agreement between them regarding these two rivers. But, there are a few bilateral agreements between some countries, though never applied on the ground. History shows a significant failure of these negotiations and often deepens the disputes among the nations. The delay does not favor downstream countries, specifically Iraq. As mentioned previously in this chapter, the water resources in this basin cannot meet the current and future demands of water in all the riparian countries. Therefore, the nations must develop a scheme for regional cooperation according to the basin’s characteristics based on economic, environmental, and security factors to manage water resources.

As water becomes scarce and demand increases as a result of population growth, these nations should create a new atmosphere for negotiation with new and flexible strategies that benefit all of them in order to prevent armed conflicts in the future. This thesis provides some suggestions, taking into consideration the points that each country insisted on in previous negotiations, to produce a mechanism for sharing the Tigris and Euphrates Rivers:

1. Inspect the yearly water discharge in both of the Tigris and Euphrates Basin.
2. Identify the current and future needs of water for irrigation and other uses in each country.
3. Identify the population that lives in the Tigris and Euphrates Basin in each nation.
4. Evaluate the amount of shortage of water in the basin and possibilities of covering any shortages.
5. Establish a joint committee to develop the entire basin to benefit the basin residents in all countries.

18 Some of these points were mentioned in other sections with references.
6. Direct negotiation and cooperation among all nations during the drought seasons and the allowable storage water in upstream reservoirs to minimize harm to those downstream.

7. Set up a regional cooperation system to use water resources as efficiently as possible. For example, each country should inform the others when its demand for water decreases in order to facilitate their storage of the surplus amount of water for the peak demand time instead of wasting that water.

8. Establish a neutral committee of experts to develop, assess, and observe water resources in the region in order to develop a sustainable management strategy to use water resources.

9. Establish a political committee to solve the other issues that are not related to the Tigris and Euphrates River in order to smooth the atmosphere to resolve the Tigris and Euphrates Rivers’ issues.

Without solving political issues among these nations it will be impossible to make an agreement to share the Tigris and Euphrates Rivers or most probably these two rivers will be used against downstream nations for political reasons. Therefore, the three nations should solve their political problems in order to develop the Tigris and Euphrates basin as a single ecosystem without taking into consideration the political borders because the consequences of large scale environmental decline will damage the entire basin and region directly and indirectly.
Chapter 7

Strategies to Combat Desertification in Iraq and the Kurdistan Region

This chapter provides details about methods of using local resources such as rainwater in Iraq to combat desertification. These methods include harvesting rainwater and forestry systems. Two case studies in arid and semi-arid regions, Sudan and Egypt, are provided regarding harvesting rainwater to be used as a model for using such type of techniques in Iraq. Also, forestry systems including managing vegetation cover, agroforestry systems, sand dunes fixation and establishing national park and genetic resources to combat desertification are proposed. Recommendations are provided for how to establish these systems. Generally, proposed forestry systems and harvesting rainwater techniques are suitable or possible to be implemented mostly in north of Iraq because the availability of resources such as effective precipitation, 200 – 1200 mm. But in south and central Iraq, these systems are not effective because the lack of enough annual rainfall, below 100 mm.

Rain Water Harvesting (RWH)

One of the significant methods to combat desertification in Iraq is harvesting rain water. Even though precipitation levels vary from north to south, rainwater can be harvested and be used in some parts of the country. Since Iraq is located in an arid and semi-arid region of the Middle East, two successful rainwater harvesting cases in arid and semi-arid regions, Sudan and Egypt, will be mentioned in order to show the opportunities for harvesting rainwater in Iraq.

Harvesting rainwater requires techniques for collecting, storing and distributing rainwater as efficiently as possible. The rainwater can be harvested from different places such as roofs, ground surface, and intermittent or ephemeral watercourses. The harvested water can be used for different purposes such as domestic and stock use, watering crops, fodder and tree production,
and water supply for fish and duck ponds. Depending on the water sources, different techniques have been used to harvest rainwater such as terraces, counter–ridge terracing, dams, micro-catchments, cisterns, earth dykes, wadi-bank enforcement, and earth canals (Nasr 1999).

Most of the Middle East and North African (MENA) region, including Iraq, is water scarce. The amount of seasonal rainfall is highly variable and unpredictable. Harvesting rainwater helps local people meet their water demands without needing additional amounts of water, which reduces the side effects of inefficient use of water such as desertification. Therefore, effective harvesting of rainfall can be used to control desertification. People in the MENA region consider harvesting rainwater as techniques for survival because it will increase agricultural and fruit tree productivity, control erosion, conserve soil moisture, and improve grass and rangelands conditions (Nasr 1999).

