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THE AGRICULTURE SECTOR AND ITS IMPACT ON SYRIA'S WATER BASINS BETWEEN 1980 -2010.

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Abstract

In the Syrian Arab Republic, water has become progressively scarcer and the demand has exceeded the supply and the availability of extant resources. Syria is considered a country of limited water resources. The Syrian climate is characterized by two seasons: a hot dry summer and a cold wet winter. 80% of the rain falls in winter, namely from October through April, while the summer, from June to September is nearly completely dry.

Syria is principally an agricultural state, and therefore the agricultural sector is the largest water consumer. The principal causes of the shortage of water in Syria are primitive irrigation methods that are still common, despite government incentives of low-interest loans to replace them with modern systems. The lack of investment in technology and a delay in legislation regarding irrigation intensified the water shortage.

This paper will show how irrational use of water resources in the agricultural sector influences this sector negatively. The growth of agricultural areas without considering the availability of water, both extant and replenishing, lead to a substantial shortage in all the hydrological basins in the country. Moreover, over-pumping from legal and illegal wells have led to the lowering of groundwater levels, changes in the quality of the water, and the drying out of springs that the government relies upon for water collection for agricultural projects.

Keywords: *Water balance, water deficit, basin, surface water sources, groundwater, available water, water consumption.*

1. INTRODUCTION

Syria, like the other eastern Mediterranean countries, is characterized by a limited supply of water. Most of Syria is arid or partially arid, and rain falls only in winter with significant differences in amount. For example, the coast receives up to 1,500 millimeters of precipitation per year, in contrast to an annual average of only 200 millimeters in the southeastern part of the country. This difference causes a heterogeneous distribution of water that is unequal to its availability in the various water basins in the country. Most of the water basins suffer from a relative, and sometimes absolute, deficit of water. With some of the basins, their use nears their potential over even exceeds it.

Syria, like many other countries in the Middle East, has regions that are rich in water and sparsely populated, and, on the other hand, areas that are water-poor and densely populated. For example, the water available in the Damascus basin is less than 5% of all the water available in Syria, yet the population reaches 29,7% of the country's inhabitants. In contrast, the available water in the Euphrates Basin makes up 60,5% of all available water, while its

population is only 31.1% of the inhabitants of the country (Abed Rabboh, 2007). Water is gradually decreasing in Syria but the demand has already exceeded its availability and the ability to provide it from current resources (Varela-Ortega and Sagarody, 2002). Syria's population reached approximately 18,000,000 in 2002, and the renewable water resources were evaluated at 16 billion metric cubes per year. In other words, the renewable water resources reach less than 1,000 metric cubes of water per capita per year, which puts Syria in the category of a country suffering from a lack of water. If the population continues to grow rapidly, Syria may soon be considered a country with a serious water crisis (Mualla and Salman, 2002).

The situation further deteriorated towards the end of 2010 when the population of Syria reached 20,000,000 residents, and the renewable water resources remained the same as in 2002, approximately 16,8 billion cubic meters (CIA, 2010; FAO Statistical Data Base). The agricultural sector is the greatest consumer of water in Syria, using over 85% of all available water sources in the country. This makes the efficient use of water in agriculture a central issue facing Syria's governments over generations. The need for irrigation in agriculture has steadily grown in recent decades, and has nearly doubled since 1985. This point has received attention in Syria's national security policies in order to feed the country's fast-growing population which has one of the highest rates of natural increase in the world, reaching 3,7% in 1985. This rate decreased in 1996 to 2,7% (Winckler, 1998 table 2,1: p. 26) and to 2,04% according to the data of the World Bank for 2009-2010. Syria's various governments have tried to achieve a balance between the consumption of water for agriculture and the intelligent use of extant resources through advanced methods of irrigation that conserve water use (Varela-Ortega & Sagardoy, 2001).

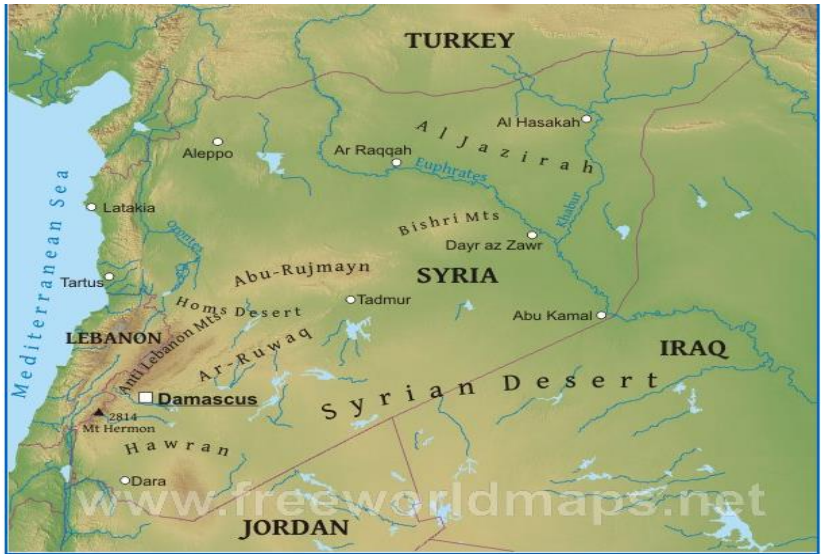
This article examines the development of the use of water resources for agriculture and its influence on the water sources in the various drainage basins in Syria. It is noteworthy that this article was completed by the end of 2010, and in March 2011 civil war broke out in Syria, making it nearly impossible to receive data from the various Syrian sources dealing with water such as the Irrigation Ministry and Agriculture Ministry. Even receiving data from outside sources such as international organizations in reference to Syria met with difficulties in the period following the outbreak of war.

