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Ministry of Local Administration and Environment

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# Vulnerability Assessment and Possible Adaptation Measures of Water Resources

## (Water Policy)

***Related to the Project Activity***

Programs Containing Measures to facilitate Adaptation to Climate Change

***Project Title***

Enabling activities for preparation of Syria's initial national Communication to the UNFCCC, (Project Nr.00045323).


***National Project Director***

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Project Title: "Enabling activities for Preparation of Syria's Initial National Communication to UNFCCC", (Project Nr. 00045323).

The project implemented in the ministry of local administration and Environment (MLAE)/General Commission of Environmental Affairs (GCEA), in collaboration with Global Environmental Facility (GEF) and United Nation Development Programme (UNDP) in Syria.

# Vulnerability Assessment and Possible Adaptation Measures of Water Policy

(INC-SY_V&A_ Water-Policy -En)

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**March / 2009**

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*This report has been approved unanimously by the technical committee, during the Technical Workshop which took place on 24/ 03/ 2009 in the Dedeman Hotel Palmyra.*

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# 1. Water Resources

## 1. 1. Precipitation

Syria is considered as an arid to semi arid country, about 2 thirds of its area is considered very arid (Fig.1). This situation is reflected directly on the available renewable water resources of the country, which was divided into 7 hydrological basins (Fig.2).This subdivision was based mainly on river basin base or geographical area such as the steppe and coastal basins.

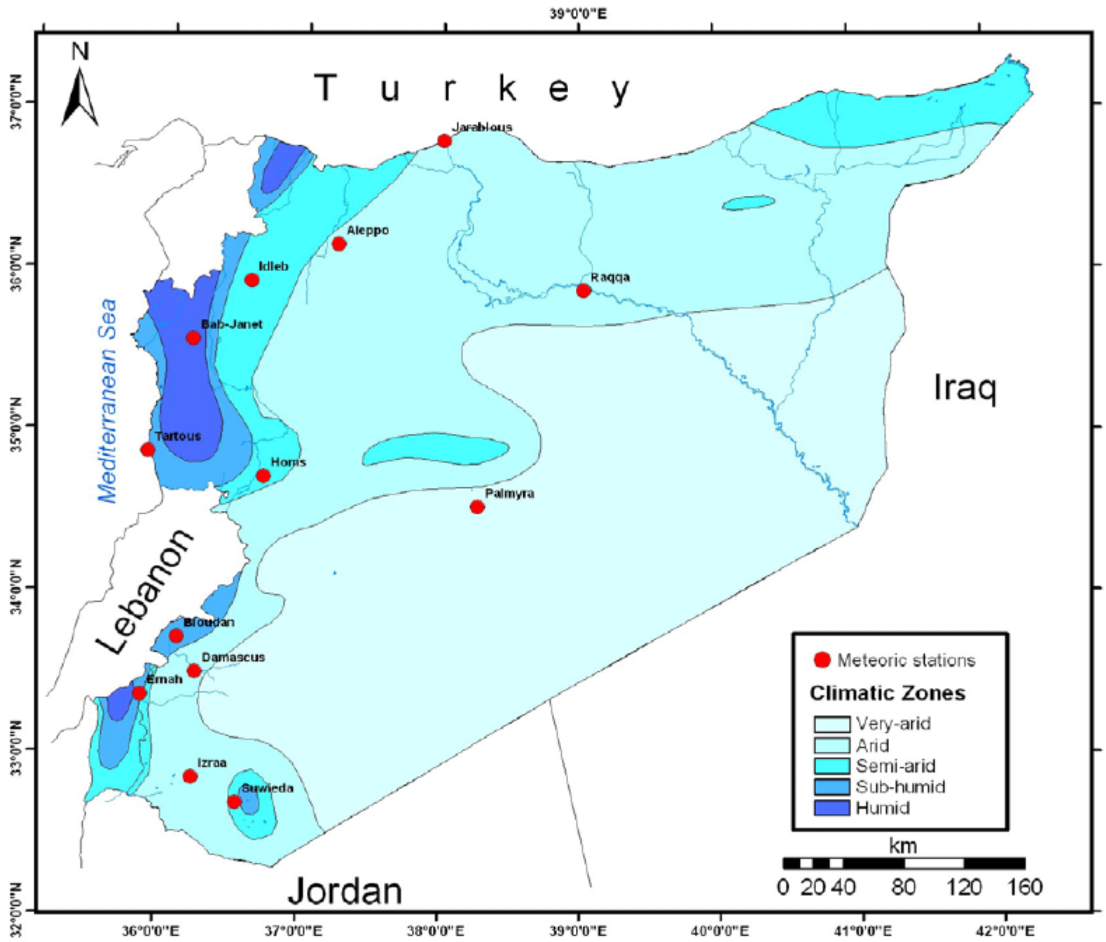


**Fig. (1):** Climatic zones in Syria (UNDP 1982 )

Syria's climate is of Mediterranean type with continental influence: cool wet winters and warm dry summers, with relatively short spring and autumn seasons. The Mountainous area along the coast and at the borders between Lebanon and Syria (Anti-Lebanon) has a direct impact on rainfall distribution. They constitute barriers for the wet depressions from the Mediterranean. Most rains fall along the coast and the top of these mountains. Only deep and strong depressions cross the mountainous, and arrive the interior plain of Syria.

Extensive parts of the country are exposed to high variability in daily temperature. The maximum difference in daily temperature can be as high as 32C° in the interior and about 13C° in the coastal region. Annual precipitation ranges from 100 to 150 mm in the north-west, 150 to 200 mm in the south central and east-central, 300 to 600 mm in the plains and along the foothills in the west, and 800 to 1 000 mm along the coast, increasing to 1 400 mm in the coastal mountains. The average annual rainfall over the country is estimated at 256 mm, (the annual average is less than 350 mm in more than 90% of the country) generating a surface runoff of about 46.6 billion cubic meters (Fig.3).