**Sudan**

Gadaref city is located in the semi-arid area of east central Sudan; it is the capital city of Gadaref state. Gadaref state is one of the major states for livestock and crop production in Sudan. Annual precipitation varies from 900 mm in the south, to 200 mm in the North; the average yearly precipitation in the Gadaref state is 600 mm. Gadaref city suffered from a shortage of drinking water for decades and imported half of its daily water requirements from Al-Showak water station 50 km away through pipes and from local salty wells, in addition to borehole wells in Abu Al-Naja area 10 km away. The situation became more complicated as a result of the consequences of climate change and a steady growth of population. Population increased from 66,467 in 1973 to 354,927 in 2007 (Ibrahim 2009).

In 1995, the authorities in Gadaref city built a small dam, Al-Saraf, on the Khor Abu Fargha stream. The purpose of building Al-Saraf dam was to protect the city from seasonal flooding. In addition to protecting the city from floods, Al-Saraf dam increased ground water
levels by a few meters in the area through infiltration of water stored behind a dam. The increase in ground water level provided a pure and safe water source for drinking, farming and other domestic uses. The first indication of increasing ground water appeared from a farmer who earlier had abandoned his farm because his well went dry, but after building the dam the farmer noticed that the well was supplied with water again. The positive consequences of Al-Saraf dam to provide sustainable sources of water to the city encouraged the authorities to build more such small dams to harvest rain water (Ibrahim 2009).

A few more small dams were built for the same purpose. Generally these dams, through increasing the ground water table, supported improved food security, helped to eradicate poverty, created recreational areas, increased water availability, improved environmental quality, improved fauna and flora conditions, increased incomes and improved socio-economic conditions in the Gadaref area. For example, before these dams existed, the farmers left their farms and people brought vegetables from far away to sell at considerable prices in Gadaref. But now the land owners and farmers are able to produce a portion of vegetable needs for Gadaref with affordable prices in addition to creating jobs for the laborers. The success of these small dams in Gadaref region encouraged the authorities to take harvesting rainwater into consideration in order to solve the current and future problems related to fresh water availability in Gadaref as a result of population growth and climate changes (Ibrahim 2009).

**Egypt**

In Egypt more than 161,000 inhabitants, 59% of whom raise livestock, depend on harvesting rainwater to raise goats, sheep, crops and fruit trees in wadis and depressions where water can be harvested. Despite some issues related to soil erosion here and there, harvesting rainwater in Egypt is considered one of the successful cases of efficient use of rainwater. For example, from 1980s to 1996, 40% of the cultivated area increased in the surveyed areas in Egypt, and this resulted from harvesting rainwater. Also, the rainwater harvesting techniques
significantly contributed to restoring vegetation cover and reversing soil erosion in degraded areas in northwest coastal Egypt (Nasr 1999).

The increase of water and soil conservation activities strengthened efforts to combat desertification and increased desert reclamation efforts. As a result of rainwater harvesting mechanisms, newly cultivated land increased by 15% among surveyed farms in Egypt with the possibility of more increases if appropriate policies were applied. Generally, rainwater harvesting motivated farmers to care more about vegetation cover, soil quality, windbreaks, and fruit trees. For example, plantations of fruit trees have increased by 30% among existing farmers. Also harvesting rainwater resulted in increasing crop production, encouraged the farmers to reduce use of chemical fertilizers and this in turn supported efforts to develop sustainable land management methods (Nasr 1999).

Harvesting rainwater techniques have significant impact on improving livestock production for Bedouin herders and farmers in Egypt. Livestock for people\textsuperscript{19} is not only a source of income, but a way of life. Livestock for farmers or Bedouin herders is like a bank. They tend to increase the quantity of their herds when they have surplus of money and convert animals to cash when they need money. Increasing the size of livestock herds increases the demand for grain (barley). The increased demand for grain encouraged farmers to increase cultivated lands through more efficient use of water and soil conservation. Also, the economic benefits from increasing grain production and livestock population increased the effort to establish more rainwater harvesting systems and more efficient use of water and land resources (Nasr 1999).