2. BACKGROUND AND STUDY AREA

2.1 Syria's Geographic Location and its influence on the Water Shortage

The Syrian Arab Republic is located on the eastern Mediterranean coast. In the north, it borders on Turkey (822 km) and in the east and southeast with Iraq (605 km). Its southern border is with Jordan (375 km) and in the west, Israel (76 km) and Lebanon (375 km) and the Mediterranean Sea (193 km) (CIA, 2014).

The length of the country's borders is approximately 2,274 km, of which there are 150 km of rivers, the Tigris serves as the border with Turkey for about 39 km and another 5 km with Iraq, the El-Khabir Al-Janubi runs for about 56 km on the Syrian-Lebanese border and the Yarmuk for about 40 km between Syria and Jordan. The area of the Syrian Arab republic within these borders is approximately 185,180 square meters (Kout, 2008) of which 13,410 square meters are irrigated agricultural fields, 34,530 square meters dry-land farming (rain being the only source of water, approximately 9,030 square meters unused agricultural land, 87,950 square meters are pastureland and woods, and the remaining area is not appropriate for agricultural use (SADB, 2010).

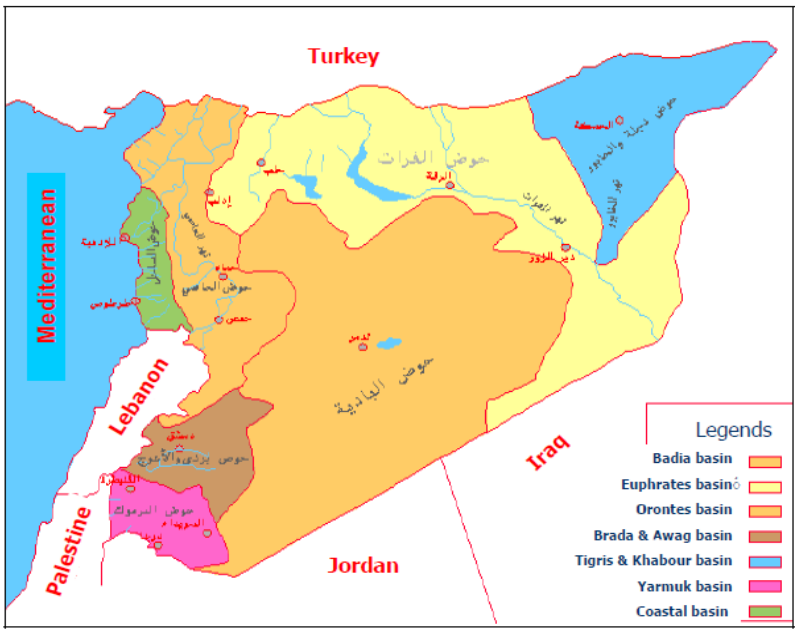


Source (free world map)

Figure 1. Topographic Map of Syria

2.1.1 Syria's Drainage Basins

There are seven principle drainage basins in Syria (Figure 2): The Yarmuk Basin, the Brada and Awag Basin, Orontes Basin, the Coastal Basin, the Aleppo Basin, the Badia Basin and the Euphrates Basin (World Bank, 2001, p.2). Other sources categorize the basins in a slightly different manner, counting the Aleppo and Euphrates Basin as one, and adding the Tigris and Khabour Basins.



Source: (Muslimani, 2009)