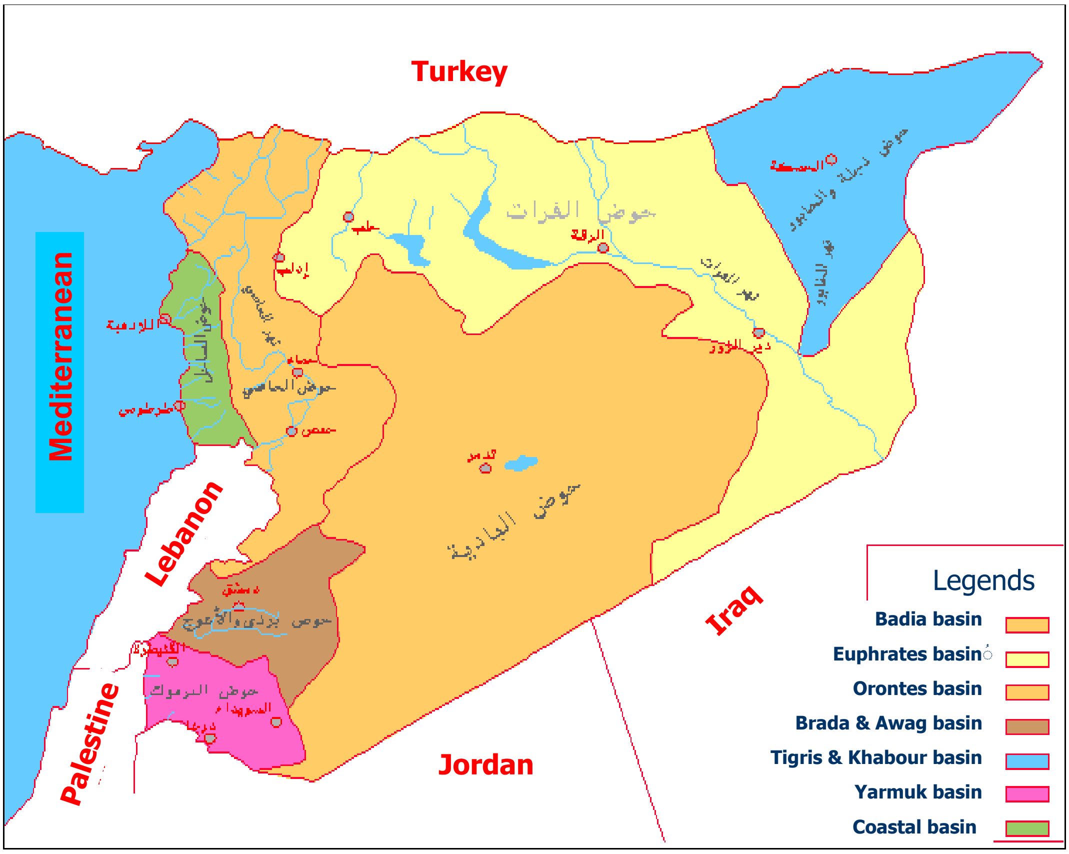


**Fig. (2):** Main hydrological basins in Syria

Rainfall in Syria is characterized by high rate of variability. *Abou Zakhem and Hafez* (2007) studied rainfall variability on Damascus meteorological station which has a long series of measurement from to 1919 to 2006.The annual average for the station is 212 mm. The highest value of 360 mm was observed in 1945 and 1953 and the lowest (60 mm) was in1999. There is some equilibrium between wet and dry years, but it seems that there is some trend towards drought in the region starting from 1982. The annual average was predicted to be about 180 mm within the coming 25 years (Fig4).

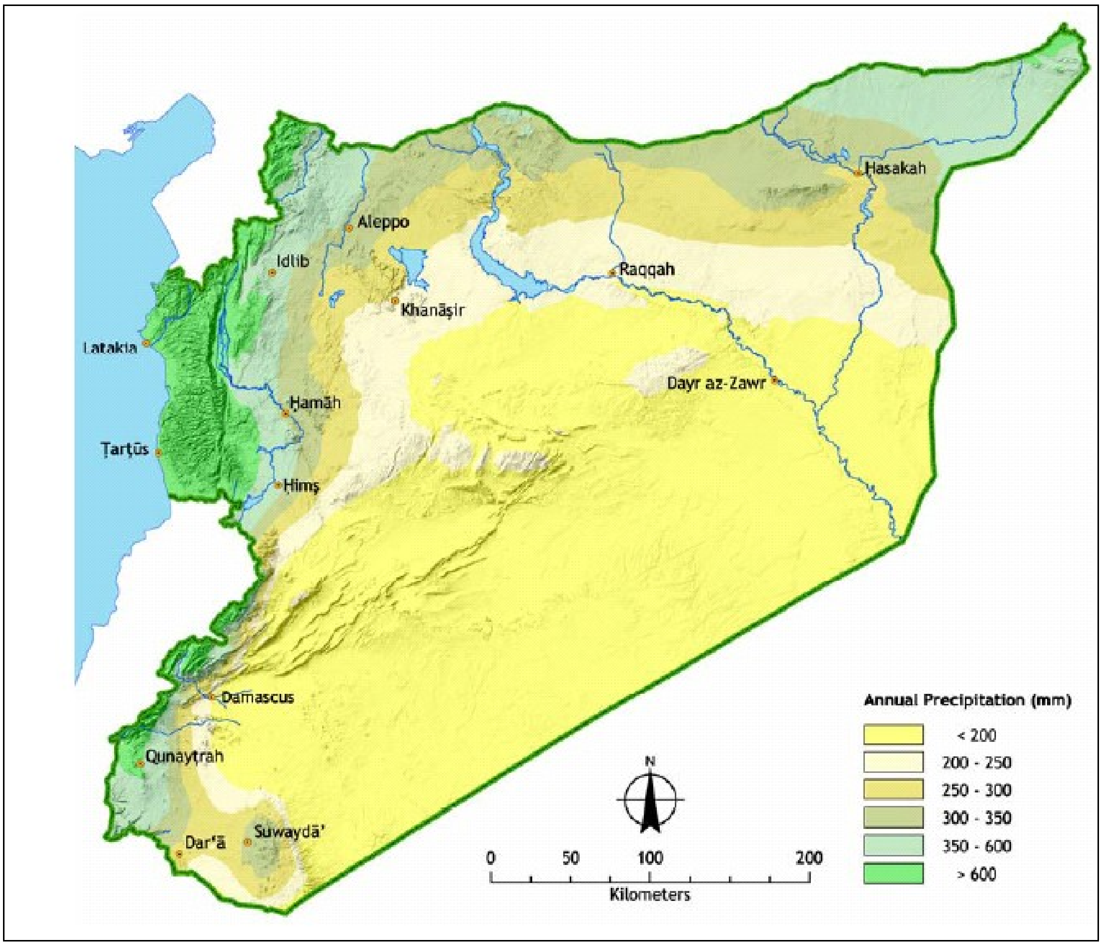


**Fig (2):** Average annual precipitation.

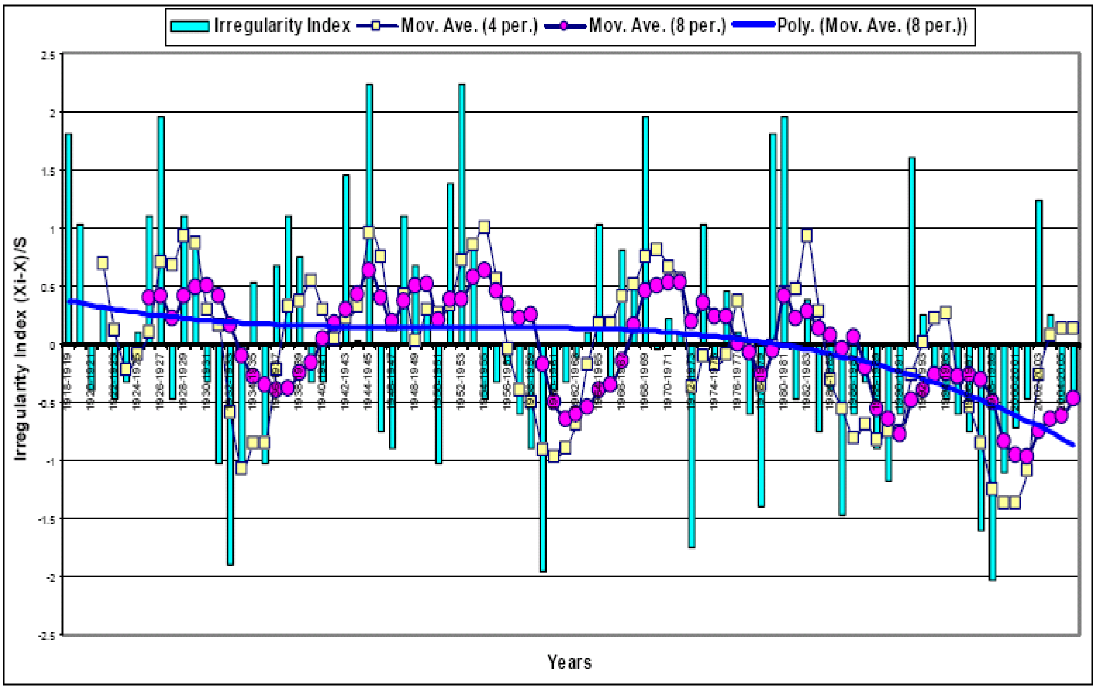


**Fig. (4):** The irregularity of rainfall precipitation of Damascus station Mov.
Moving average 4, and 8 years – Poly: polynomial line 3rd. degree (*Abou Zakhem and Hafez*, 2007)

The country is divided into five agricultural zones, based on a number of variables of which the amount of annual precipitation and altitude are the most critical ones (Fig. 5).

- The Highest rainfall is registered in the coastal region (Zone 1) and along the Turkish border in the North. This area covers about 15% of the country with an annual average precipitation of about 350 to 1500 mm and can also be also subdivided into 2 zones; zone- a with an average higher than 600 mm where rain fed agriculture is dominants without any risk, and Zone- b where the annual average is 350 to 600 mm and where two seasons of rain fed agriculture from three are secured.
- Zone 2 (about 13% of the country); Annual rainfall is between 250 to 350mm.
- Zone 3 (about 7% of the country); Annual rainfall is less than 250
- Zone 4 (10% of the country); annual average is between 200 to 250 mm
- Zone 5(about 55% of the country); annual average is less than 200 mm.