\textsuperscript{19} Farmers, herders and Bedouins
Harvesting Rainwater in Iraq

It is worth mentioning that some parts of Iraq (details were provided in chapter one) have a higher precipitation rate while other parts have lower rates compared with the Sudanese and Egyptian cases. Generally, the effectiveness of rainwater harvesting systems decreases when moving toward southern Iraq as a result of decreasing average annual precipitation below 100 mm. The Northern Iraq and Kurdistan regions are suitable for harvesting of rainwater as a result of good precipitation, varying from above 1000 mm in top north and northeastern parts of Iraq to about the 200 – 400 mm zone in the southern part of north Iraq. Rainwater harvesting techniques can be used especially in Northern Iraq as a method to combat desertification and increase the surface and ground water tables in the region, in addition to other environmental and economic benefits as addressed in the Sudanese and Egyptian cases. Also, the harvested rainwater from the north can be used to stabilize the water flow of the Tigris River in order to reduce the impact of water shortage in southern Iraq. The following are possible techniques for harvesting rainwater in Kurdistan and North Iraq:

- **RWH on farms system**: The purpose of this system is to use rainwater as efficiently as possible on croplands. This system works in a way that captures rainwater where it falls. In short, this system is designed to reduce the total run off in cropped areas by keeping rainwater in place and extending the time for infiltration. Basically the idea is conserving soil and water through increasing water infiltration into soil. Examples of such types of systems are deep tillage, dry seeding, mixed cropping, ridges and borders, and terraces (B.P. Mbilinyi 2005).

- **Micro Catchment HRW System**: The cropped land system is located in a runoff catchment area and a cultivated basin. The runoff is concentrated in a cultivated basin where the water is stored and effectively used by plants. The catchment area and cultivated basin are bordering each other. This rainwater harvesting system is
suitable for medium water demanding crops such as sorghum, groundnuts, and millet. Examples of such type of HRW system are pitting, strip catchment tillage, contour bunds, semi-circular bunds and charco dams. (B.P. Mbilinyi 2005) The following are descriptions about each system:

- **Pitting**: These are small semi-circular pits dug to break the crusted soil surface. Diameter in depth of pits is varied according to the regional characteristics. Seeds are planted in the middle of the pits; this technique is suitable in the areas that have a mean rainfall of 350 – 600 mm (Mahoo 1995).

- **Strip catchment tillage**: Mahoo (1995) describes this system as involving “...tilling strips of land along crop rows and leaving appropriate sections of the inter-row space uncultivated so as to release runoff. It is normally used where the slopes are gentle and the runoff from the uncultivated parts adds water to the cropped strips.”

- **Contour bunds**: Mahoo (1995) describes this system as, “the system consists of small trash, earth or stone embankments, constructed along the
contour lines. The embankments trap the water flow behind the bunds allowing deeper infiltration into the soil. The height of the bund determines the net storage of the structure.”

- **Semi-circular bunds**: Mahoo (1995) describes this system as following “Runoff water is collected within the hoop from the area above it and impounded by the depth decided by the height of the bund and the position of the tips. Excess water is discharged around the tips and is intercepted by the second row and so on.”

- **Macro Catchment RWH system**: This system is characterized by a large catchment area. Usually the cropped land is located outside the border of catchment area. In this system the farmers have little or no control of the catchment area. This system has intermediate elements for collecting, transferring and storing runoff. Generally in this system farmers are planting in lower lands in the region and getting water from the surrounding high lands, where the catchment is located (B.P. Mbilinyi 2005).

- **Terraces**: These are a combination of ridges and channels that intercept and hold runoff in fields characterized by moderate to steep slopes. The purpose of terraces is to decrease the force of sheet and rill erosion, prevent gully development and conserve soil moisture through retaining runoff. Strong well-maintained terraces will lead to less sediment pollution reaching lakes and streams. Terraces are used in areas with topography and soil characteristic that allows terrace construction and farming by reasonable efforts, need water conservation, and have excess runoff problem. The effectiveness of terraces depends on the climatic condition, soil
erodibility, agriculture activity, maintenance and plans. There are two types of terraces: storage terraces and gradient terraces. Storage terraces are the type that hold water until it can infiltrate the ground or be released through a controlled outlet. Gradient terraces are those that are designed in a way to slow runoff water and carry it out in a manageable way to reduce erosion such as a grassed waterway (Carman n.d.).

- **Small Dams:** Details about this rainwater harvesting method were provided in the section on Gedaref Sudan. It is worth mentioning that the Kurdistan region is moving toward developing small dams to harvest rain and snow melt in the region instead of large scale dams (rudaw.net 2010). But small and medium scale dams are facing challenges because of disputes among Iraqis to control resources, as mentioned in chapter three.