Figure 2. The Hydrological Basins in Syria

3. THE AGRICULTURE SECTOR, THE LARGEST WATER CONSUMER IN COMPARISON WITH OTHER SECTORS

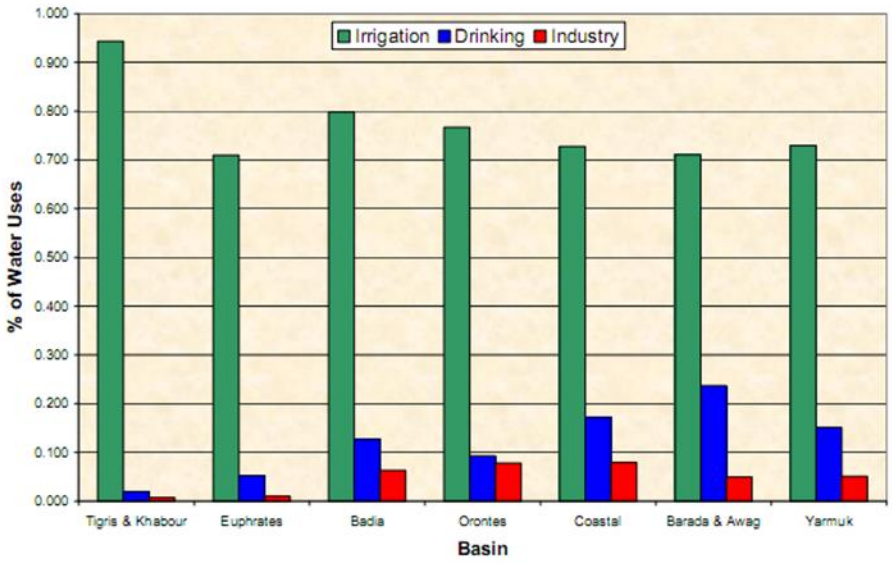
Historically, agriculture provided the principle basis for economic activity in Syria. However, in recent years the importance of the production of fuel and gas has risen. Nevertheless, the agricultural sector has continued to be significant in economic activity and has supplied a source of employment the main portion of the GNP until the beginning of 2000. After 2000, the contribution of agriculture to the GNP noticeably decreased, reaching 17,6% in 2010. In 2009, 16,4% of the workforce was employed in agriculture, as compared to 28% in 1999 and 51% in 1970. However, the percentage of those working in the industry were 32.4% in 2009, compared with 38% in 1999 and 21% in 1970. Those working in services were 51,3% in 2009, as compared with 34% in 1999 and 28% in 1970. (Richard &Waterbury, 1990, 74; Arabic News 26.3.1999; Syria Central Bureau of Statistics).

It is noteworthy that, despite the drastic decrease in the percentage of those employed in agriculture in Syria at the beginning of the first decade of the present century, this is still considered relatively high in comparison with countries with a similar GNP, such as Jordan, Iraq, and Lebanon. For purposes of comparison, in Iraq, the GNP is $7,100 and the percentage of agricultural workers is approximately 21,6%. In Jordan the GNP is $6,100 and the percentage of those working in agriculture is approximately 2,7%. In Lebanon, the GNP is $16,000 and the percentage of agricultural workers is approximately 2,5%. (CIA, 2009-2013). Because of the relatively high percentage of those employed in the field of agriculture, Syria is especially vulnerable to climate change and drought, as indeed has occurred in the present decade.

3.1 Pressures on Water Sources for Agriculture

Syria is considered to be a country with limited water sources, but there is no real danger to the supply of water for home and industrial use. These sectors do not consume more than 15% of the total amount of available water in Syria. Water for agriculture, however, is in danger of becoming sparse, since this sector requires a great deal of water. The amount of water required for agriculture reaches approximately 11,7 billion cubic meters annually, which is 93,6% of all water. Industry requires up to 0,194 billion cubic meters of water annually, and the private sector consumes up to 0,534 cubic meters per year, which is 4,7% of the volume of all water (ʿArʿar, 1997).

According to Khaldon and Brendtsson (2012), relying on the Syrian Ministry of Irrigation and Construction, in 2008 the agricultural sector used approximately 15,395 billion metric cubes of water, 88% of all water, industry used approximately 519 million cubic meters which were nearly 3% of total water use, and the private sector consumed 1,576 million cubic meters of water, which were 9% of all water used.



Source (Kaial, 2006)

Figure 3. Division of Water According to Sectors in the Various Basins in Syria.

From Figure 3 it is possible to learn that agriculture is the largest consumer of water in all the basins in Syria, especially the Euphrates/Kahbour Basin. The need for water is connected, as stated previously to the importance assigned to agriculture, especially in the 1980's. Almost 32% of the GNP comes from agriculture and nearly 31% of the workforce in Syria is employed in this field. In 2000, cultivated land in Syria was estimated to reach 5,5 million hectares, covering nearly 30% of the surface of that country. 20% of this area, namely about 1 million hectares, were irrigated. From 1985 until 2004, cultivated land that was under irrigation increased from 650,000 hectares to 1,439 million. However, since 2004 there has been a decrease and the irrigated land comes to approximately 1,239 million hectares in 2009 (SADB; Somi et al., 2001 and 2002).

The accelerated rate of growth in irrigated areas comes from the need to provide agricultural produce and the dependence on ground water sources in addition to surface sources. The use of groundwater, especially for irrigation, rose dramatically in the last two decades. In the last 15 years, between 50-60% of the irrigated areas in Syria were watered by means of groundwater pumped from wells. A good deal of the rise in the use of ground water comes from the irrigation of fields of wheat, cotton, sugar beets and citrus orchards. The cost of pumping was subsidized by the government and ground water costs do not reflect their real value because the energy required for pumping was also subsidized (Rodriquez et al., 1999).