Generally precipitation decreases towards the central parts of Syria and in the south and east (Zone 5). On average, about 55% of the country receives less than 200 mm of rainfall annually, and only 15% receives rainfall higher than 350 mm.

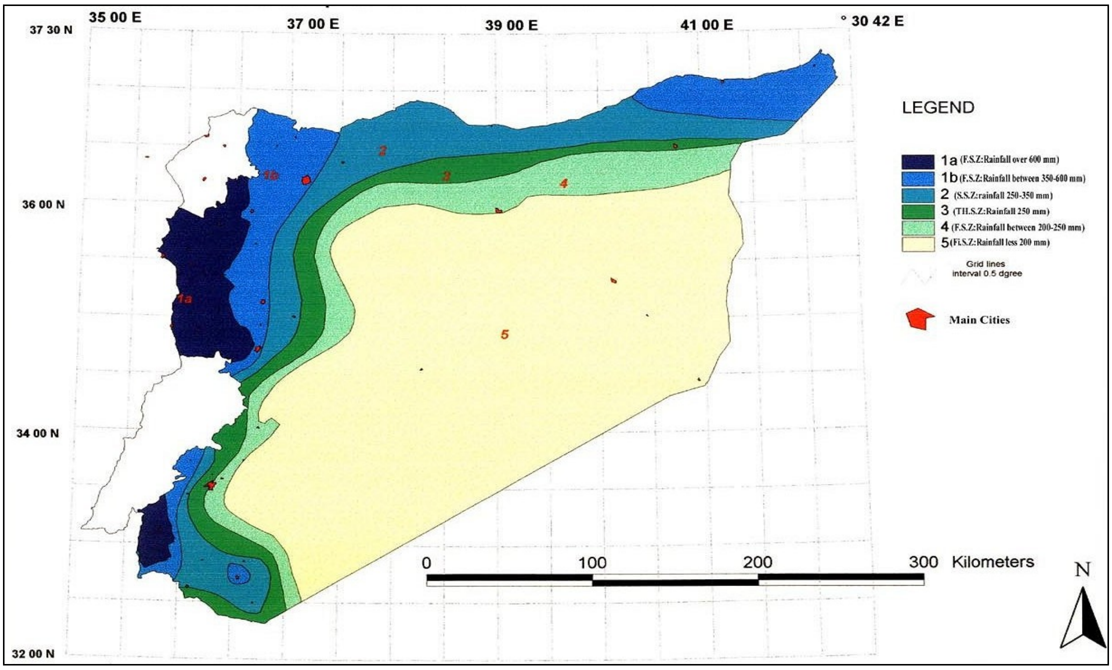


**Fig. (5):** Agriculture zones (Source: UNDP)

## 1. 2. Surface water:

Syria has about 16 rivers and tributaries flowing in the country, of which five are sharing with other countries and constitute about 75 % of the total surface water resources of the country which is estimated at 10923 $Mm^3$/ y (Ministry of irrigation, 2001). The rivers of Euphrates and Tigris are shared with Turkey and Iraq and they are the two major rivers of the country. The third river is the Orontes which is shared with and Lebanon (about 2400$Mm^3$/ y), *Yarmouk* shared with Jordan (about 180 $Mm^3$/ y) and *Nahr El Kabir Janoubi* (about 250$Mm^3$/ y) shared with Lebanon. Internal rivers with almost permanent flow are *Balikh, Khabou , Barada, AlAwaj, Al Kabir Shemali and Al Sin* (total 2750 $Mm^3$/ y).

*Euphrates*: is the largest river in Syria. It is originates from Turkey (Anatolian plateau) at about 3000 to 3500 m above sea level. Its total length is about 2800 km. The river enters the Syrian territories at *Jarablus* and flows over a distance of about 680 km until *Aboukamal* at the Iraqi borders. *Balikh* and *Khabour* are the main tributaries to the river in Syria. The average annual discharge of the Euphrates River at the Turkish-Syrian borders is estimated at 22.0 billion $m^3$/ y (Fig.6). According to a provisional agreement between Turkey, Iraq and Syria (protocol signed with Turkey in 1987) Turkey would release a minimum discharge of 500 $m^3$/second to the river (15.7 billion $m^3$ per year) at the Turkish-Syrian border. Of this amount, about 42% equivalent to an average annual discharge of about 6.6 billion $m^3$ per year is considered for use within Syria (after the agreement signed between Syria and Iraq in 1989). However, up to now, there has been no final agreement between the three countries to this regard.

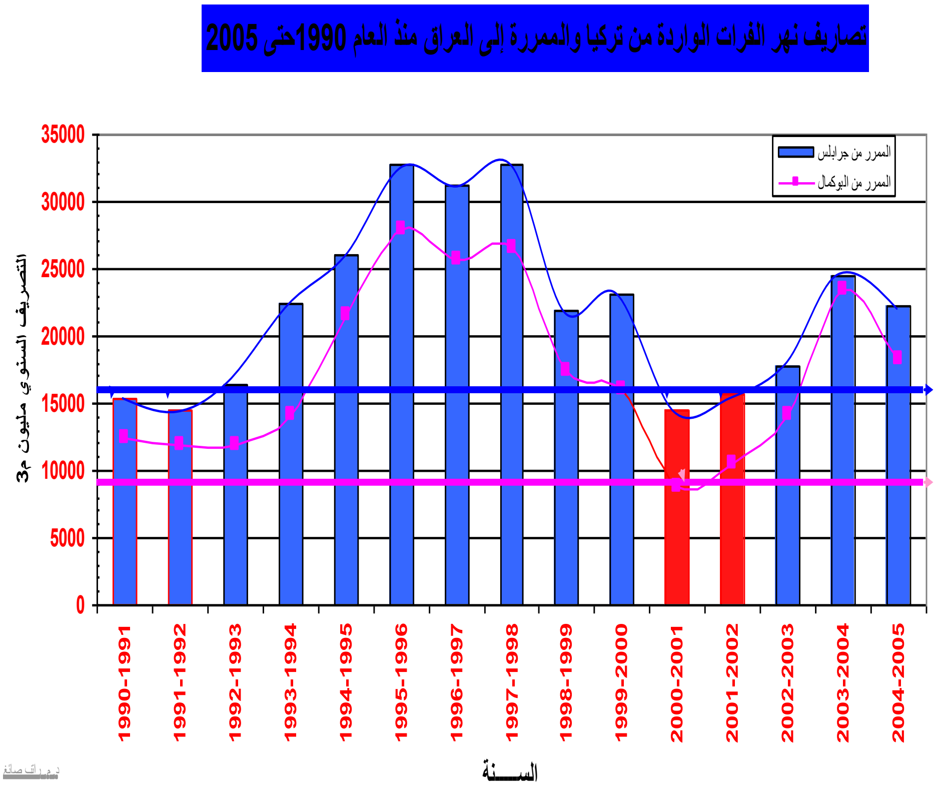


**Fig.(6):** Euphrates discharge at Jarablus and flow released to Iraq between 1990 to 2005 (*Kayal,* 2006).

*Tigris:* originates in Eastern *Tourous* mountain in Turkey and forms the borders between Syria and Turkey for 37 km and between Syria and Iraq for 7 km. The average annual flow is about 18500 $Mm^3$/ y. There is no agreement between Syria, Turkey and Iraq regarding the sharing of the water river, However, Turkey has recently accorded to Syria to irrigate about 50000 ha from the Tigris.