  The scale of this conflict over dam construction has already appeared through concerns raised in Baghdad about plans for small and medium scale dams to catch rain and surface water in Kurdistan Region because of the negative impacts on the rest of Iraq (rudaw.net 2010). On the other hand, authorities in Kurdistan Region claim that only small and medium scale dams will serve this region because of the regional land characteristics while large dams, preferred by Baghdad, will only damage the region through flooding fertile lands. (Asmahel 2004)

Other rainwater harvesting techniques such as counter ridge terracing, cisterns, earth canals, earth dykes (spate irrigation and small-head pumps & earth canals) and wadi-bank

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20 *Spate irrigation is a type of water management that makes use of water from “spates”, short duration floods. Spates – lasting from a few hours to a few days – are diverted from normally dry riverbeds and spread gently over agricultural land. After the land is inundated crops are sometimes sown immediately. Often the moisture is stored in the soil profile and used later. The spate irrigation systems support low economic value farming systems, usually cereals (sorghum, wheat, barley), oilseeds (mustard, castor, rapeseed), pulses (chickpea, cluster-bean), but also cotton, cucurbits and even vegetables. Besides providing irrigation, spates recharge shallow groundwater (especially in a river bed), they fill (cattle) ponds*
enforcement are used in arid and semi-arid lands of the Middle East. These systems are possibilities for harvesting rainwater in Iraq. The objectives of these systems are; soil and water conservation, storing harvested water, divert water to limited water resource areas, and divert water for irrigation (Nasr 1999).

It is worth mentioning that in Iraq the government is responsible for such type of projects. Therefore, the people or the farmers/land owners are not responsible for the costs of building these facilities for rainwater harvesting. It is the governments’ motivation to improve agricultural and environmental conditions in the country. For example, if a small dam is built in a certain area to irrigate few thousand hectares of privately owned farms, the government will own the dam but will never charge farmers for costs of building this dam. In case of flooding privately owned lands as a result of building dams, the government is responsible to provide fair compensation to the land owners. The government is also responsible for managing and maintaining the dam and sometimes guiding the farmers on how to get best benefits from available resources. In case of building such facilities on public lands, the government decides how to manage these lands, in most of the cases if the project is for agricultural purposes, the government distributes the land among local farmers but the land is government property provided freely to the local farmers to use it for a certain period of time. This period of time varies according to government policy. For example, if the land is close to a city or a town and after 20 years city is expanded, then the government has a right to take the land from the farmers without any significant compensation.

**Forestry systems to Combat Desertification**

The United Nations’ FAO identified different types of forestry activities to combat desertification and to rehabilitate degraded lands. The following are the major forestry activities to combat desertification and to rehabilitate degraded lands: (1) management of natural and they are used to spread water for pasture or forest land in some places (Frank Steenbergen, Abraham Mehari 2006)."
vegetation, (2) agroforestry systems, (3) sand dune fixation, and (4) creation of national parks and conservation of genetic resources (FAO 1993). These general forestry activities identified by FAO can be implemented to combat desertification and to rehabilitate degraded lands in Iraq.

- **Management of Natural Vegetation**: Vegetation cover has a critical role in protecting the surface soil from erosion and to control soil salinity. In addition to soil protection benefits, vegetation cover is a good source of wood, fuel wood, forage, and non wood forest products. (FAO 1993) Iraqi vegetation cover was severely degraded in the past, with details provided about Northern forests and Southern marshes in chapters one and two. Therefore, any anti-desertification actions and rehabilitation of degraded lands should pay particular attention to protecting the remaining vegetation cover and redeveloping these areas.

Restoring Southern marshes is critical to controlling and reducing the impact of dust storms that come from the Arabian Peninsula to Iraq. The effort to restore Iraqi marshlands started in 2003 through re-flooding of the drained marshes. But the challenges that remain are the lack of sufficient and sustained sources of water as a result of Iran, Turkey, and Syria’s water management policies, Iraqi use of the Tigris and Euphrates’ water for irrigation and the resulting water quality. Though there is an improvement in the Iraqi marshes’ vegetative cover from 2000 to 2005 as it is shown in figure 29 (CURTIS J. RICHARDSON , NAJAH A. HUSSAIN 2006). Generally, restoring Iraqi marshes is one of the most significant steps to combat desertification in the country.
The destruction of Iraqi date palm trees in the southern and central parts of Iraq has had a significant impact on Iraq’s environment. Part of the solution to the desert expansion issue in Iraq involves restoring this vegetative cover (mostly date palms) in southern and central Iraq. The recommendation to restore date palm orchards will depend on the causes of their declining numbers. The major cause of declining date palm orchards are fungi, pests, and lack of water, it is worth mentioning that Iraq once was producing three quarter of world’s dates and has 629 varieties of date palm trees. The challenges that confront the effort to restore date palm orchards are the lack of sufficient electricity, machinery and persistent drought, in addition to devastating diseases that attacked date palm trees (Williams 2009).

