Harnessing salty water to enhance sustainable livelihoods of the rural poor in four countries in West Asia and North Africa:

Syria

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Syrian Arab Republic

Background information

Demography

The total area of the Syrian Arab Republic (S.A.R) is 18 518 000 ha (Map 1), and the total population is 18 866 000 , of which 51% male and 49% female. The total rural population is 9 395 000 and constituting 49.8% of the total population distributed as 50.7% males and 49.3% females (The annual agricultural statistical abstract 2002). The working population is 4 821 000, 81.6 % male and 18.4% female.

Climate

The climate is mostly semi-arid and is generally dominated by the moderate climate of the Mediterranean Sea, which is characterized by four seasons. Winter season in Syria is characterized by relatively higher rainfall in comparison with the remaining seasons of the year. Temperatures are generally low during winter. Summer is hot and dry. Spring and autumn are relatively short and mild.

The rainy season in Syria starts in September over the coastal and north-east areas of the country, and it spreads out by October to cover most of the country. Precipitation reaches its maximum during December and January. The Rainy season usually ends in April for most of the country, except for the coastal area where it may last until June.

Precipitation generally decreases in Syria from west to east and from north to south. Certain gaps in the coastal mountainous terrain help to drive higher quantities of rainfall towards the inland areas. Annual precipitation in Syria ranges from 1400 mm over the western coastal heights to approximately 100 mm in the far east of the country, and from about 600 mm in the north to 100 mm in the south of the country, with the exception of the Golan Heights and As-Suwayda Mountain in the far south-west of the country where precipitation may reach 800mm and 400mm, respectively. Total annual precipitation in Syria varies between 35 and 60 billion cubic meters for dry and wet year, respectively. However, average annual precipitation is estimated at 46.76 billion m^3. Map 2 shows the mean annual precipitation quantities over Syria.

However, it is estimated that more than three quarters of the total precipitation over Syria is lost again to the atmosphere through evaporation, and that runoff alone constitutes about 4.5 billions m^3 (*calculated on the basis of 9% runoff coefficient*). Annual precipitation provides just the required quantities of rainfall which is necessary for the irrigation of about 4 million hectares of total arable lands in Syria.

The mean annual temperature ranges between 10 and 12 ºC at mountain tops of the south western parts of Syria (*i.e.*, *Lebanese eastern Mountains Series*) to 14 and 16 ºC at the top of coastal mountains series in the north-west of Syria. Temperature gradually increases to about 18 ºC as we go down west toward the Mediterranean Sea. In the eastern and south-eastern parts of the country, mean temperatures also reach about 20 ºC, whereas in the mountainous area of As-Suwayda in the south of Syria, the recorded mean temperatures are between 12 and 14 ºC. In the north, the mean annual temperature ranges between 16 and 19 ºC (Map 3).

The continent and sea effects are clear on temperature, where we can observe that in the coastal region, where humidity is usually high, and the average maximum temperatures do not normally exceed 24 ºC (*less than 18ºC at the coastal mountains*). Whereas, the mean maximum temperature may exceed 27 ºC in the eastern and southern regions of the country where relative humidity is usually low due less pronounced sea-effects. January is considered the coldest month of the year in all parts of the country, whereas August is considered the hottest month.

The Mediterranean Sea is considered the major source for humidity in Syria. We can clearly observe that relative humidity decreases during summer as we move from west to east and in a direct proportion as we move away from the Mediterranean sea (Map 4). Relative humidity decreases from 70% in the coastal region to about 45% in south-eastern parts of Syria.

There are more than 100 meteorological monitoring stations distributed all over the country (Map 5). These stations monitor: minimum and maximum temperatures, relative humidity, and wind speed and direction. Certain stations also monitor solar radiation and other parameters. Generally, the number of monitoring stations is higher in populous areas.

Agriculture in economy

Agriculture dominates the Syrian economy as the single largest contributor to GDP at about 30 percent of the total (Fig 1), employing nearly 25 percent of the workforce, with another 50 percent of the manufacturing workforce dependent on it for employment. Agriculture also employs the majority of the female workforce (Darweesh et al. 2001). The cultivated area in Syria was estimated at *5.5* million ha, i.e. about 30% of the total country area in 1998 of which about 20 percent (1.2 million ha) was irrigated. With a rural population of 40%, agriculture, and irrigated agriculture in particular, have strong impact on poverty alleviation and income distribution.

In general, the salinity of irrigation water and soil reduce the productivity as a result of increasing water potential. And due to the scarcity of fresh water, adding new sources of irrigation water, even low quality water, will increase the production of the agricultural lands and will provide additional feed for human and animal.

Water rights/issues

The right to use surface or groundwater is acquired through the issuance of water use license by the MOI (World Bank Report 2001). Whoever, installing a pump on public surface water without having a license is subjected to a nominal fine. The license can be withdrawn if the user does not comply with license conditions or if he uses water for purposes other than those authorized. At present, licenses specify discharge, well numbers and maximum depth of 150m. According to MOI officials, over 140 laws have been passed since 1924 that address water. Water use priorities have not, however, been set in any official legislation. There is, however, a widely accepted consensus among related ministries about priority of water usage. Drinking water has the top priority followed by agricultural water and industrial water. According to MOI officials, disputes over water rights and other water management issues are currently resolved through the normal court system. This often involves a committee chaired by a judge and contains representatives from the MOI, local authorities and the Farmers' Union.

In the public irrigation systems, operation and maintenance costs of the irrigation and drainage networks are charged through a flat fee of 3500 SP/ha for permanent irrigation and 600 SP /ha for winter irrigation. These fees were determined under a legal regulation established in 1999. It is interesting to note that the national average coincides practically with the amount charged as a flat rate. Actual cost of operation and maintenance for pump irrigation, is considerably higher (5,594 SP/ha) than for gravity irrigation (1,708 SP/ha.) as could be expected, and it has been reported that the percentage of payment of the stablished O&M fees is close to 90% which is very high for world standards. Beneficiaries from the public irrigation systems are also subject to a fee which intends to recover a percentage of the investment costs and ranges between 2000 to 7000 SP/ ha. The capital costs are regulated by several legislative decrees issued to recover the cost of the specific irrigation projects (MAAR 2001, Kaisi et al 2000)

Given their highly fragmented nature, the MOI has drafted a new bill to supersede and replace existing water laws. These laws are currently being considered by the Parliament. The justification for the proposed laws is based on the fragmented nature of current laws and the absence of a comprehensive and unified water law that matches the development of irrigation and land reclamation projects. The MOI expects to issue a decree in parallel with the new law to define water duties in each basin, establish separate licenses for pumps based on their capacity and establish fees for irrigating lands from wells, and the licensing of wells and pumps. The new water law also includes sections about water pollution control and legal actions in case of violations.