*Orontes:* originates in Lebanon and flows into the Syrian territories from South to North and discharge in the Mediterranean sea. The Orontes river flows in Lebanon for about 65 km and in Syria about 342 km.The average annual discharge is about 2400$Mm^3$/y. An agreement has been signed between Lebanon and Syria for allocation of the Orontes river flows. Accordingly, 80 million cubic meters per year is allocated

to Lebanon and the remainder would be for Syria (Ministry of Agriculture and Agrarian Reform and International Fund for Agriculture development, 2004).
*AlKabir Janoubi river:* it forms the borders between Lebanon and Syria over a distance of about 65 km.The average annual flow is 250Mm$^3$/ y (BGR, GTZ, KFW and MOI, 2004). Recently in 2002, an agreement was concluded between Syria and Lebanon for the joint management of the river basin and sharing the water resources of the river by 60% of the all annual water flow for Syria and 40% for Lebanon). Accordingly, a dam of a capacity of 70 Million m$^3$ will be constructed jointly for irrigation purposes on both sides of the borders.
*Al Yarmouk river:* It forms part of the Jordanian Syrian borders and joins the Jordan river some 10 km downstream of Lake Tiberiah. The water of the river comes mainly from the discharge of groundwater through a group of springs. The surface runoff is estimated at 180 mm$^3$/ y with additional water coming from the springs (about 245 Mm$^3$/ y. An agreement was signed in 1955 between Syria and Jordan regarding the allocation and sharing of its discharge. This agreement was further revised in 1987.
For internal river, the most important one is the *Khabour* river which is the major tributary river of the *Euphrates* and originates at the border between Turkey and Syria through a group of springs known as *Ras El ain*. The average discharge of the spring was about 40m$^3$/ s during the 1960s. Due to over pumping from the aquifer feeding the springs from both the Turkish and the Syrian sides for irrigation development, the discharge of the spring and consequently the river flow decreased and is almost dry (Fig.7).

Decrease in the discharge has started in the 1990. (Fig 8) shows the agriculture development on both sides between the year 1990 and 2000 using remote sensing (ACSAD, 2002).

## 1. 3. Groundwater

Groundwater is available in most of the geological formations in the country. Many studies have been implemented for estimating the water budget of different aquifers using mathematical modelling and isotopic techniques for defining the degree of renew ability of groundwater. Many of the main aquifers of the country are proved to be non renewable and their exploitation is considered as a mining procedure.

The total renewable groundwater is estimated at 6116 Mm$^3$/ y for wet years (2003-2004), but the total average is about 4389 Mm$^3$/ y, and the lowest value is 3927 Mm$^3$/ y (*Kayal*, 2006).

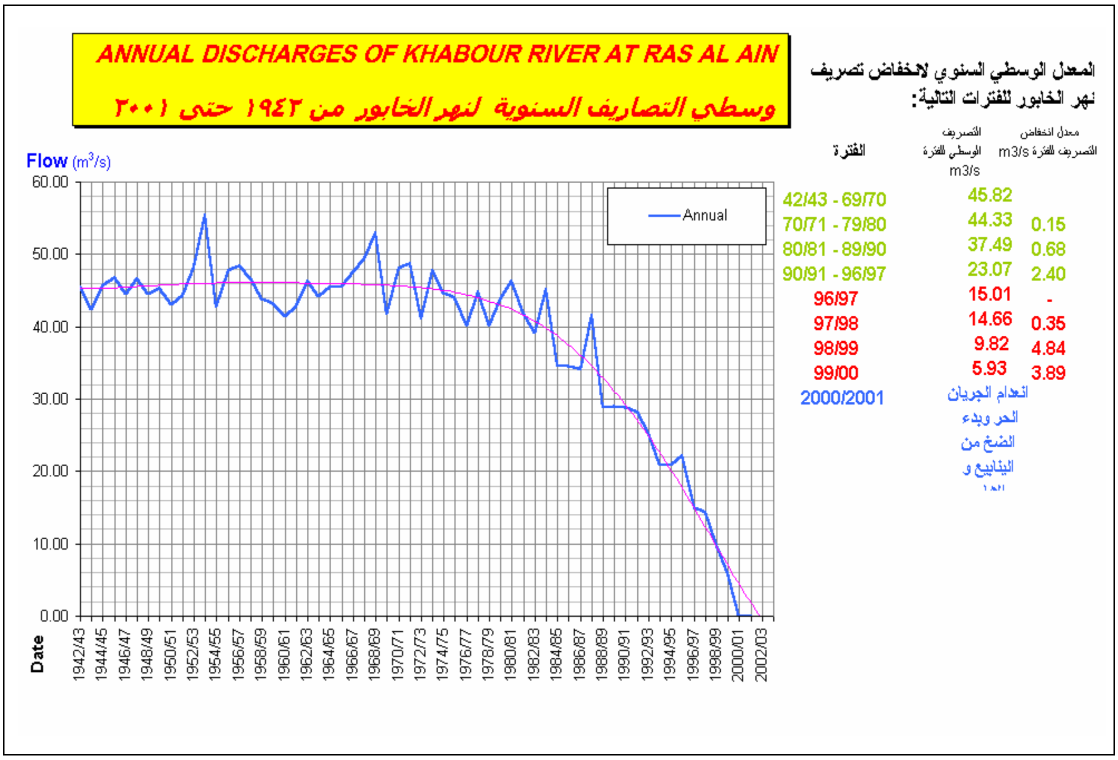


**Fig. (7):** Annual discharge of *Khabour* river at *Ras El Ain* (IFAD and MAAR, 2004)

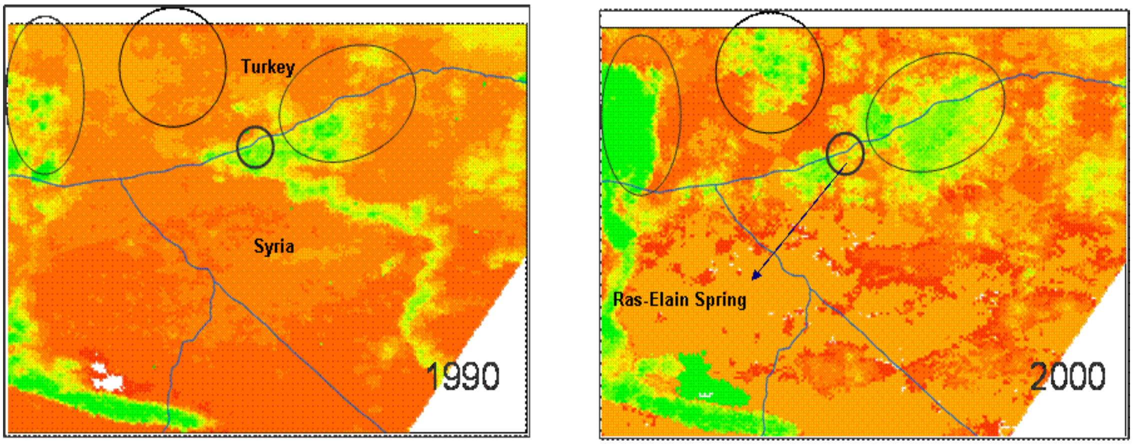


**Fig. (8):** Satellite images showing agricultural development (green areas) in Turkey and Syria side between 1990 and 2000 (ACSAD, 2002).

Over pumping of groundwater beyond the save yield of different aquifers for meeting increased water demand has led to a sharp deterioration of both water quality and quantity of the aquifers. For example in the very rich aquifer along the borders with Turkey, near *Kamishli* (Fig. 9) the drawdown in the groundwater level was about 20 meters within 10 years (1.6 m per year).This situation is also observed in many regions of Syria where groundwater extraction exceeds by far the recharge potential to groundwater.

## 1. 4. None Traditional Water Resources

This means all water resources treated and reused for different purposes. Treated quantities are still very limited in Syria due to delay in constructing of wastewater treatment plants (WWTP). Desalination is not utilized at all in the country.