The following recommendations are provided for restoration of the date palm orchards: (1) offer government subsidies to farmers to reestablish their farms, (2) provide sufficient electricity to the farms, (3) solve the water issue, as described above, (4) promote varieties of date palms resistant to the diseases plaguing the trees, (5) research the remaining species, the rare

Figure 29: Shows the progresses of restoring Southern Iraqi Marshes until 2005 (CURTIS J. RICHARDSON, NAJAH A. HUSSAIN 2006).
species, and the extinct ones in order to put efforts in the right place, and (6) support farmers to maintain their farms.

In the north of Iraq the destruction of forests and vegetation cover have been severe. The restoration of destroyed forests and vegetation cover is not an easy task for the following reasons: (1) a massive government effort to increase grain production, (2) lack of sufficient budget availability to support forest and range land development, (3) government subsidies encourage monoculture development in the region, (4) supplementary irrigation systems encourage planting of marginal rainfall lands, which lead to damage to wild plant species, (5) climatic conditions, especially in summer, make seedling survival unlikely without irrigation, (6) costs of maintaining afforested and reforested areas is very high as a result of irrigation requirements especially in summer, and (7) lack of advanced machinery to maintain forests such as firefighting equipment.

There are signs of improvement in the forestry conditions in the Kurdistan Region. According to the Ministry of Agriculture in Kurdistan region, the areas covered with afforestation projects in Kurdistan region are about 38,701 Dunums or 9,674.25 hectares. Information is not available about the reforestation actions themselves. The infrastructure for producing seedlings is available in Kurdistan region. The available nurseries are able to produce about 4,245,000 seedlings per year if used in full capacity and properly (Agrawi 2008).

The following are recommendations to improve forestry and vegetation cover in Kurdistan Region and North of Iraq: (1) enact regulations that require each farm to have 10% to 15% of the farm area covered with trees in order to get government support for agricultural product subsides, (2) provide farmers with free seedlings that have economic value so the farmers can reap benefits from these trees, (3) establish new forestry infrastructure and restore those used in the past, (4) reduce agricultural activities in marginal and non-guaranteed rainfall regions to protect the vegetation cover over long term, (5) establish restoration projects on range and
grazing lands instead of supporting monoculture development by providing farmers with supplementary irrigation systems, (6) implement rotational grazing systems in marginal, non guaranteed and grazing lands instead of implementation of monoculture systems, (7) develop nurseries to produce seeds of wild plant species to reintroduce them to the range and grazing land, (8) establish projects to protect wildlife and reintroduce them to the ecosystem, and (9) enact strict regulations to protect forests and wildlife.

These facilities and infrastructures are owned and sponsored by government except privately owned farms. In case of establishing nurseries, restoring grazing lands and forest areas, the government owns these facilities. In most of the cases, the reforested areas will be under government observation and harvesting trees and hunting wildlife’s are prohibited\(^{21}\). Grazing land is open for the local herders but managed by the government to prevent overusing of resources. These facilities are managed by the government but it is open for public benefit. For example, if a farm owner wants to establish a living fence around his farm. The government provides him with free forest tree seedlings for that purpose. The species are mostly picked by government forestry and agricultural experts who determine the maximum environmental benefits.

- **Agroforestry Systems:** Agroforestry systems are an effective method in arid and semi-arid areas to tackle the fluctuation of rainfall amounts and the economic consequences of this fluctuation through providing various fruits, fiber, energy and fodder crops in agricultural lands. Agroforestry can also improve soil and water conservation efforts and aid environmental protection (FAO 1993). There are two types of agroforestry systems that are popular in Western Asian Countries including Iraq: windbreaks, shelterbelts and fruit orchards (FAO n.d.). The multipurpose tree species that are suitable for windbreaks

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\(^{21}\) Generally hunting is prohibited in the entire Kurdistan Region. But of course there are numerous numbers of illegal hunters.
and shelterbelts agroforestry system in Near Eastern Countries including Iraq are the following: poplars, walnuts, pines and cypresses (FAO 1993). Also, the tree species identified in appendices one and two can be used depending on regional characteristic and purposes of planting forest trees.