Irrigation serves as a strategy for making agriculture more secure in arid areas like Syria. The data indicates that crops and the produce of irrigation can reach five times that of crops watered by precipitation (Allan, 1987: p.28).

The expansion of irrigation from underground water sources has brought to the nearly total exploitation of most of the country's drainage basins. Continuing to draw upon groundwater is liable to influence the runoff of water sources, such as streams, wadis/valleys, and is also in danger of causing the salinization of groundwater in areas close to the seashore. Digging new wells and the widespread use of water drawn from them, as part of the Syrian government's economic policy of supporting the agricultural sector, influenced the increase of irrigated land between 1990 and 2004 (Munlahasan, 2007). Between 1985 and 2009 irrigated areas grew by 587,000 hectares as is shown in Table 1.

Table 1. Sources of Irrigation in Various years

Year	Surface irrigated (000 hectares)	Groundwater irrigated (000 hectares)	Total irrigated area (000 hectares)
1985	334 (51%)	318 (49%)	652
1990	351 (51%)	342 (49%)	693
1995	388 (36%)	694 (64%)	1,082
2000	512 (42%)	698 (58%)	1,210
2002	583 (43%)	764 (57%)	1,332
2003	506(37%)	855(63%)	1,361
2004	574(40%)	865(60%)	1,439
2005	560(39%)	865(61%)	1,425
2006	551(39%)	851(61%)	1,402
2007	584(42%)	813(58%)	1,397
2008	595 (44%)	761 (56%)	1,356
2009	583 (47%)	656 (53%)	1,239

Source: Until 2002 Somi et al. 2002; from 2002 SADB

The increase in areas watered by groundwater grew by 338,000 hectares, which constitutes 58% of the total of additional area. The increase in areas irrigated by above-ground sources was 249,000 hectares, a 42% addition. Most of the above-ground water coming from drainage basins is supplied by dams. With the exception of the Euphrates River, most of the irrigation systems are inefficient, and the Ministry of Irrigation plans to replace the old, open irrigation systems with pipelines, and renovate the system of canals (Mualla and Salman, 2002). However, the primary goal of the government is to provide drinking water to the inhabitants. The demand for water in urban areas has grown rapidly in the last decade as a result of a high natural increase (3%) and the development of the industry. The 95% of city dwellers and 80% of the rural population have access to clean water today. The supply of water for sanitation services (in both urban and rural areas) has risen significantly with population growth (Mualla and Salman, 2002).

Syria's Minister of Construction and Housing, engineer Halah Nassar, reported that 92% of the population are connected to fresh water through the water system established by the Syrian government, while 8% receive water in containers financed by her ministry. (Interview broadcast by the Syrian satellite television channel on 31/7/2011).

The water balance in most of the drainage basins is in a deficit and the situation is likely to deteriorate further, especially in the drainage basins that serve densely populated areas. The Brada-Awag Basin, for example, is significantly lacking in both surface and ground water sources. Great efforts have been invested in order to supply drinking water to the residents, a result of the high rate of natural increase and internal immigration towards the capital. Many farmers have already reported on wells that have run dry from over-pumping in favor of other sectors (Mualla and Salman, 2002), a point that heightens internal conflicts regarding the issue of the sale of water and its use for various purposes.

Efficient use of water for agricultural needs depends on technical, economic, sociological and political factors. These factors have a mutual effect of dictating the level of general

efficiency of water use. Two actions on different levels must be taken into account in order to deal with the wasteful use of agricultural water: actions on the administrative level and on the organizational level.

3.2 The Syrian Government's Investment in Agricultural Irrigation

The investment of Syrian governments in the agricultural sector in the past 30 years has been estimated to be 212 billion Syrian pounds. The majority of that sum, approximately 194 billion or 92%, was invested in the years between 1981 and 2000. The World Bank's report, "Syrian Arab Republic Irrigation Sector Report," published on August 6, 2001, dealing with yearly allocations in the agricultural sector according to the eighth five-year plan (1996-2000), states that "irrigation receives the majority of the allocated investment, approximately 78% (World Bank, 2001, pp. 5-6). The World Bank report also shows that the majority of quality land is connected to "building infrastructure for drainage and irrigation, including storage, dam construction, pumping stations, primary and secondary irrigation, drainage systems, leveling and straining saline soil when necessary" (World Bank, 2001 p. 30).

Table 2 shows that irrigated areas have risen in the past five decades in Syria approximately 838,000 hectares, from 558,000 hectares to 1,396,000. The percent of cultivated land that is irrigated rose from 8,7% to 24,6%. On the other hand, irrigated land decreased approximately 19,000 hectares between 1961 and 1980, from 558,000 hectares to 539,000. At the beginning of the 1980's, this trend was reversed. Between 1980 and 1990, irrigated land rose 154,000 hectares, from 539,000 to 693,000 hectares. This shows a 29% growth. In the course of subsequent decades, an additional 75% increase is noted of 518,000 hectares, from 693,000 to 1,211,000 hectares. A significant increase was discernable in the seventh five-year plan between 1990 and 1995 of 57%, from 693,000 to 1,089,000 hectares.