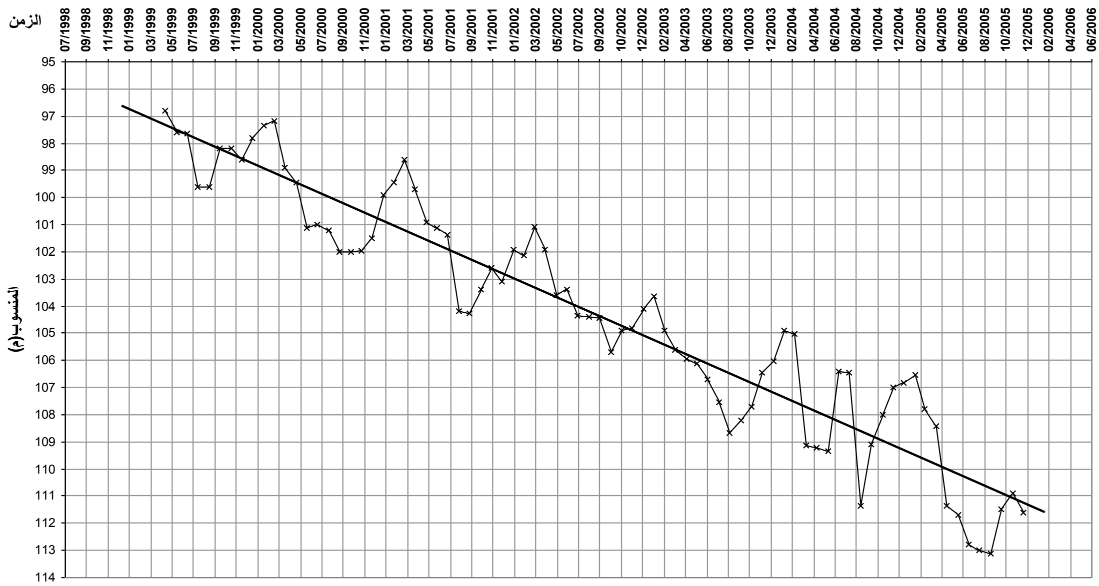


**Fig. (9):** Decline of groundwater level near *Kamishli* (North Eastern Syria )
(IFAD and MAAR, 2004)

In total, the available water resources of the country is estimated at 15200 $Mm^3$/ y. About 2000 $Mm^3$/ y can be added from treated sewage water and irrigation drainage and the total water resources would be about 17200 $Mm^3$/ y. In some references this sum is about 15965 $Mm^3$/ y (*Kayal*, 2006), 17454 $Mm^3$/ y and 16556 $Mm^3$/ y (Ministerial commission 2001).The differences are attributed to dependence of calculations on wet and dry years. However, the figure of about 16000 $Mm^3$/ y can be considered reasonable for the country. This means that the per capita available water resources is about 860$m^3$/ y which is below the international water poverty standard of 1000 cubic meters. This is without taking into consideration that the deterioration of water quality, which is well demonstrated in many cases in the country since surface and groundwater might reduce the amount of usable water resources.

## 2. Water Resources Use

Since the economy of the country is mainly dominated by agriculture, Syria has placed great emphasis on developing and stabilizing agricultural production by expanding irrigation facilities, in spite the in favorable conditions of the climatic conditions are not very favorable.

### 2. 1. Present water use in different sectors

Agriculture is by far the largest user of water and accounts for nearly 89 % of the total water consumed and thus agricultural policies and irrigation practices have significant impact on water use in Syria. Municipal and industrial uses are 8.5 % and 3%, respectively (average between 1995 -2006). However, high population growth rate and industrial development have rapidly increased the demands for water. Water demand has annually increased by 2.5 % for irrigated agriculture, 3.4 % for drinking water and by 6.6% for industrial sector duting the period 1995-2006 (*Kayal*, 2006; and IFAD and MAAR, 2004). Fig. 10 compares water availability and water use in Syria.

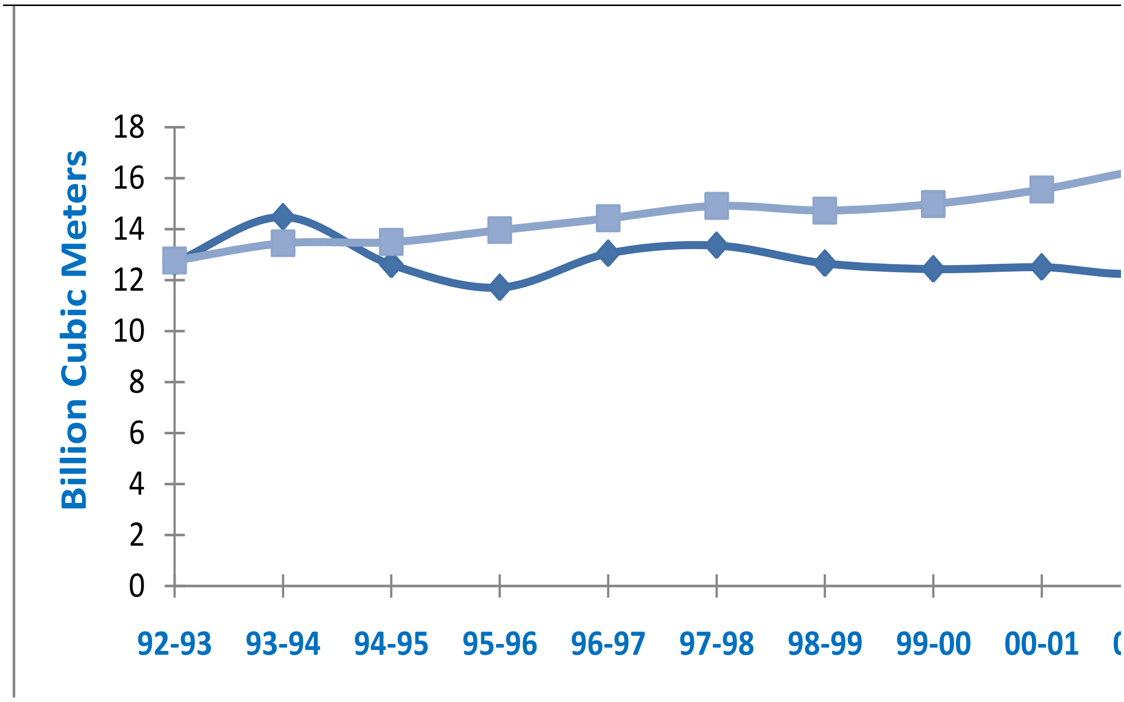


**Fig. (10):** Water resources availability and water use in Syria (IFAD and MAAR, 2004).

Total water use has become greater than the available resources showing a deficit of about 4000 Mm$^3$ starting 2002. This deficit decreased to about 2000 Mm$^3$/ y in 2003 due to the new agricultural policy adopted in the country to reduce the areas cultivated by cotton mainly.

The total average water use during the period 1995 to 2006 is estimated at about 16618 Mm$^3$/ y (in some references this figure is about 14668 Mm$^3$/ y for the period 1995- 2003 in MAAR and IFAD, 2004; or 17454 Mm$^3$/ y in BGR, GTZ and KFW, 2004) of which shares were about 13000 Mm$^3$/ y for agriculture, 1215 Mm$^3$/ y for domestic use and 452 Mm$^3$/ y for industry. There is also a loss of about 2000 Mm$^3$/ y by evaporation (*Kayal*, 2006; MOI, 2006). Comparing the average total use with the average total available water resources for the period 1995- 2006 deficit of about 653 Mm$^3$/ y could be observed. Other deficit estimates were 1724 and 374 Mm$^3$/ y for an average year (BGR, GTZ and KFW, 2004). *Kayal* (2006) estimated the maximum deficit at about 3801 Mm$^3$/ y in 2004- 2005 and the lowest at about 2138 Mm$^3$/ y in 1995- 1996.It seems that there are differences in estimated figures among different references, even that the origin of all data is the Syrian Ministry of Irrigation (MOI). This means that approaches to data analysis are different or data validity is still questionable for the country.

A total area of 1.4 million hectare is under irrigation in Syria, according to official agricultural statistics for 2004. Sixty percent of this area is irrigated by 191 600 private wells, nearly 58% of which are illegal (has increased from 25 % in 1999). The remaining irrigated areas (40 %) is supplied by surface water resources and managed by both the public and the private sector, of which 23.7 % is managed by the Government through large and extensive infrastructures, 16.3% by private sector through small river diversions and pumping units. Generally, the irrigated areas have increased with an impressive average annual growth rate of nearly 10 %, from 0.65 million ha. in 1985 to 1.4 million ha. in 2004 (about 26 % of the cultivated area in Syria), mostly through expansion of groundwater irrigation. Unsustainable groundwater use has led to overexploitation and pollution in many areas making groundwater management one of the key challenges in Syrian irrigated agriculture (Fig. 11). But rain fed agriculture is still dominating the cultivated area in Syria (78 % in 1995 and 70 % in 2004).