The Syrian farmers are operating under an area-based administered water pricing system and are not charged for the actual use of water. This system does not ensure an efficient use of water. In fact, farmers benefit from subsidies for irrigation water as well as for strategic products and inputs, which characterize the basis of the government's agricultural production plan. Currently, irrigators use large volumes of water well above what will be considered the optimal crop irrigation requirements without any penalty.

Limiting the amount of water/ha that can be used in every well considering the aquifer's recharge rate and penalizing those that exceed it with a penalty fee. However, the implementation of this measure is not easy and requires the installation of flow meters

Water Resources

Introduction:

The water resources in the Syrian Arab Republic consist of rainwater, permanent and temporary rivers, runoff and ground-water. The annual average rainfall is about (46.76 billion m^3/year) about (36.43 billion m^3) evaporates annually (i.e about 78% of rainfall) (Ministry of environmental affairs/World Bank/UNDP 2003).

The amount of the average surface and ground incoming water is estimated to be about (16.559 billion m3/year) and it is distributed into 7 water basins within the lands of the Syrian Arab Republic (Map 6). These basins are: al-Yarmuk, Barada and Awaj, the Coastal, Orontes, the Steppe, Euphrates, Tigris and al-Khabour.

Surface water resources:

The main permanent rivers in Syria have co-sharing characteristic with the neighboring countries. And in turn, the flows are not constant and affected by the on-going projects and physical conditions out of Syrian borders. The ephemeral rivers are concentrated at the coastal area, and characterized by short trunks, flash floods that cause a large part of water to be lost.

The amount of surface water is estimated to be about (4.288 billion m^3/year) that flow in rivers and valleys. It is added to these internal resources the temporary share of Syria from the water of Euphrates that amounts to more than (500 m3/s) according to the protocol of the year 1987 with Turkey. To regulate the surface flow of water and store the biggest possible amount of surface water, several dams for several purposes were constructed on the permanent and seasonal rivers.

Groundwater resources:

The amount of the renewable groundwater is estimated to be about (5.644) billion m^3/year. This renewable groundwater appears on the ground surface forming springs or it is stored in the water bearing rocks (Map 7) and exploited by means of wells.

It is necessary to indicate that the first water bearing formations starting from the ground surface (First, below- the surface water, bearing formation) that exist in the Syrian lands are vulnerable to pollution because of the high permeability of the uncovered rocks forming the formations. These formations are composed of the following:

1) Fractured carbonate and Karstic rocks.

2) Fractured basalt rocks.

3) Quaternary dolomitic and prolophic alluvial.

Map 8. Shows the distribution of water productivity of formations.

The resources of water basins:

As we mentioned earlier, Syria is divided into seven hydrological basins. In the following paragraphs, more details about the morphological, climate and water situation in each basin will be shown:

1. Al-Yarmuk Basin :

This basin is situated at the south eastern part of Syria. The AntiLebanon, the al-Haramon mountain and the occupied Golan Heights form its western part while the al-Arab mountain, its hills and slopes form its Eastern part, and between them there are the plains of Horan. The area of the basin is 6721 Km^2 and it is mostly made up of basaltic castings.

This basin is characterized by different climates varying from the climate of high mountainous areas to the climate of plains till the climate of the semi – arid areas in the eastern parts of the sector that are near al-Badieh. The average rainfall is estimated to be about 290mm. Consequently the quantity of rain that falls on this basin in a medium year with a probability of (50%) amounts to about 1930 millions m^3.

The average annual renewable incoming water in al-Yarmuk basin is about 447 million m^3, distributed as follows:

1- Ground-water: The amount of the renewable ground-water in a year of medium humidity with a probability of 50% is estimated to be about 267 millions m^3.

2- Surface water: The amount of surface water that flows in the valleys in a year of a medium humidity with a possibility of 50% is estimated to be about 180 million m^3.

Most of surface and ground-water in this basin are of good quality.

2. Barada And Awaj Basin :

The area of the basin is about 8596 km^2. This area forms the mountains that are prevailed by the climate of the Mediterranean Sea (i.e. the eastern part of the basin which is followed by the mountainous plains then al-Badieh to the East), while the semi-arid climate prevails towards the east. The rainfall is about 267 mm and the rainfall quantity in the basin in a year of medium humidity is estimated to be about /2295/ million m^3.

The average annual volume of water resources is about 850 million m^3. The main part of these water resources is situated in the mountainous region of the basin, in the Anti-Lebanon and the neighboring basins. The general direction of the surface water flow is to the depression of Damascus in the central part where the big part of the surface flow infiltrates and recharges alluvial water bearing formation.

1- Ground-water: The amou of the renewable ground-water in a year of medium humidity with a probability of 50% is estimated to be about 838 million m^3.

2- Surface water: The amount of surface water that flows in the valleys of this basin in a year of a medium humidity with a probability of 50% is estimated to be about 12 million m^3.

Ground-water movement is from west to east, and salinity increases in the same direction from less than 0.5 dS/m to more than 40 dS/m in Al-Eteiba discharge zone.

3. Coastal Basin :

It lies to the West of the Syrian Arab Republic, at the coast of the Mediterranean Sea. It is composed of a relatively narrow coastal plain where the width varies between 3 and 15 km. It is followed by the mountainous hills then the mountains. The peaks of mountains form the water divide of the coastal basin. The area of the coastal basin is 5086 km^2. This basin is characterized by moderate weather of the Mediterranean Sea, which is humid in winter and dry in summer. The annual average of rainfall in this basin is about 960 mm. Thus, the annual average volume of rainfall in this basin amounts to about 4880 millions m^3.

1) Ground-water: The average volume of ground-water which can be exploited is estimated to be about 778 millions m^3.

2) Surface water: The permanent and the seasonal rivers in addition to valleys are plentiful in the coastal basin. It is very steep in mountains and flows from the east towards the west and pours into the sea. The amount of surface flow in a year of medium rainfall is estimated to be about 1557 million m^3.