This change is the result of the efforts of the government and the private sector. Approximately 60% of the agricultural land in Syria is watered with groundwater. All the irrigation from groundwater is developed and operated by the private sector (World Bank, 2001, p.IX). Between 1988 and 2000 the private sector increased the use of underground water from 47% to 60%. This trend continued nearly without a change in 2008. In this period, government investment in above-ground water brought about the expansion of irrigated land by above-ground water from 350,000 to 595,000 hectares, an increase of 245,000 hectares.

In contrast with irrigation in the private sector, these numbers are quite modest. Despite the discrimination against the private sector under the socialist rule in the late 1950's, that sector was able to take advantage of groundwater for an area that was twice as large as the area that was irrigated by water supplied by the government at that time (503,000 hectares vs. 234,000). On the other hand, the expansion of irrigation has led to the depletion of underground water sources and damage to their quality. The use of groundwater in an unsustainable manner led to over-pumping and pollution in various places. This explains why the administration of underground water is one of the outstanding challenges for irrigated agriculture in Syria (World Bank, 2001, p.IX). The Syrian government's efforts in the field of irrigation were expressed by the construction of 160 dams with a holding capability of 18 billion metric cubes of water. The most complicated project, which was deemed a political-economic achievement for the Syrian government was the Tabqa Dam (Alasad lake) on the Euphrates. Construction began in 1968, and the dam was dedicated formally in 1978. The dam's length is 4,6 km and 500 meters at the base, with a height of approximately 60 meters. The dam created the Assad Lake whose length is 80 km, with a width of 8 km on the average, and can hold 14 billion cubic meters of water.

Table 2. Expansion of Cultivatable Land, Permanent Crops and Irrigated Areas 1961-2009.

Year	Arable and Permanent Crops (000 hectares)	Irrigation agriculture (000 hectares)
1961	6,381	558
1965	6,599	522
1970	5,909	451
1975	5,476	516
1980	5,684	539
1985	5,623	652
1990	5,626	693
1995	5,502	1,089
2000	5,352	1,211
2005	5,563	1,426
2009	5,664	1,239

Source: FAO Statistical Database, Syrian Agricultural Database

The purpose of the dam's construction was to expand the irrigated areas to 640,000 hectares by 2000 (Europa, 2002: p. 973). In reality, only 124,000 hectares had been added by 2000, achieving only 19% of the goal. The report of Syria's Ministry of Irrigation reveals that there are plans to increase the irrigated areas with above-ground water in the Euphrates Basin between 2000 and 2020 by approximately 180,545 hectares, yielding a total of 304,545 hectares. In this way, 47% of the original planned goal will be achieved (MOI, 2001: table 17).

4. DECREASED DEPENDENCY ON INCONSISTENT RAINFALL

The government's projects expanded the irrigated areas of cultivatable land from 8,7% to 24%. Even so, this growth has not been sufficient to protect the country from the effects of fluctuating rainfall.

Table 3 reflects the fluctuations in grain yield in the past three decades in Syria, between 1972 and 2008. In 1978 the yield was 6,098,000 tons, in comparison with this, there was a decrease to 3,032,000 in 1999 (a 54% drop). Production rose slightly in 2000, and in 2001 there was an increase of 96% to 6,916,000 tons. Significant fluctuations took place in these last three decades. For example, in 1972 there was a yield of 2,562,000 tons, and in 1973 this fell 72% to 0,726,000 tons. This figure was nearly tripled in 1974 to 2,324,000. In 1988 grain production reached 5,007,000 tons. In 1989, the yield was reduced once more by 72% to 1,407,000 tons, and then doubled to 3,103,000 in the following year. In 2002 production fell once more in comparison to 2001, which had reached 5,927,000 tons of grain, and this trend continued with small changes until 2007. In 2009 there was a drastic reduction in the harvest

as a result of the drought that Syria suffered in 2007-2008, and in 2009 there was once more an increase in the yield of grain.

It is clear that the investment of the Syrian government in irrigation and land improvement projects did not solve the problem of fluctuating rainfall once and for all. Nevertheless, the government's investment in agriculture did reduce the uncertainty and the dependence upon rainfall to a significant extent.

Table 3. Grain Yield in Syria 1972-2009 (000 tones).