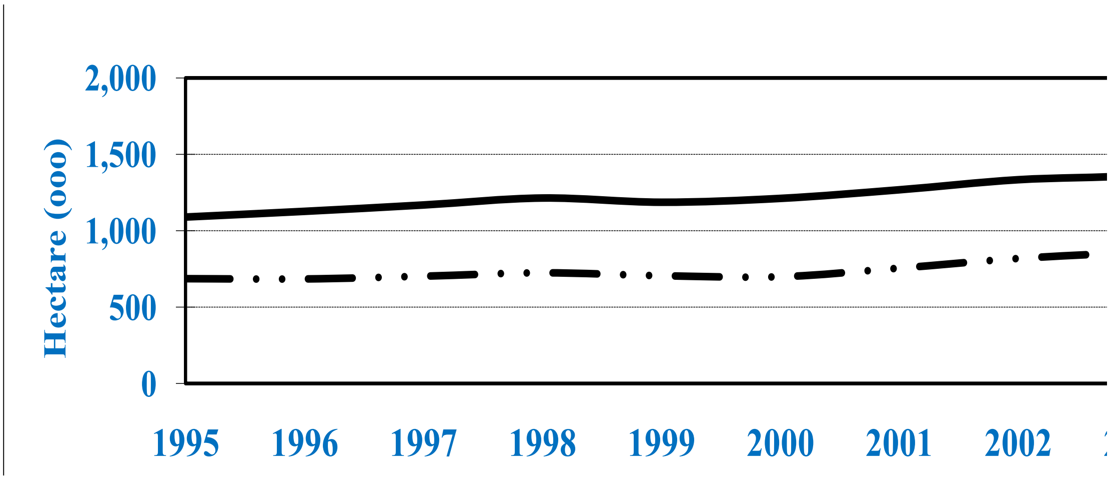


**Fig. (11):** Total irrigated area and areas irrigated from groundwater (Source: MAAR and IFAD, 2004)

## 2. 2. Evolution trend and perspectives:

As it was mentioned in the previous section that irrigation areas has been relatively doubled between 1985 and 2004. Regarding the future water demand (2003-2027), the agriculture sector, depending on the new water policy, will not benefit of any increase in water use (increasing rate in water demand will be zero). The idea is to exert more efforts for developing agriculture saving water (water demand management than water supply management). For other sectors, it is proposed for the industrial sector an increase of about 5 % (water demand will increase from 595 $Mm^3$/ y in 2003 to about 1658 in 2027, which means an increase of about 1063 $Mm^3$. For domestic and drinking water, an increase from 1426 $Mm^3$ in 2003 to about 2102 $Mm^3$ in 2027 is proposed (an increase of 676 $Mm^3$) for a population growth rate of about 2.15 %.

## 3. 3. Supply-demand balance:

The actual water balance (2006) for different regions in Syria is deficient with the exception of coastal and Euphrates-Aleppo basins (Table 1 & Fig. 12).Taking into consideration the prospective water demand for 2027 (Table 2 & Fig. 13) water balance of the country will have a deficit of about 2078 $Mm^3$. The average of deficit for the period 1995- 2006 (Table 3 & Fig.14 ) was 653 $Mm^3$ ( *Kayal*, 2006).This means that even with stopping any increase of water demand for irrigation the deficit will be tripled within the coming 20 years. Almost all the regions in Syria will face a shortage of water with the exception of the coastal zone which will have a surplus of about 979 $Mm^3$ in 2027 (Table 4 & Fig. 15 ).This fact is mainly due to the limited irrigation areas and the climatic conditions (annual average precipitation of about 800 mm).

It is also important to mention that the shortage in quantitative aspect of water resources is not the only challenge facing the water issue in the country, but also the qualitative aspect which became a matter of great concerns for the Syrian authority. Many of the rivers, lake dams and even groundwater are polluted due mainly to the lack of enforcement of water legislations, absence of sufficient wastewater treatment plants (WWTPs), lack of awareness, lack of appropriate sewage systems (mainly in illegal urban areas surrounding the main cities) and over-extraction of groundwater. This issue has led to many hygienic problems in some areas and polluted water became inadequate for different uses which consequently would reduce the availability of fresh water.

**Table (1):** Average water budget of different basins (for the period 1995-1996 and 2005-2006) *in Million m³*

| Basin | *Yarmouk* | *Barada & Awaj* | Coastal | Orontes | *Badia* | Euphrates & Aleppo | *Balikh & Khabour* | Total (Million m³) |
|---|---|---|---|---|---|---|---|---|
| **Surface and groundwater** | 355 | 817 | 1109 | 1505 | 338 | 7030 | 2104 | **13258** |
| **Waste water** | 46 | 264 | 0 | 283 | 44 | 304 | 80 | **1021** |
| **Agricultural drainage** | 49 | 140 | 80 | 272 | 0 | 751 | 395 | **1687** |
| **Total water resources** | 450 | 1221 | 1189 | 2059 | 382 | 8085 | 2579 | **15965** |

**Table (2):** Future water demand for all sectors (2003-2027) *in Million m³*

| Water use | 2002-2003 | 2026-2027 | Amount of increase |
|---|---|---|---|
| **Irrigation** | 14669 | 14669 | 0 |
| **Domestic** | 1426 | 2102 | 676 |
| **Industry** | 595 | 1658 | 1063 |
| **Total** | 16690 | 18429 | 1739 |

**Table (3):** Average water use 1996-2006 in million m³

| Basin | *Yarmok* | *Barada & Awaj* | Coastal | Orontes | *Badia* | *Euphrates& Aleppo* | *Balikh& Khabor* | **Total** |
|---|---|---|---|---|---|---|---|---|
| **Irrigation** | 329 | 935 | 532 | 1811 | 265 | 5010 | 4119 | **13001** |
| **Domestic** | 68 | 312 | 125 | 219 | 42 | 366 | 83 | **1215** |
| **Industry** | 23 | 65 | 58 | 184 | 21 | 69 | 32 | **452** |
| **Evaporation** | 31 | 4 | 16 | 148 | 4 | 1614 | 132 | **1949** |
| Total water use | 452 | 1316 | 731 | 2363 | 332 | 7059 | 4365 | **16618** |

**Table (4):** Expected total water budget in 2024-2027, *in Million m³*

| Basin | *Yarmouk* | *Barada & Awaj* | Coastal | Orontes | *Badia* | *Euphrates& Aleppo* | *Balikh & Khabor* | **Total** |
|---|---|---|---|---|---|---|---|---|
| **Total water resources** | 551 | 1532 | 1844 | 2644 | 409 | 8652 | 2669 | **18300** |
| **Total water use** | 75 | 1742 | 866 | 3024 | 459 | 8860 | 4723 | **20378** |
| **Water budget** | -154 | -210 | 979 | -380 | -50 | -208 | -2054 | **452** |
| **evaporation** | 31 | 4 | 16 | 148 | 4 | 1614 | 132 | **1949** |
| **Total water use** | 452 | 1316 | 731 | 2363 | 332 | 7059 | 4365 | **16618** |