Water quality in this basin was of very good quality, with a salinity less than 1 dS/m.

4. Orontes Basin:

The area of this basin is 21624 km^2. It spreads out in the western part of the middle of Syrian till the Turkish borders. The western coastal mountains border it from the West and al-Badieh borders it from the East. The average rainfall in this basin is about 403 mm, and the annual average of the rainfall is about 8715 million m^3, while the total average of water resources in this basin is 2717 million m^3.

1) Ground-water: The amount of ground-water in the medium humid year with a probability of 50% is estimated to be about 1607 million m^3. Some of this water appears on the earth surface in the form of big abundant and small springs.
2) The surface water: The amount of renewable surface water resources in a medium year with a probability of 50% is about 1110 million m^3. This amount flows in rivers and valleys and the majority of which discharge to the Orontes River.

5. Al-Badieh Basin:

The area of this basin is 70786 km^2 and includes big parts of most of the Syrian governorates. This basin is prevailed by the semi-arid climate, as it is hot in summer and cold in winter. The average rainfall in this basin is less than 138 mm annually where the amount of rainfall in this basin is about 9800 billions m^3 in the medium humid years, therefore, most of the basin lands are alloocated for the natural pastures except some sites near the demographic settlements where they are planted with trees and some winter and summer crops “Oases”.

1) Ground-water: The amount of renewable ground-water in a year of medium humidity with a probability of 50% is estimated to be about 183 million m^3.

2) Surface water: The amount of surface water that flows in the valleys of this basin in a year of medium humidity with a probability of 50% is estimated to be about 163 million m^3.

The direction of groundwater flow is from the southwest towards the north and northeast. Since water salinity conforms to the direction of groundwater flow, the groundwater salinity also increases towards the north and northeast. The groundwater salinity generally increases from 1.2 to 12 dS/m in these directions, except in the Al Daw depression, where the salinity 100 dS/m at its center, where sodium chloride (salt) is produced.

6. Euphrates + Aleppo basin:

The Euphrates basin is located to the East of Syria and extends from the Turkish borders at the North to the Iraqi borders at the South. To the East the Tigris and al-Khabour basin follows it, while to the West both Orontes and al-Badieh basins border it. This basin includes the basin of the Euphrates valley and a big part of the Aleppo Uplift. The area of the basin amounts to about (51238) Km^2 of which (11155) Km^2 is in the Aleppo basin.

Most parts of this basin are prevailed by a cold weather in winter and a hot and dry one in summer. The rainfall varies between 400 mm in the feet of Torous Mountain and 150 mm in the south and east of the basin. The annual average of rainfall in this basin is estimated to be about 208 mm, whereas the amount of rainfall in the basin in a medium year with a probability of (50%) is estimated to be about (10658) million m^3.

The average volume of the natural flow of the Euphrates river amounts to 31.4 billion m3 per year, whereas the Syrian temporary share from Euphrates water is more than (500 m^3/s) according to the protocol of the year 1987 with Turkey and it is (6.627) billion m^3/year according to the Syrian – Iraqi agreement for the year 1989 (58 % for Iraq and 42 % for Syria).

This makes it difficult to determine an accurate water balance in Syria as the river is subject to variables outside of Syria’s borders.

In Al-Khanaser depression, south-east of Aleppo, the salinity of ground-water ranges between 2 to 3 dS/m. In Al Rassafa-Al Raqqa the salinity ranges between 7 and 14 dS/m (Joudeh 2003) and it decreased significantly after building Ba’ath dam.

7. Tigris and al-Khabour Basin:

This basin is situated to the northeastern part of the Syrian Arab Republic .The area of this basin amounts to (21129) Km^2, and its weather is hot in summer and cold in winter. The annual average of rainfall in this basin is 402 mm and the amount of rainfall in this basin in the medium humid years amounts to about 8494 million m^3.

1. Surface water resources: The amount of surface water flow in a year of medium humidity is estimated to be about 788 million m3 per year.

2. Ground-water resources: The amount of renewable ground-water in the medium years is estimated to be about 1600 million m^3.

Table 1. Summarizes the water resources in the above-mentioned seven basins:

Ground-water salinity in the Northern part of the basin is about 1 dS/m and it increases towards South to South-west to get to about 8 dS/m in the area extending between Belikh and Khabour rivers.

Map 9 shows the salinity of ground-water during late 1980 and early 1990, which was taken from Joudeh's report prepared in 2003, and Map 10 shows the composition of ground-water from the same source after reproducing it.

The recent records of ground-water salinity show a decrease in salinity . This decrease in salinity reaches 50% in some cases (i.e. the vertical drainage wells in the lower Euphrates basin). Due to the inaccuracy of the existing ground-water salinity maps and the dramatic changes of ground-water salinity, the Natural Resources Research Administration started to collect data and produce an upgraded map of ground-water in the country.

Most of the saline ground-water resources that is associated with medium to high transmissivity are located in Euphtates and Aleppo basin and Tigris and Khabour basin in addition to some parts of Al-Badieh basin (Map 8). The most recent water quality and discharge data of the well in these areas were collected, and for the ease of the classification we used the following division:

1- **Vertical drainage wells: in the lower Euphrates and Aleppo basin**:

A study on a total of 204 vertical drainage wells distributed on 8 sectors covering showed that 18% of the wells had EC between 2 and 5 dS/m, and 44% had EC between 5 and 15 dS/m, and 38% had EC between 15 and 49 dS/m. The total discarge of these wells is 13321 m^3/h. These amounts of water can be used to irrigated more than 100000 ha of land.

2- Hassaka province: Tigris and Al-Khabur basin:

A study on a total of 233 wells showed that 81% of the wells had EC between 2 and 5 dS/m, 17% had EC between 5 and 15 dS/m, and 2% had EC over 15 dS/m. The depth of these wells range between 650 and 140 m. the area irrigated on each of these wells range between 5 and 52 ha.

3- Deir Al-Zoor province: Euphrates and Aleppo basin:

A study on a total of 225 wells showed that 98% of the wells had EC between 2 and 5 dS/m, and 2% had EC between 5 and 15 dS/m. the pH of the water is between 7.21 and 7.63

4- Raqqa province: Euphrates and Aleppo basin

A study on a total of 186 wells showed that 33% of the wells had EC between 2 and 5 dS/m, and 67% had EC between 5 and 15 dS/m. Most of the well water had a pH values between 7 and 8 except some which had values outside this range.