Fruit trees are significant with regard to their economic benefits either in agriculture fields (as a windbreaks) or in orchards. These trees provide fruit as a main product with the possibility to provide fuel wood in addition to environmental protection benefits. In Iraq, especially in the southern and middle part of the country, the government encouraged farmers to plant date palm and olive trees in agricultural fields to protect the field from weather fluctuation impacts, while improving soil quality and production capacity (FAO n.d.). In the northern part of Iraq, where the precipitation is generally greater than other parts of the country, different species are suitable to use in different agroforestry activities (Hussein 1998).

According to experiments conducted at Mosul University in Iraq in 2007, the results shows that two species of forest trees, *Robinia pseudoacacia* and *Leucaena leucocephala*, are very successful in the areas with a mean rainfall between 600 mm to 400 mm. These two species are fast growing trees and therefore they produce high amounts of biomass and green manure in a short period of time. In addition they provide other benefits such as protecting farm plants from winds and weather fluctuations, and improvement of soil structure and properties. For example *Robinia pseudoacacia* and *Leucaena leucocephala* significantly improved physical characteristics of soil such as bulk density, particle density, porosity, and infiltration rates. The improvement of soil organic matter and chemical characteristics such as pH, organic matter, total N, and K were significant too. Finally, nutrient concentration improved significantly through using both addressed species (A. Youkhana 2008).
The recommendations regarding the application of agroforestry systems in the North of Iraq and Kurdistan Region are the following:

1. Implement the right agroforestry system designs in the right places:
   - In non-guaranteed rainfall zones, place trees throughout the land in order to provide shelter for livestock, in addition to improving soil and water conservation and providing food, fodder and fuel wood,
   - In guaranteed rainfall zones, where monoculture design is dominating land use activities, use shelterbelts, windbreaks and living fences around big farms. These agroforestry designs are the best designs to motivate land owners to implement agroforestry systems in big farms because they will restrict the farm’s use for grain production. Also, the landowners will get a variety of benefits from these systems such as protecting farm from winds, while providing green manure, food, fodder, and fuel wood
   - In hilly and mountainous zones, establish terraces along contour lines to protect the land from erosion and plant forest and fruit trees and shrubs on them.

2. In addition to planting multipurpose trees in non-guaranteed rainfall zones, follow strategies to improve the quality and quantity of herbaceous species,

3. Improve efficiency of using rain water, and

4. Balance the land use and its carrying capacity.

- **Sand Dune Fixation:** Sand dune movement is a significant issue in Iraq, especially in the southern and middle parts of the country. Figure 30 below shows the geographic distribution of sand dunes in Iraq. Controlling these sand dunes is significant to combat desertification in Iraq. Two categories of methods were used to control sand dunes: mechanical methods and biological methods (AL-Farrajii 2000).
The mechanical method that covers mobile sand dunes with clay soil by using chain-tractor Bulldozer, weal shovel and leveling grader to stabilize sand dunes. The mechanical methods showed a significant success through increases in vegetative cover after stopping sand dune shifts. After stabilizing sand dunes the natural regeneration started to emerge. One to two years later the vegetation recovered. Generally, 1,250,000 hectares of sand dunes are controlled by this method in south Iraq but an area twice as big needs to be managed in the same way. The biological method provides a sustainable stabilization of sand dunes shifting through establishing windbreaks and shelter belts beside vegetation cover. Drought and salinity tolerant species of trees and shrubs are used for that purpose. About 5,000,000 seedlings were planted for that purpose, especially in southern Iraq. But about 400,000 hectares need to be managed in the same way (AL-Farrajii 2000).

Figure 30: Shows geographic distribution of sand dunes in Iraq (AL-Farrajii 2000).

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22 These lands are owned and sponsored by government.
The recommendations to combat sand dunes are the following: (1) pay particular attention to fixing sand dunes by using both mechanical and biological methods, (2) establish new nurseries and increase the productivity of the available ones to produce salinity and drought tolerant trees and shrubs, and (3) maintain and manage the controlled sand dune regions through controlled grazing and expanding sand dune fixation projects to uncontrolled regions.