Year	Production	Year	Production	Year	Production	Year	Production
1972	2,563	1982	2,283	1992	4,368	2002	5,927
1973	726	1983	2,696	1993	5,393	2003	6,218
1974	2,324	1984	1,444	1994	5,397	2004	5,275
1975	2,196	1985	2,543	1995	6,098	2005	5,623
1976	2,919	1986	3,167	1996	5,995	2006	6,293
1977	1,639	1987	2,300	1997	4,325	2007	5,003
1978	2,456	1988	5,007	1998	5,270	2008	2,694
1979	1,763	1989	1,407	1999	3,303	2009	4,730
1980	3,884	1990	3,103	2000	3,512		
1981	3,559	1991	3,294	2001	6,916		

Source: Until 2001 FAO Statistical, Database: From 2001 SADB Database

Cultivated cotton fields increased significantly in the 1990's from 156,000 hectares in 1990 to 275,000 in 1998. This increase was made possible by the expansion of irrigated land in Syria, thanks to the use of water from the Euphrates dams that were constructed in 1974 and those that were built in the beginning of the 90's in the Al-Hasakah region. From 1988, due to drought and an irrigation shortage, there was a downward trend in cotton fields from 200,000 hectares in 2002-2003 to 175,000 in 2008.

Table 4. Division of irrigated Land in Syria (000 ha) between Wheat, Cotton, and Other Produce (Fruit Trees, Vegetables, Corn, etc.)

Year	Irrigated area	Wheat	%	Cotton	%	Others	%
1990	693	274	40	156	23	263	37
1995	1,089	625	57	204	19	260	24
2000	1,210	695	57	270	22	245	21
2005	1,425	855	60	238	17	332	23
2006	1,402	810	58	216	15	376	27
2007	1,397	791	57	193	14	413	29
2008	1356	730	54	176	13	450	33
2009	1,239	657	53	164	13	418	34

Source: SADB Various Years

In Syria, cotton is an irrigated summer crop that covers 20% of the irrigated land in that country. This area was estimated in 2001 to be 1,3 million hectares that use 3-4 billion cubic meters of water (Somi et al., 2001). Since 2005, and especially in 2007-2008, there has been a sharp decrease in cotton fields, reaching only 176,000 hectares in 2008-2009.

Most of the farms are irrigated by flooding, while the Agriculture Ministry encourages the utilization of modern irrigation technologies, such as dripping. This is done through

professional advice and loans that reach a total of 75,000 Syrian Pounds/Hectare (Westlake, 2001). Irrigation is considered to be one of the most important factors influencing the quantity and quality of cotton production. Therefore, various studies suggest that the distribution of sufficient water is likely to increase the cotton crop up to 50% (Somi et al., 2001).

Water consumption for cotton varies according to ecological changes such as humidity, precipitation and the type of soil. For example, a hectare of cotton in the Alghab region consumes 7,771 cubic meters of water per year, while in the Al-Haskah region, 12,408 are needed. After adopting modern irrigation methods in 1983, the crop per hectare grew from 2,800 kilograms of cotton to 4,000 in 2003 and 2005. The crop grew from 500,000 tons in 1985 to more than 1 million tons in 2001. Later, it decreased to 700,000 tons in 2006.

The wheat crop, in comparison, is dramatically different, since it depends on the type of soil. Growing wheat is based on rainfall, and the harvest tends to be low and unstable with an average of 0,5 tons per hectare in dry areas and more than 1,7 tons per hectare when the annual average rainfall is reasonable. For purposes of comparison, in the harvest of irrigated crops, where there is greater stability, the average yield reaches between 3,0 tons to 4,4 tons per hectare. Due to the instability of the wheat harvest, it is difficult to identify a trend. In general, in 1990 there was a moderate improvement in irrigated wheat yields over the yields in the 80's. Between 1997 and 2001, there was a decrease in the wheat harvest to less than 3,9 tons per hectare.

Between 1992 and 1995, there was a stable increase, reaching a yield of 4,5 ton per hectare. In 1999 and 2000, due to drought conditions, nearly 80% of the wheat came from irrigated land. In the years 1997 and 1999, there was a sharp fall in the wheat yield as a result of the severe drought that Syria suffered.

The wheat crop in Syria is based on rainfall or irrigation. The area of irrigated wheat fields grew from 200,000 hectares in 1985 to 810,000 hectares in 2006. In this way, the irrigated land approached the area of dry-farming, which totaled approximately 977,000 hectares at that time. As a result of the increase of private wells and the construction of new dams by the government in Syria, the amount of irrigated wheat fields rose, especially in the Euphrates and Khabour Basin. Wheat fields are concentrated in areas where rainfall is plentiful. In other areas, there is no alternative but to irrigate the fields in order to produce a harvest. In areas where irrigation supplements rainfall, there is no need for irrigation for the entire year. Because of this, water consumption changes in these areas from year to year, according to the amount and distribution of rainfall in the region. The two techniques used to provide irrigation for wheat are flooding and sprinkling. Sprinkling is a useful technique only in the case where the water source is a well since there is a difficulty in base sprinkling on open water channels or tunnels.