5- Aleppo province: Euphrates and Aleppo basin:

The recent saline water quality data of Aleppo province shows an increase in salinity of the well water from southern border of the city toward the south east. The salinity of the well water collected from the second, third and fourth establishment zones had the values 5, 7, and 10 dS/m respectively (Dahan Maisoon 2004). The productivity of these wells are low (Map 8). Saline water was also found in Samaan mountain area too. The study on a total of 29 wells showed that 46.4% of the wells had EC between 2 and 5 dS/m, and 55.4% had EC between 5 and 15 dS/m. Most of the well water had a pH values between 6.6 and 8.1 .

6- Homs province:Palmyra area in Badieh Basin:

Both the upper and lower aquifers are found in the Palmyra basin. The lower aquifer in this area consists of limestone and dolomite of the Cenomanian-Turonian age. The lower aquifer is generally confined and could be tapped by wells of depths ranging from 160 to 450 m. Present recharge to the aquifers in the Palmyra Basin is rather low. The upper aquifer has higher salinity than the deep aquifer in this area. Most of the farms and oases in the Palmyra area have wells tapping the shallow upper aquifer, which is over-developed. They have high salinities, ranging from 2,000 to 8,500 ppm. The salinity of the deep aquifer ranges from 1,100 to 1,500 ppm.

7- Homs province: Al-Dawwa area in Badieh basin:

The groundwater salinity ranges from 1,000 to 90,000 ppm distributed as follows:

- The groundwater salinity ranges from 1,000 to 1,500 ppm, in the southwestern area of the basin (Al Baida Town).

- The salinity gradually increases southward from this road to about 4,500 ppm in Marhatan, and eastward to reach about 8,000 ppm near Al Maqsam town.
- The groundwater salinity in the northern part of the basin is moderate, ranging from 2,000 to 2,500 ppm.
- Between the northern and southern zones, and in the middle of the basin, the groundwater salinity increases to about 90,000 ppm.

8- Rural Damascus province: Barada-Awaj basin:

Groundwater in the central and southern part of the Damascus plain is generally fresh. The dissolved solids content in these areas ranges from 500 to 800 ppm. The salinity increases eastward and northward, and exceeds 10,000 ppm in Ateibeh Discharge zone. The annual groundwater flow into the discharge area is estimated at 250 million m^3/yr. The salinity reaches 60,000 ppm in the northern parts of Ateiba Lake.

From above discussion we find Euphrates and Aleppo basin is the most promising basin for biosaline agriculture because of the presence of saline water and its medium to high productivity. If we rank the possible success in descending order it can be as follows:

1. The vertical drainage wells in the lower Euphrates basin.
2. The regular well in Deir Al-Zoor province

3. The regular well in the North Eastern part of the country
4. The saline wells in Raqqa province

Rural poverty

The GDP of Syria increased from \$42.2 to \$59.4 billion during 1999 to 2002 (CIA world Factbook 2003) (Fig. 2). The per capita GDP is \$3609.78. The population below national poverty line is 4 500 000 , which is about 24% of the total Syrian population, 3 500 000 of them live in the rural areas which is about 37% of the rural population. The literacy between females is about 64% according to 2003 estimate and between males is about 89.7%. The number of people who are working in agriculture is 1 462 000 according to 2002 statistics, 946 000 of them are males and 516 000 females. The agricultural sector provides about 29% of the natural income. According to 2000 statistics, female enrolment share – primary level is 47.2% and female enrolment share - secondary level is 46.4%. Infant mortality rate ranks 90th in the world and is decreasing with time (34.86, and 31.67 deaths/1000 live births in 2000 and 2003 respectively (Fig. 3). The percentage of the Syrian population with access to piped water is 98% in the urban areas and 38% in the rural areas.

The socio-economic survey studies of the nomad families in the Syrian Badieh showed that the percentage of nomads capable of working (10 to 55 years old) constitute 55% of the total Badieh's population. Cheap herding is the main job of the nomads, in addition to a very small rate depend on agriculture and other free jobs (Darwish et al. 2001). The nomadic families provide most of the water needed for their sheep herds and municipal use from the scattered wells, dams, springs, and

Khabras, while they buy their drinking water from traversing tanks as they provide it by their trucks. The ownership of the nomads families of sheep fall in one of these categories:

33.5% own less than 50 sheep

43% own between 51 and 200 sheep

17.5% own between 201 and 500 sheep

6% own more than 500 sheep

The 1.5 million nomads who live in the Syrian Badieh have 3 types of living:

1- 250 000 who are stable and connected to agricultural production
2- 750 000 semi stable
3- 500 000 non stable.

Below 6 years old kids, get infected by a large number of diseases and diarrheas such as chicken bugs, rubella, malaria, eye diseases, ….

Current status of the farming systems of the Syrian Arab Republic

The current status was described and mapped (Map 11) according to Wattebbach (2004) by the following:

1. **Coastal intensive irrigated farming system (FS1):** This farming system covers 140 000 ha along the Mediterranean cost. It contributes a very high share of its specialized products, especially citrus and greenhouse crops. Small average sizes (1.3 ha invested land) reflect the high population density and result in a disproportional share of holders (5.6%) compared the size of the broad farming system.

2. **Hilly and mountainous farming system (FS2):** Cover the Syrian western mountains from Lattakia and Rural Damascus to the northern hills in Idleb and Aleppo governorates. The basic farming systems characteristics of the broad farming systems are their smallholder structure based on tree crop cultivation and high reliance on off-farm income and little livestock presence. The agricultural income of the producers depends mainly on Olive, apple cherries and tobacco.
3. **Farming system of the northern and north-eastern plains (FS3):** Are the largest in terms of area (4.7 Million hectares), covering one quarter of the national area, one third of the agricultural holders (346 000 ha) and almost half of the invested land (2 570 000 ha, i.e. 47%). A high dependence on so-called strategic crops, relatively large holding sizes and low marked access conditions characterize these farming systems. Rainfall levels are in parts relatively good and are in other (large) parts improved with public investment or private wells. Crops considered strategic by the government, especially wheat (51%), cotton (6%) as well as barley (18%) and olives 6%), dominate the invested land in the farming system. The latter are the result of recent government projects in the western part of the system. The irrigated farming system is based on large-scale irrigation schemes covering approximately 180 000 ha.
4. **Farming systems of Al Ghab and the central rainfed and irrigated plains (FS4):** the Farming systems of Al Ghab and the central rainfed cover an area of approximately 1.15 Million hectares (6.3% of national) along the central section of the international road, which also

connects Aleppo and Damascus. The intensive irrigated farming system of Al-Ghab is the only farming system, which is already a separate unit in the agricultural statistics of MAAR. The most dominant crops are wheat (52% of invested land), followed by industrial crops (cotton 13.6% and sugar beet 11.1). The farming system further includes 17% of the national irrigated potato area and is a major contributor to the national market.