- **National Parks and Genetic Resources:** As mentioned in the previous section, Iraqi forests, rangelands and natural life have been severely compromised and even destroyed since the middle ages and especially during the recent wars and conflicts. Iraq started plant genetic resources improvement activities in 1977 to collect plant species and improve biodiversity in the country through collaboration among Iraqi Minister of Agriculture, FAO and International Board for Plant Genetic Resources. But in the second Gulf War the plant genetic bank collapsed and most of its components were destroyed or stolen (FAO - Iraqi Office 2004). The only hope for restoring plant genetic bank is to use what is protected outside Iraq for instance by the International Board for Plant Genetic Resources.

Establishing national parks is a significant way to combat desertification. National Parks will assist protecting biodiversity and provide a source of drought and salt tolerant tree and shrub species in arid and semi arid zones. Desertification is eroding habitat and plant and animal population in arid lands and narrowing the genetic base of drought tolerant species in addition to depleting biodiversity. Therefore, conserving genetic resources is a significant way to promote survival and reproduce drought and salt tolerant species in arid and semi-arid lands. This in turn will increase the productivity of arid and semi-arid lands. Also, these species are playing a significant role reclaiming degraded lands (FAO 1993).
The following are recommendations to conserve and improve biodiversity and genetic diversity in Iraq: (1) rehabilitate a genetic resources center that was established in 1977 and destroyed in Second Gulf War, (2) research the current available species and their status, (3) identify the endangered and rare species and the opportunities to rehabilitate them, (4) establish genetic and biodiversity banks in different parts of the country, (5) establish national parks to protect available and native species, and (6) cooperate with international agencies such as the United Nations agencies to restore Iraq’s depleted biodiversity and genetic diversity.
Chapter 8

Conclusions

In this chapter the conclusion of this thesis is identified. The following are the major conclusion of this thesis:

1. The division of the Tigris and Euphrates River Basins among newly established nations at the end of a First World War created a complicated problem for the newly established nations in the Basin. The Tigris and Euphrates Rivers were considered an internal system during the time of Ottoman Empire and therefore there were no agreements to identify or resolve legal cases involving these two rivers but after the World War I as a result of creation of relatively newly established nations, the Tigris and Euphrates River were not considered internal (National) rivers because they were divided among new established nations.

2. The global climate change problem along with the fast growth of the region’s population created significant barriers to implement a management model that satisfies all players.

3. The destruction of Iraqi forests in the north and date palm orchards and marshlands in the central and southern regions resulted in sharply reduced vegetation cover in Iraq. Therefore, Iraq is extremely vulnerable to climate change and desertification.

4. Turkey’s GAP project, Syria’s water management strategies and Iran’s water resource plans resulted in decreasing water availability in Iraq. Therefore, stimulating recovery of Iraq’s vegetation cover is not an easy task and will require multilateral treaties based on economic, environmental and security factors among/between riparian nations.
5. Demand for increasing irrigated lands in all basin nations caused damage to the environment through increasing soil salinity, alkalinity, and changing its structure in addition to depleting biodiversity.

6. Hussein’s strategy to increase irrigated lands in response to the UN economic sanctions against Iraq along with irrigated land expansion in Syria and Turkey caused further destruction of already depleted marshlands and date palm orchards in Iraq.

7. As a result of population growth in the region, the region’s nations including Kurdistan moved toward monoculture systems in order to meet agricultural self-sufficiency and be agricultural product exporters.

8. Use of modernization theory resulted in developing a monoculture dominated agricultural system, which causes decreased land productivity in the short term and desertification in long term.

9. Identifying environmental refugees in Iraq is very hard as a result of poor security conditions. However, the population of internally and externally displaced people is above 4 million out of an overall population of about 31 million.

10. Desertification undermines land productivity, biological and genetic diversity, food production, livelihoods, health, environmental and national security.

11. Global climate change scenarios show further complications of the existing issues in the basin.

12. The Tigris and Euphrates Rivers Basin needs an interdisciplinary plan to develop the basin as a single ecosystem.
13. The basin needs regional and international cooperation based on economic, environmental and security factors in order to develop a survival strategy that confronts the regional security issues and environmental challenges.

14. The basin nations should develop advanced strategies regarding efficient use of water, combating droughts, while promoting economic and environmental development of the basin,

15. A regional and international cooperation agreement is needed to restore depleted ecosystems especially in Iraq.

16. The consequences of any conflicts regarding controlling resources among/between riparian nations will undermine regional and international security.

17. The solution to desertification in Iraq and Kurdistan Region goes beyond Iraq’s border. Desertification problems in Iraq will not be solved unless the Tigris and Euphrates River Basin Nations agree on a fair and sustainable management of these two rivers. Therefore, the internally proposed solutions are only a part of the overall solution but not a sufficient on their own.