4.1 Increase of illegal wells in Syria in general and in the Damascus Basin in particular.

The development and use of underground water sources are the most important challenge facing Syria in the field of supplying water. Like in all developing countries, wells are a trusted water source for farmers (in contrast with government surface irrigation projects. The report of the Syrian North Eastern Region Rural Development project (North Eastern Region Rural Development Project, 2007) showed that in the year 2001 one of the three consecutive dry years) witnessed a 21% increase in the number of drilled wells, equivalent to about 167,000, where only 42% of them were licensed.

The report also indicates an obvious increase in the amount of actual water consumption in comparison with the water available between 1992-2002 (Abed Rabboh, 2007). The use of wells requires a license to drill and use them. The license specifies the extent of

water use and the requirement to renew every ten years. Administration and enforcement have led to a rise in the number of illegal wells. The number of illegal wells rose to 56% of the total number of wells in 2008, in comparison to 46% in 1999 (see Table 5). The number of unauthorized wells rose between 1999 and 2010 from 63,078 to 130,997, an increase of 67,919. In contrast, legal wells rose from 72,011 to 98,884, an increase of 26,873 wells. The situation reflected in the table indicates a significant decrease in the groundwater level in various areas in Syria and in particular, the Damascus Basin. In other areas, the groundwater level decreased as a result of over-pumping. Thus, for example, it turns out that 25 km south of Aleppo the groundwater level decreased over the last 20 years at an average of 1,75 meters per year (Diekmann, 2003).

Table 5. Licensed and Unlicensed Wells in Syria in Various Years.

Year	Number of wells		
	Legal	**Illegal**	**Total**
1999	72,011	63,078	135,089
2005	86,030	116,244	202,274
2006	88,408	124,716	213,124
2007	91,185	122,150	213,335
2008	91,518	130,543	222,061
2009	90,058	129,494	219,552
2010	98,884	130,997	229,861

Source: Syrian Agricultural Database

In 2001, the Syrian government demanded that the farmers act to obtain licenses for their extant wells. This step was taken in light of the yearly plan that the government had set. The goal of the plan was to make it possible for the farmers to receive loans for their agricultural expenditures from the main bank and to benefit from repayment after the harvest. Most of the users did not request authorization due to the difficulty in proving ownership over fields and wells. As of 2010, out of the total of 230,000 wells that functioned throughout Syria, only 43% were authorized. In areas such as the Damascus Rif (the rural area of Damascus), Aleppo and Dayr Azzawr, the percentage of unauthorized wells was two-thirds greater than the total number of wells there.

4.2 The need to improve the technology of irrigation methods and modernize irrigation in Syria.

Modernization in agriculture is a complex process whose goal is to achieve basic changes in the rules and regulations that influence the operation of irrigation, in order to improve the provision of water to the users. The process includes physical intervention in the infrastructure and administration. In addition, it involves political and organizational reform in the irrigation infrastructure program. The FAO, Food and Agriculture Organization, declared that “modernization of irrigation systems is a technical and administrative process for upgrading irrigation programs, alongside organizational reforms whose purpose is improved utilization of sources and supply services of water to farms”. This was said at a conference that took place in Bangkok, Thailand in 1996 (FAO, 1997).

As has been shown, Syria is a semi-arid country, with limited water resources and a growing demand for water. This demand is growing, especially after the improvement in the

state of the economy and the rise in the standard of living (Ghadban, 1993). The balance of water in most of Syria's drainage basins is at a deficit, and the situation is likely to deteriorate even more as a result of intensive irrigation, urbanization, industrialization and the high rate of natural increase. If this situation continues, it is likely to lead to negative economic and ecological influences. In order to overcome this difficult situation, there is a need to adopt administrative strategies for water preservation in various sectors.

The agricultural sector is the biggest consumer of water, with an estimated consumption of 88%, equal to 15,395 billion cubic meters, of the water used in the country (Khaldon & Brendtsson, 2012). Saving water in this sector would positively influence the balance of water in the country.

The irrigated area is estimated at 1,3 million hectares in 2009. Approximately 53% or 0,87 million hectares depend on groundwater that are constantly decreasing in most of Syria's basins (SADB, various years). Actions to make irrigation more efficient in Syria were limited to physical intervention accompanied by improving the efficiency of distribution within the farms.

The crop yield from irrigated agriculture is relatively low, from averages of wheat of 3-6 ton per hectare, and cotton at 3-7 ton per hectare (SADB, 1998). This is much less than the average crop yield in neighboring countries, such as Egypt. This low yield is a partial result of the lack of water and poor management of the water system.

Irrigation efficiency is low. It is estimated at 50% efficiency, with the exception of the Euphrates Project which is estimated at 60% (World Bank, 2001). Poor water transfer efficiency contributes to an ineffective administration of water systems. Allocation of funds for operation and maintenance made up only 10% of the budget of the Syrian Irrigation Ministry for 2000, totaling 1,556 billion Syrian Pounds. These allocations did not cover the basic requirements set for operation and maintenance (World Bank, 2001). In addition, fee and tax collection from farmers cover only 80% of operation and maintenance needs.