5. **Farming systems of the southern semi-arid mountains and plains(FS5)**: cover an area of 1.9 Million hectares (10% of total), of which 610 000 ha are cultivable (2/3 of which are invested). The systems contain an estimated agricultural population of 1 million and are bordered by agro-pastoral system to the east and north-east, while Jebel Sheickh of the neighboring hill farming systems (FS2) is an landmark towards the north-west.
6. **Pastoral and agro-pastoral farming systems (FS6):** represent slightly over half (ca 10.2 Million hectares, i.e. 55.2%) of the Syrian area, making it the largest farming system in terms of size (Dayoub K 2003). Accordingly the system includes about 1.5 Million inhabitants, who jointly raise the far majority of the 14 Million sheep. Of the broad farming systems, 890 000 ha are invested land and slightly above 70% of the cultivated area was planted with barley.

The analysis of irrigation water sector in Syria at national aggregated level and at regional basin's level by Valera-Ortega and Sagardoy (2001) showed that irrigated lands are not distributed evenly across the country and most concentrate along the Euphrates river, in the coastal areas and in the central regions. The size of the irrigated holdings is substantially smaller than the size of the rain-fed holdings and varies distinctively across regions (governorates). At nations' level, the average holding size is 9,2 ha and for irrigated farms is 3,6 ha (Fig. 4). Larger holdings grow mostly extensive crops such as wheat and cotton, as more intensive crops such as sugar beet, potato, tomato and maize are grown predominantly in medium size farms. Vineyards are basically grown in reclaimed mountain and hill areas whereas intensive corps such as vegetables are grown primarily in the coastal smaller farms and in the outskirts of the urban districts. Fruit trees are planted largely in rainfed lands in newly reclaimed territories in the central regions and also in the coastal areas. The distribution of the irrigated areas by basins is reflected in Table 2. Surface irrigation is the prevailing irrigation system in Syria covering about 90% of the irrigated area. Basin irrigation is the predominant technique used in surface irrigation and most of the irrigated wheat and barley are irrigated by this method. Irrigation field efficiency is reportedly low (often 40% to 60%). Cotton and vegetables are irrigated by furrows and because the land is rarely leveled the efficiency of such technique is also low.

The average consumption of the irrigated hectare is 12,434 cubic meters per year and that the average consumption of the irrigated hectare in the Euphrates basin is 16,750 cubic meters per year. This is a significantly huge quantity that necessitates a serious reconsideration of the irrigation methods and shifting to modern irrigation systems. There are also numerous small and medium size irrigation networks that operate with waters coming from rivers or springs and managed by cooperatives. In these irrigation systems land holdings tend to be very small and the cooperative is responsible for providing its members with a large number of services such as the maintenance of the irrigation system, the distribution of water, the provision of inputs and the sale of produce. Water distribution is normally organized by groups of farmers that receive water from the same canal . The water in the main canal and pumping station is managed by a hired person or sometimes by the leaders of the cooperatives. Water in the lateral canals is

Prospects for biosaline agriculture

Since agriculture uses around 80% of water resources, non-conventional water resources (saline drainage water, brackish groundwater, waste-water) new approaches for water planning and management are needed if escalating conflicts are to be avoided and environmental degradation is to be halted and reversed. Clearly, there is an urgent need to use non-conventional water resources to meet the present and future needs.

The main objective is to reduce the demand on fresh water and reduce the drainage water volume by reusing the saline brackish and agricultural drainage water in biosaline agriculture production system that is sustainable, environmentally sound.

Therefore, we should focus on water, crop, farming system, and soil management. The economic value of using saline water resources can be considerable, but without careful management, irrigation can lead to the over-exploitation of aquifers close to the sea, resulting in seawater intrusion and causing contamination of irrigation water, and reduce the river water quality because of receiving saline drainage water. It is wise to combine scientific and practical expertise to tackle challenges for sustainable production in the country. That can be achieved directly and indirectly fulfils several objectives:

- **Determination of the area having saline water that can be used for biosaline agriculture**: previous studies and data collected showed the presence of such water as saline ground-water and presented in Map 9 and 10, in addition to over 1 billion cubic meter of agricultural drainage water concentrated on Euphrates rives – Aleppo basin. The analysis of the available data shows that the salinity (quality) of such water is changing with time. For example the average electrical conductivity of over 200 vertical drainage wells spread along the lower Euphrates basin (180 km long and 12 km wide) deceased significantly during a short period of time (6 month) (Based on data collected through GCSAR for this study, Table 2). A similar trend (reduction of the EC of the vertical drainage wells) was presented by Affat B in a workshop on traditional and non-traditional water resources in the Syrian Arab Republic, 27/3/2002. The total discharge of the above mentioned wells is 4770 l/s which is equivalent of about 150 million m^3/year. The dominant anions in the water are Cl and SO_4, and cations are Ca, Na and Mg. These wells are distributed over 125 000 ha of lands in the lower Euphrates basin. Monitoring the EC of the water withdrawn from a new dug well in the same area during 1998, 1999, 2000, 2001 and 2002 showed a decrease of The EC in the order 33, 27.27, 22.3, 17.04, and 15.2 dS/m (Khalifa et al. 2003). Taking advantage of the saline water produced by these well could produce salinity tolerant forage plants and reduce Easting and Westing of nomads with their sheep in the Syrian Badieh looking for food for their sheep. Similar approach can be adopted in the other parts of Euphrates basin and other basins where agricultural drainage water collected from the covered horizontal drainage system. These saline drainage water (EC ranges between 5 and 15 dS/m) totals over 1 billion m3/year.