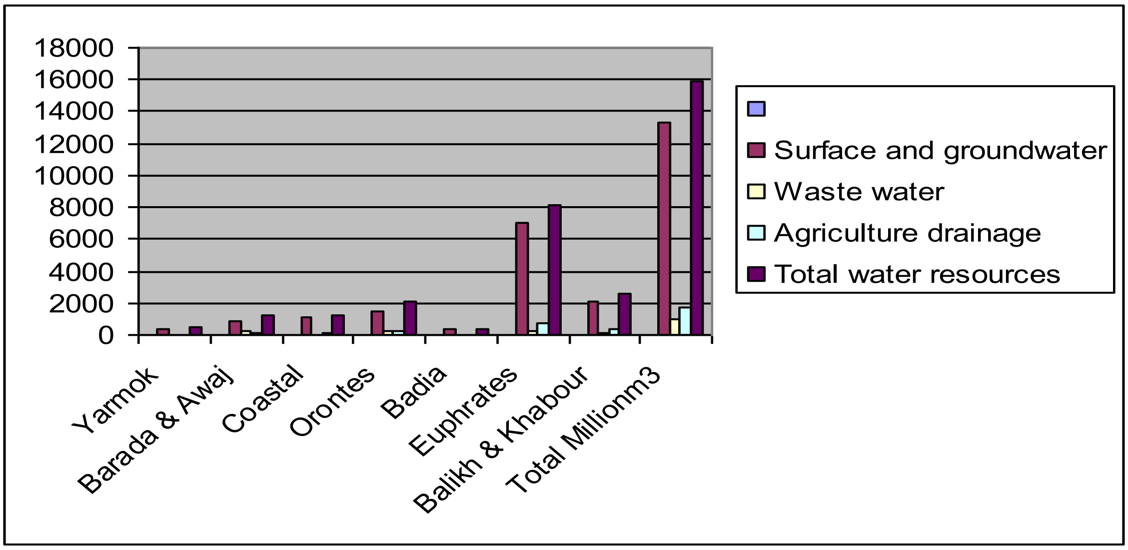


**Fig. (12):**Average water budget of different basins

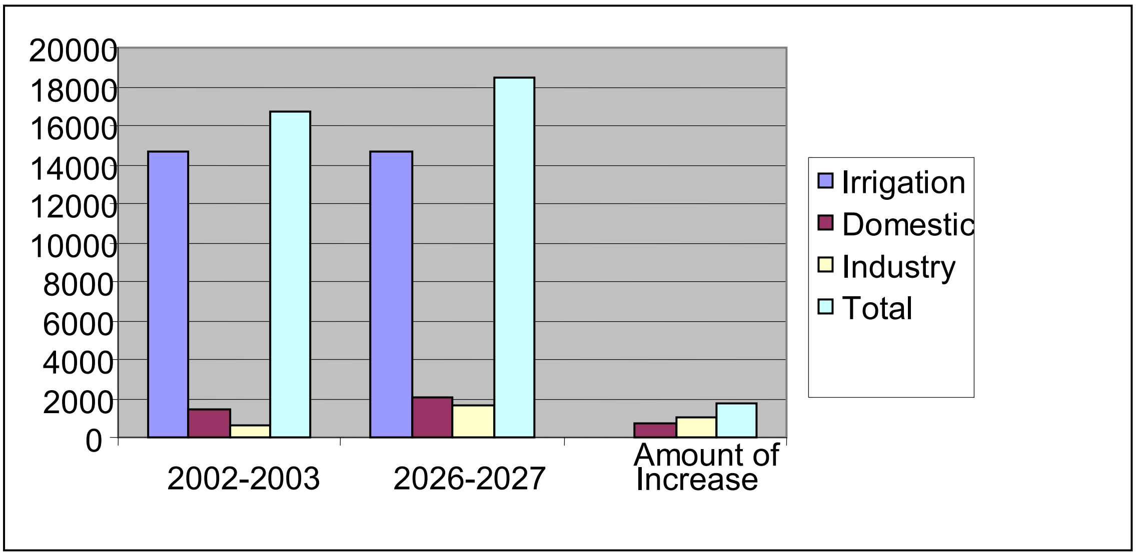


**Fig. (13):** Future water demand for all sectors (2003-2027), *in Million m³*

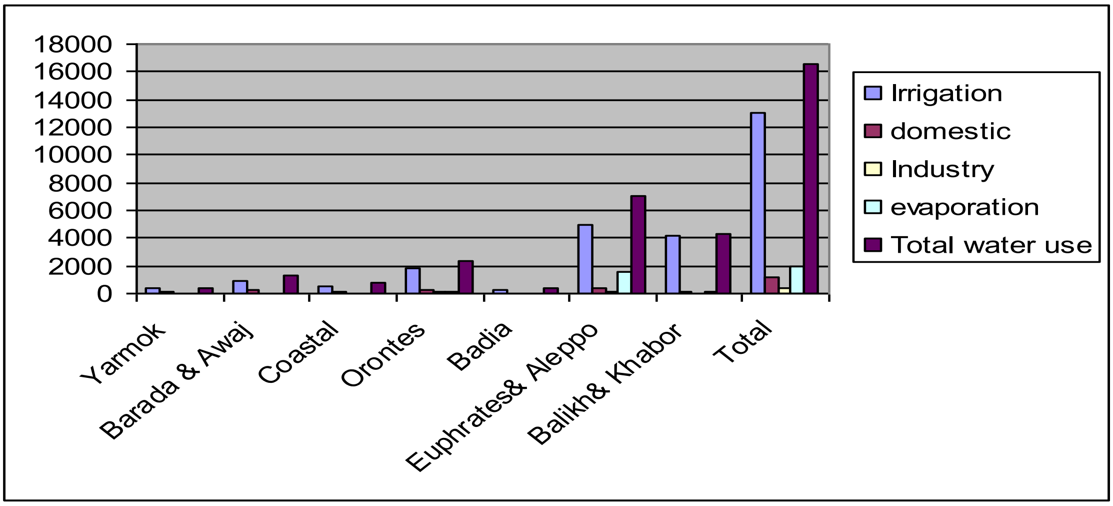


**Fig. (14):** Average water use 1996-2006, *in million $m^3$*

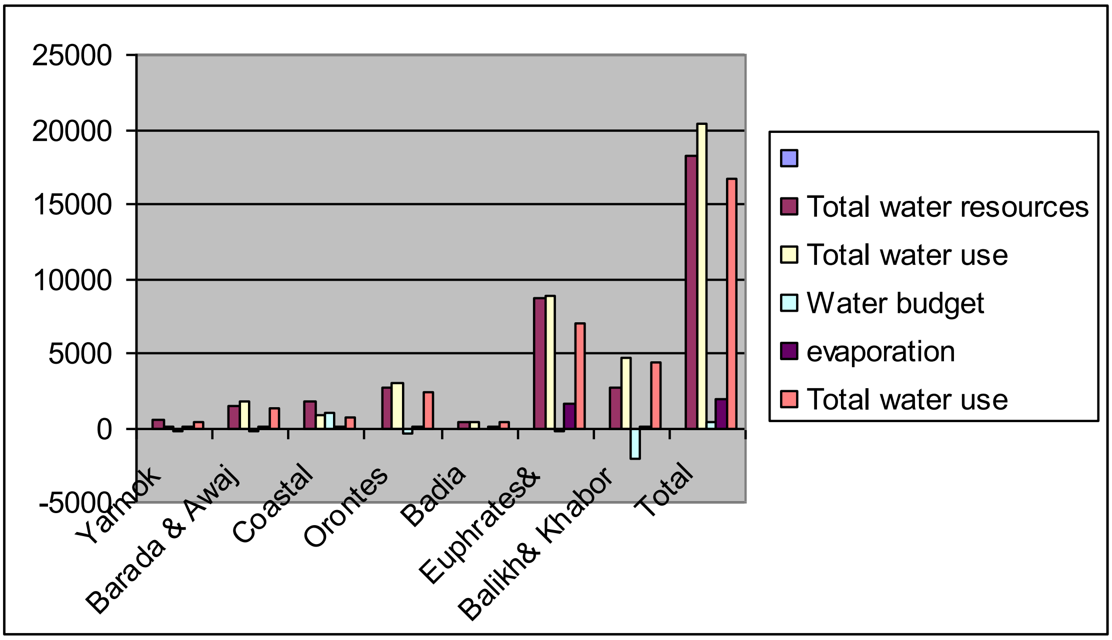


**Fig. (15):** Expected total water budget in 2024-2027, *in Million $m^3$*

## 3. Water Resources Management

Currently several institutions in Syria are involved in water resources, management, supply and use. They are:

### 3. 1. Ministry of Irrigation (MOI):

It has the overall responsibility for management of water resources in the country in terms of:

a) Policy formulation and research/ studies regarding the water resources development including water quantity and quality and water allocation among sectors,
b) Collection of data, monitoring and issuing water permits both for surface and ground water use.

c) Planning, construction, operation and maintenance of most of the hydraulic structures and facilities, such as dams, canals, and pumping stations.