Most of the above-ground water sources in Syria have reached their maximum use. The country has limited capability to develop below-ground water sources and the drainage basins are in deficit. In order to achieve economic development and improve the state of the water sources, there is an urgent need for strategic change from developing water sources to administrating those water sources. In accordance with a Syrian government decision, irrigated areas will be equipped with modern irrigation technologies within the next four years. This means that a total area of 1,149,349 hectares will have to be equipped at a rate of 287,337 hectares each year. The modernization policy aims at decreasing the use of water from 12,434 cubic meters of water per hectare annually, to 8,000 cubic meters. The average amount of water used to irrigate one hectare by primitive irrigation is estimated to be about 14,446 cubic meters annually. Changing to sprinkler irrigation is likely to decrease this amount to 8,920 cubic meters, which is a 38% savings in water, and increasing the annual crop yield by 31%. In contrast, changing to modern drip irrigation would lower the amount of water used annually to 6113 cubic meters per hectare, which would be a 58% savings and yield a 35% increase in crops.

Table 6 shows the land area irrigated with modern methods in all Syria and the increase over the years. The area irrigated by modern methods up until 2009 did not total more than 282,000 hectares, approximately 23% of irrigated land in Syria. In addition, there were numerous fluctuations in the process, so that in certain years the land irrigated with modern methods decreased, as it did in 2001, 2003 and 2006. This data contradicts the aspiration of the government to convert 287,000 hectares each year to modern irrigation.

Table 6. The Total Area using Sprinklers and Drip Irrigation

Year	Drips (ha)	Sprinkles(ha)	Total(ha)	Add year(ha)
1998	8,553	80,480	89,.033	NA
2000	16,087.7	110,631.3	126,719	NA
2001	44.100	66.100	110.300	(16,419)
2002	76.400	138.400	214.800	104,500
2003	52.200	133.300	185.500	(29,300)
2004	57.500	130.200	187.700	2,200
2005	84.400	160.000	244.400	56,700
2006	72.600	163.200	235.900	(8,500)
2007	79,721	164,109	243,830	7,930
2008	91.300	162.100	253.400	28,500
2009	103.000	178.900	281.900	

Source: Varela-Ortega & Sagardoy, 2008, Syria Central Bureau of Statistics

Many farmers refrained from using these irrigation methods due to technical and financial limitations – or did not even know that they existed. Abu Shuah, a Syrian farmer from the Euphrates River region in northeast Syria the first to convert the use of primitive methods of irrigation to modern drip irrigation that draws water from the Tishrin Lake, says that he did so to save water. But since he could not prove ownership of his agricultural land, he did not receive a subsidy or help through loans. The cost of the watering system was 125,000 Syrian Pounds ($2,600) and he installed it himself according to the directions he received in the store where he bought it. Most of the farmers with whom the reporter from Syria Today spoke adopted modern drip and sprinkler irrigation and installed it themselves since they found cooperation with government elements exhausting.

Many owners of a small and medium-size farm who inherited their farms from their parents lack ownership documents. Therefore they did not receive government help and funding. In Abu Shuah's case, not receiving expert agricultural advice from the government and a lack of knowledge regarding modern irrigation systems led to obstruction in the pipes as a result of pumping saline water. Abu Shuah adds: "I also suffer from problems in the system due to blockages in the hoses from little stones and algae. I began to switch the filters at least twice a day, and I even built a small system in the lake to decrease the quantity of mud and debris, but it didn't help. I harvested the cotton in October and stopped irrigating my land with drippers. I did not save any money, diesel fuel or water." In February, Abu Shuah sold his new irrigation system for 50,000 Syrian Pounds ($1,060) and went back to using the flooding method. Like other farmers, he is unable to supply diesel fuel for pumping water (De Chatel, 2009).

5. CONCLUSIONS

The agricultural sector is the largest consumer of water in the Syrian Arab Republic. This being the case, agriculture is the principle reason for the significant decrease in underground and above-ground water sources in Syria between the years 1980-2010. Restoring the balance of water to a positive level is seen as an important national goal that requires drastic steps in some of the basins, especially those where the deficit is particularly worrisome. In light of the policy of modernization and the expansion of irrigated lands by 700,000 hectares in 30 years

(between 1980 and 2010), and the fact that some of the basins are in deficit, and others have a positive level, this indicates a need for policy change so that development should be concentrated in basins that suffer from a water deficit and preparing new land for agriculture be made possible only in basins where there is a positive balance.

Syrian farmers need to develop skills in using new methods of irrigation which will lead to decreasing the use of water to grow crops. Non-rational use of water sources for agriculture has affected this sector negatively. Growing crops without consideration of the availability of renewable and extant water has led to a real shortage in nearly all the hydrological basins in the country. Moreover, over-pumping from legal and illegal wells has led to changes in the water quality and the drying out of a large portion of the springs upon which the government depends on collecting water for agricultural projects.

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