- **International and regional Cooperation:** which involves scientific exchange across several countries in many areas such as genetic resources, saline water management, soil reclamation (leaching, chemical amendment, biological amendment, …). It promotes international and regional cooperation.
- **Scientific approach:** by applying modern techniques and innovative approaches to water resources problems. It supports the achievement of scientific excellence within the wider international framework at an international academic standard. Moreover, by using scientific approach dissemination of the achievements to the end user can be done easily and with confidence.
- **Selecting the most appropriate salt tolerant plant species:**

The overall goal is to contribute towards the sustainable use of saline water resources in the region where conflicting demand for water is combined with a wide range of hydrological, social and economic conditions.

Based on interdisciplinary investigations involving hydrology, spatial analysis (geo-informatics) and agronomy, water management, plant physiology, socio-economy and soil science improved methodologies will be applied. Since agriculture represents the major user of water, improved agricultural practices that enable smaller water consumption will be valuable. These results, together with the biophysical data collected during the project, will form the basis of a decision support system employing multi-criteria analysis, in order to derive various mutually agreeable water management schemes in a participatory approach. This will form the basis for recommendations on sustainable water management practices under current and possibly decreased precipitation rates resulting from climate change. This, will enable improved water management practices in the country.

Figure 5 shows a schematic representation of a basin wide inter-connecting drainage systems and disposal of drainage effluents in the context of management of agricultural drainage water quality to explain the potential impacts at basin wide scale and implement appropriate mitigation measures**.** It includes a combination of interventions at all levels, from on-farm level to regional and basin levels.

Conclusions

Due to the availability of old maps for the distribution of saline ground-water, the production of a new map for ground-water quality is advisable, in addition to a map of saline agricultural drainage water. These maps with other maps of soil type and geomorphologic maps and with the use of GIS technology could help in selecting pilot areas for executing a project of using such water in biosaline agriculture for further dissemination to other promising areas.

The proper use of saline water could help the establishment of nomads, reduce the poverty in the country especially in the Syrian Badieh and rural areas. Increase the Syrian GDP through increasing fodder for the existing sheep and goat herds in the country. In addition to reducing the need for governmental support of animal feed during the dry season.

Moreover, improving the establishment of nomads in the areas producing fodder for animals will increase literacy, educated women in the rural areas and Syrian Badieh.

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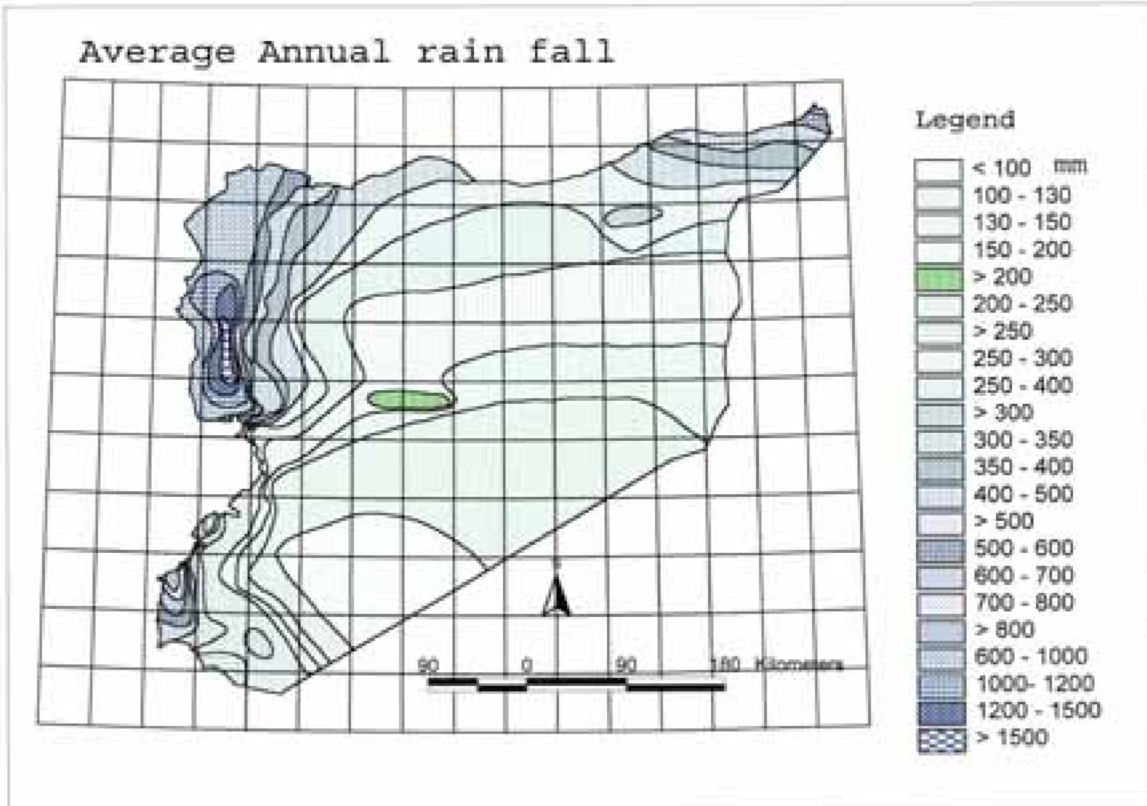
Table 1. Water resources in the Syrian Arab Republic.

Basin Name	Basin area Km^2	The annual average of rainfall		Evaporation mm	The average of the annual resources / million m^3		
		Rainfall average mm	Rainfall amount billion m^3		Surface	Ground	Total
Al–Yarmuk	6724	290	1949090	1502	180	267	447
Barada and Awaj	8596	267	2295132	1445	12	838	850
Coastal	5086	960	4882560	2547	1557	778	2335
Orontes	21624	403	8714472	5997	1110	1607	2717
Al-Badieh	70786	138	9768468	9422	163	183	346
Euphrates &Aleppo	51238	208	10657504	9408	7105	371	7476
Tigris &Al-Khabour	21129	402	8493858	6106	788	1600	2388
Total	185180	252.5	46761084	36430	10915	5644	16559