18. Rainwater harvesting systems and efforts to increase vegetative cover are the most important methods to reduce the influences of desertification in Iraq.

19. Immediate and effective policies are required to manage lands in Iraq and the Kurdistan region to prevent further destruction of land resources through moving toward monoculture systems in response to political and economic demands.

In short, any solutions to desertification and political instability in Iraq and other countries in the basin must be based on regional cooperation among basin nations. For example,
the most important driving factor behind desertification in Iraq is water shortage in the Tigris and
Euphrates Rivers as a result of Turkey’s water management policies. Therefore, the effort must
be put toward establishing a regional cooperation agreement and set of practices in the Tigris and
Euphrates Rivers Basin to develop the basin as a single ecosystem. Implementing the proposed
strategies in chapter five are significant in some parts of Iraq such as Northern Iraq and the
Kurdistan Region. However, Northern Iraq and Kurdistan Region are not protected from
environmental refugees and dust bowls as consequences of desertification in other parts of Iraq.

Providing a timeline for implementing these proposed solutions regarding watershed
management among riparian nations is impossible because of these reasons: (1) the available
water in both rivers is not enough to meet the current and future demands and therefore each
country tries to get the best results for itself, (2) the tensions still present are rooted in historic
issues among/between nations as identified in the previous JTC meetings among them since
1960s, and (3) any negotiations among these nations opens the gate to other problems
among/between these nations, which need time to be solved.

It is possible to provide a timeline to implement rainwater harvesting systems and
developing forestry systems to combat desertification in the Kurdistan Region. Currently the
Kurdistan Regional Government (KRG) is implementing agricultural strategies in order to
achieve agricultural self sufficiency in the next five years (Kurdistan Regional Government 2009)
and to be a net exporter of agricultural products in the next ten years. But the agricultural
development strategies are unsustainable strategies because the KRG stimulates farmers to: (1)
increase the land productivity through implementing subsidized irrigation systems, (2) use
subsidies for chemical fertilizers, and (3) pursue unsustainable tapping of rechargeable or
renewable ground water.
Implementing the two proposed solutions, rainwater harvesting systems and forestry systems, to combat desertification requires 5 – 10 years through modifying the current five years (2010 - 2014) agricultural strategies that are underway in the Kurdistan Region. Even though implementing rainwater harvesting systems and forestry systems might increase the time needed to reach agricultural self-sufficiency in the short term, in the long term these two systems will make agricultural strategies more sustainable because: (1) they depend more on rainwater than on groundwater, (2) they reduce use of chemical fertilizer as a result of availability of biological fertilizer from forest trees, (3) they improve the regional ecosystem, which in turn improves land productivity, and (4) they result in soil, water, environmental, biodiversity and genetic diversity conservation benefits. Therefore both of them are attractive and high priority methods for implementation to keep the resources for future generations.
Appendix 1: Shows Natural trees forest (Native trees)-Kurdistan region-Iraq (Agrawi 2008).

<table>
<thead>
<tr>
<th>N.</th>
<th>Scientific name</th>
<th>English name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Quercus aegilops</td>
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<td>Summaq</td>
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<td>Tamarisk</td>
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<td>Olever</td>
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<td>Olender</td>
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<td>25</td>
<td>Prunus mahaleb</td>
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<td>Prunus microcarpa</td>
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<td>35</td>
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**Appendix 2:** Exotic trees in the Kurdistan Region (Agrawi 2008).

<table>
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<td>Pinus pinea</td>
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</tr>
<tr>
<td>4-</td>
<td>Cupressus sempervineas v-pyramidalis</td>
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</tr>
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<td>Cypress</td>
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<td>6-</td>
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<td>Albizzia</td>
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<td>Ailathus glandulosa</td>
<td>Quassia</td>
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<td>11-</td>
<td>Melia azedarach</td>
<td>Melia</td>
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<tr>
<td>12-</td>
<td>Robinia pseudoacacia</td>
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<td>13-</td>
<td>Pistacia vera</td>
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<tr>
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Bibliography


FAO. *Subregional report of the Forestry Outlook Study for West and Central Asia. Research*, FAO.


Kent State University’s Research Center for Educational Technology. *Can the Water Issues between Turkey, Syria, and Iraq Be Dissolved?* Research, Kent University, 2008.


UNCCD Secretariat B. "Fact Sheet 1: An Introduction to the UNCCD." *UNCCD*, 2008: 1.