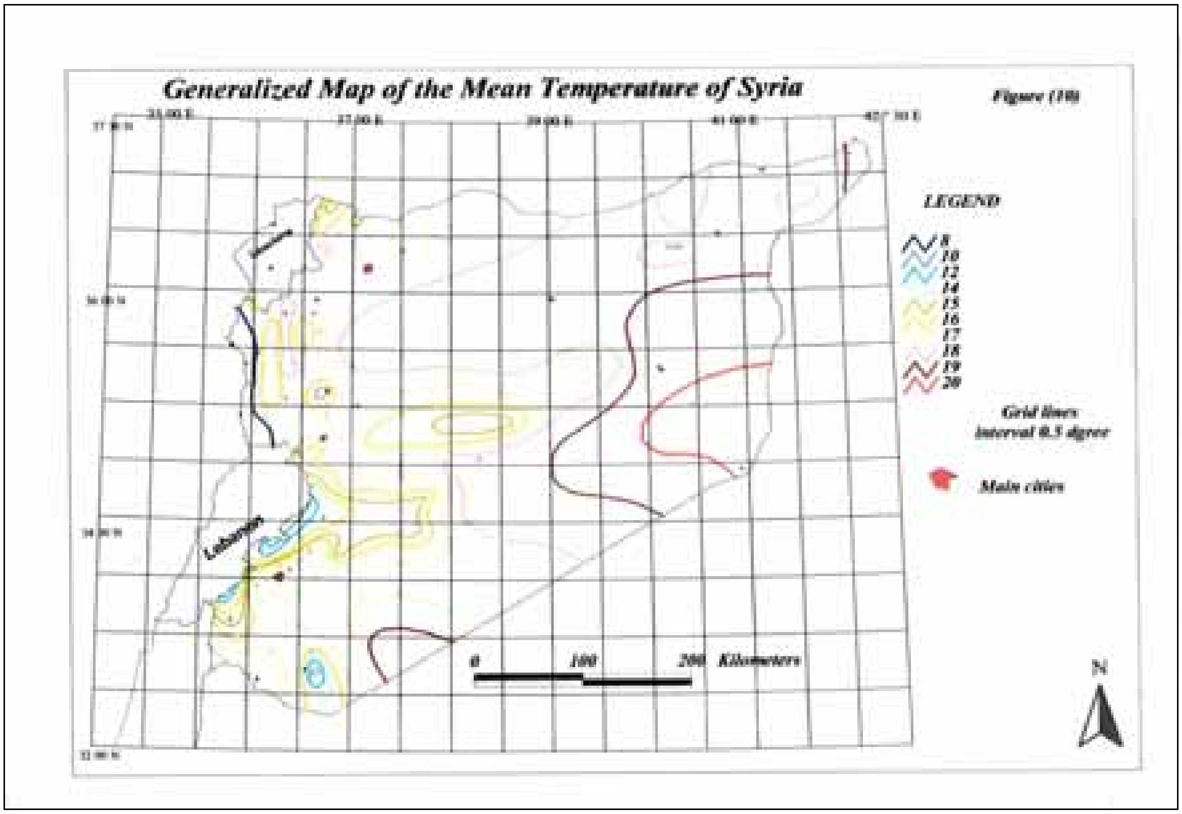
Table 2. Electrical conductivity values of 8 sectors of vertical drainage wells in the lower Euphrates basin during 2003.

Sector	# of wells	Average EC dS/m	
		May 2003	November 2003
1	3	6.82	5.52
2	5	4.00	3.03
3	43	16.76	15.79
4	5	8.4	7.5
5	47	11.35	15.46
6	10	8.19	5.34
7	72	15.55	15.00
8	19	12.84	10.22

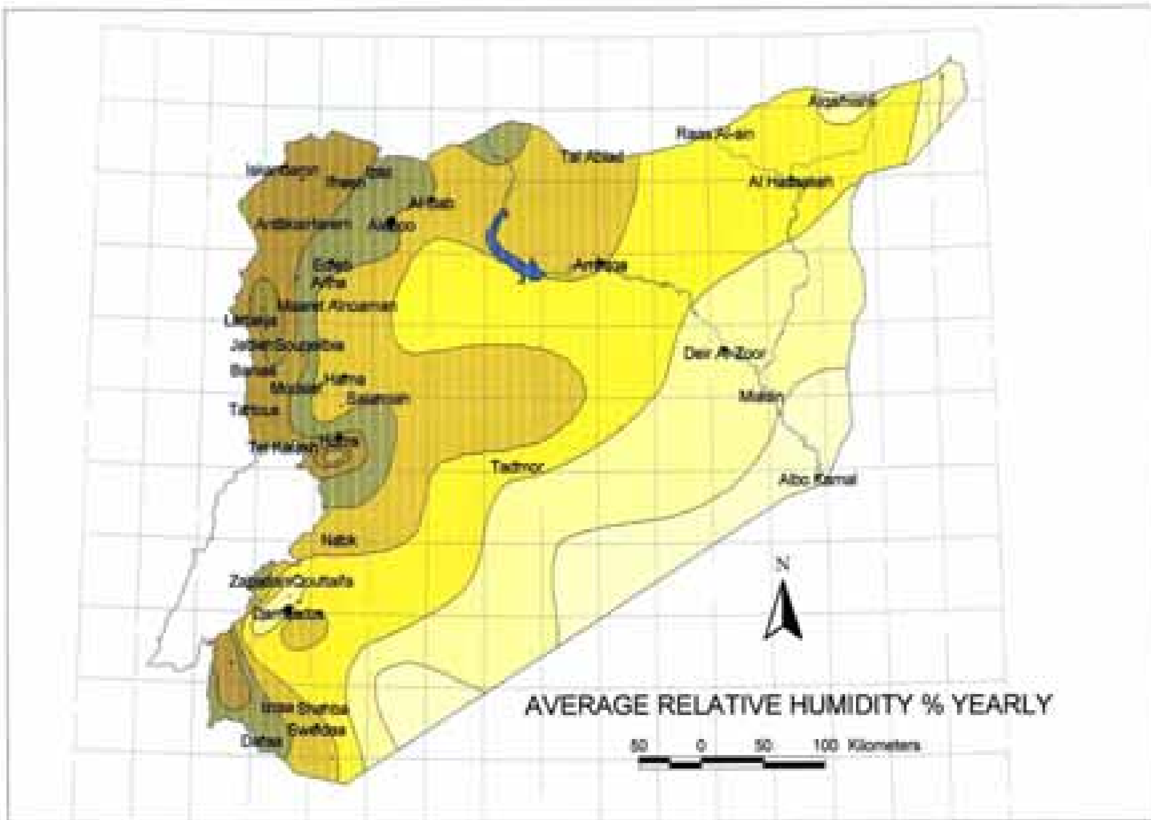
Map (1): Location of the Syrian Arab Republic in the Middle East Region.



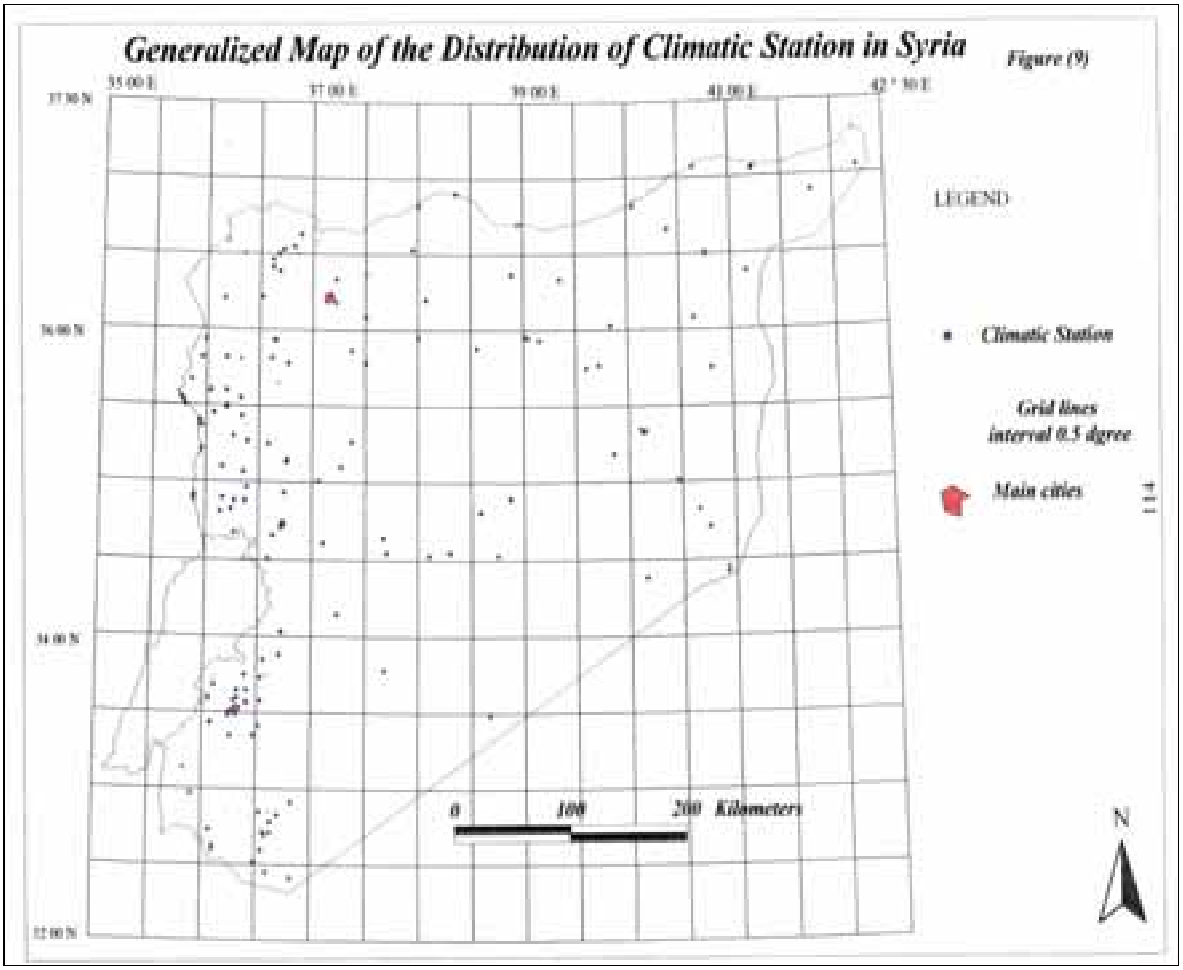
Map 2. Spatial Distribution of Annual Precipitation over Syria



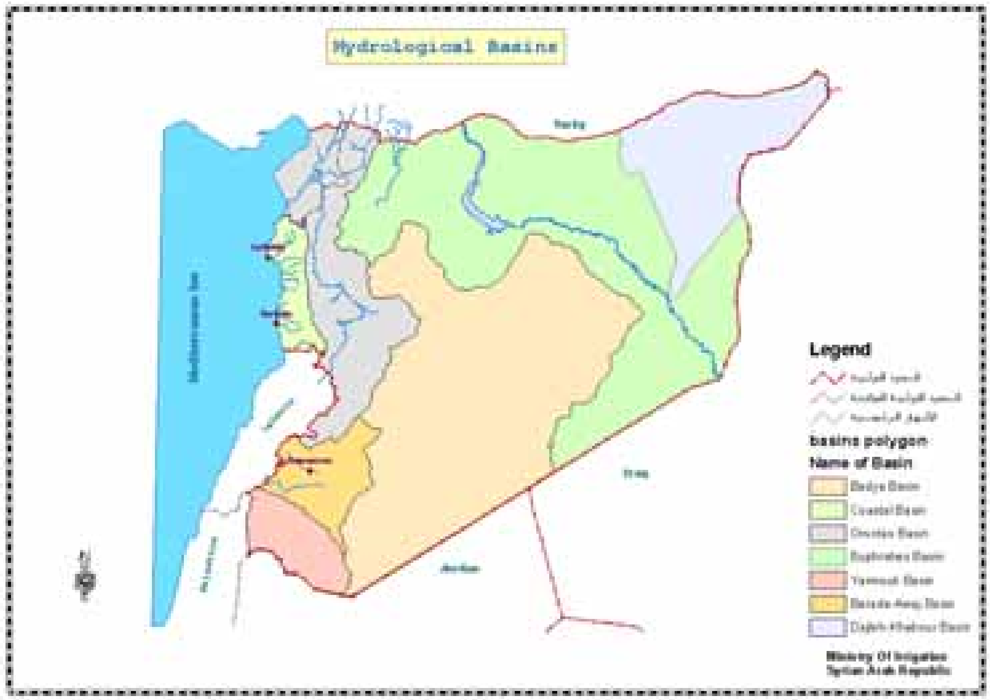
Map 3. Mean temperature in Syria



Map 4. Average relative humidity



Map 5. Spatial distribution of weather stations in Syria.



Map 6. The hydrological basins in Syria