In order to meet the future challenges in an era of water scarcity, (MOI) has gone through a major organizational restructuring. At the central level, (MOI) is responsible for policy decisions, planning and budgeting and operates through the General Commission of Water Resources (GCWR). GCWR which is a new body within the MOI has replaced the six General Directorates of the basins. Within administrative boundary of each governorate a Directorate of Water Resources has been established under the overall responsibility of GCWR and would work closely with the local authorities.

## 3. 2. Ministry of Agriculture and Agrarian Reforms (MAAR):

Has the responsibility on-farm water management and basic extension and research services to farmers. The overall coordination between the MAAR and MOI is through the State Planning Commission (SPC). MAAR also is responsible for all development activities related to agriculture, livestock, forestry and fisheries.

It operates through a number of sectoral directorates at the central and provincial levels. The agricultural research is conducted by the General Commission for Scientific Agricultural Research (GCSAR). The Directorate of Natural Resource Management (DNRM) at GCSAR is responsible for nation-wide research on crop water requirement, on-farm water management, and irrigation technologies. Within the ministry a recent centre for defining agriculture policy and strategy has been established with the technical assistance of FAO and Italy .The objective is to assist the ministry in developing the appropriate agriculture policy for the country based on related data and information.

## 3. 3. Ministry of Local Administration and Environment (MLAE):

Is the key institution responsible for environment and natural resource management in Syria, while the responsibility of dealing with the environment lies with a number of ministries. In accordance to Law 50 of 2002, MLAE has a regulatory, coordination and research functions and is responsible for such activities as:

- Identification of the environmental problems facing the country
- Stipulation of the environmental policy and preparing the necessary national strategy, action plans and programmes for implementation.
- Enhancing public awareness on importance of environmental concerns and protection.
- Research and scientific studies to mitigate the impacts of environmental problems
- Preparing draft laws, regulations and procedures for environmental protection and development, within the framework of the general policies of the Government; and
- Monitoring activities by private and public establishment to verify their conformity with the environmental standards and specifications. MLAE

operates through a number of directorates at the central and governorate levels.

### 3. 4. Ministry of Housing and Utilities:

Has the responsibility of the drinking water supply and sanitation. It operates through a number of directorates and public companies at the central and governorates level Water resources management in the country is ensuring through different legislation, the most important one is the water legislation known as the water law no. (31). The revised law was ratified by the Peoples' Assembly on October 20th 2005. It provides the legal base for improving water management and empowerment of the private water users' associations to participate in management of the Government schemes and even authorizes MOI to transfer management of these schemes to private sector in due course, entirely.

The new Water Law recognizes water from all sources (ground and surface) as public property and subject to regulation by the Government. The right to use surface or groundwater is acquired through the issuance of water use license by (MOI). The license for groundwater wells would specify discharge and maximum depth and require instalment of water measuring device on each pump. License for new irrigation wells would only be issued subject to commitment by the applicant to install modern on-farm irrigation system.

License would be valid for a period of one year and its renewal is subject to availability of water in the basin. Sever penalty for non-compliance with the provision of license is foreseen. Violations related to improper use of water would be regarded as criminal act. Unfortunately even with all these penalties the violation is still very common .Just as an example for this violation, the unlicensed water wells in Syria in 2006 were estimated at 112674 wells (*Kayal*, 2006) comparing to licensed wells of about 102562 wells (the total wells assessed are 215236 wells). This means that about more than 50 % of the wells are illegal. In 2004 the unlicensed wells were about 100000 wells and in 1997 were about 60000 wells (IFAD and MAAR, 2004).

This issue constitutes one of the major concerns for ensuring optimal management in case of disaster such as drought events because extraction from these wells is not controlled.

## 4. National capacity of the government and local administration to deal with natural water related disasters:

National water strategies in Syria are articulated by the 5-Year Development Plan. The present 10th Five- year Plan places special importance on water security as an essential ingredient of sustainable development. While water will be utilized as a mean for ensuring food security, concerted efforts will be made for its development, protection and rational use as a vital and strategic wealth. The 10th Five- year Plan places emphasis on: (i) improving the efficiency of irrigated agriculture through rehabilitation and modernization of irrigation systems (ii) optimal use of surface water resources, especially in the Euphrates and Tigris basins (iii) improved groundwater management and effective control of irrational use of groundwater resources; and (iv) protection of the environment through preventing pollution treatment of sewage water ,control of pollution in an integrated manner. The water strategy also includes a number of institutional measures to address challenges related to scarce water resources improvement and prevention of rapid deterioration of the water quality. These include: organizational restructuring, capacity building and strengthening capabilities of MOI at local, governorate and national levels.

From the previous strategy ,we can see that the first concern was, improving water use efficiency in irrigated agriculture (since this sector consume more than 80 % of the total water used in the country).So any amelioration in water use efficiency in this sector will impact positively on the availability of water and food security of the country. These measures can also help the country to deal with future natural water disasters such as drought, since the water saved could constitute a potential for the country for facing such circumstances.

**The capacity of the country to implement such strategy, to prevent, mitigate and alleviate climate change impacts is outlined as following:**

1) **Technical capacity and monitoring:** Knowledge management and information are increasingly becoming the key factors for ensuring sustainable management of the water resources and in the same time monitoring the climate change and its impacts.
   In Syria most of the available water data from the existing networks are, either not continuous in time and space and with limited accuracy.
   Climate data are dispersed within different institutions, such as the Ministry of Agriculture and Agrarian Reform, Ministry of Irrigation, National Meteorological Administration which belongs to the Ministry of Defense. Each of these institutions has own climatic monitoring network. Water monitoring network (surface and groundwater, water quality, etc) is under the responsibility of the ministry of irrigation. Sharing the information between different institutions is very limited and in most of the case data is considered as secret, and it is outdated by up to one year and is in many cases unreliable. The same is for water use for which the data is also dispersed between different ministries, institutions (at local and national levels). Such an issue makes the control over data very difficult. For monitoring water related disasters such as drought for example, meteorological services play a key role however, data are sparse and most climatic stations are located in predominantly agriculturalareas and usually not located in more arid and less populated areas such as the Badia which is the most vulnerable area to drought.
   Coordination between the concerned institutions is also very weak and there is no information sharing mechanism adopted for the country. Such an issues would certainly limit the capacity of the country to deal with natural water related disasters, such as drought, floods, etc.
   The country is also lacking many of the basic elements for building a water information system based on a good and viable water monitoring network (meteorological, surface runoff and groundwater) linked to a data base system. Data quality control is in most of the cases not well undertaken.
   Within the Ministry of Irrigation a water resources information center was created 5 years ago with the technical assistance of Japan (JAICA). The center in principal should centralize all the water monitoring data collected by the network belonging to the Ministry of Irrigation. At present, only two (*Barada and Awaj and* coastal basins) of 7 basins of the country are connected to the center. The other basins will be linked in the future. A lot of efforts are still

needed for upgrading the center, improving the quality of the data received by the center from different networks, and applying a data control mechanism.

2) **Institutional capacity**: A key dimension of climate change impact assessment is the presentation of the results. An effective tool in increasing understanding and awareness of climate change risk is hazards mapping which highlights geographic areas at risk (drought or floods). Geographical Information System (GIS) is particularly suited for such issues. But all relevant tools request a good data base and information system for monitoring and producing such maps or other outputs although remote sensing technology and GIS have significant potential to address the data and knowledge gaps.
In general there is a lack of analytical tools and technical capacity for data processing (data interpretation process for transforming the data into information useful for decision makers).
The institutional arrangements for climate change monitoring and impacts analysis are lacking. Usually the response of the government to any climate disaster is reactionary (for example, even for the drought events which is one of the measure natural disasters the country is frequently facing and for which the impacts are very severe on the country from all point of view, water, agriculture and socioeconomic), there is no early warning system or national drought preparedness plan exists. Meanwhile, the country is exposed since the mid of 1950s to a frequent drought events as it was the hydrological year 2007-2008 where the average precipitation was about 50 % of the annual average. Despite these facts and that about 55 % of the country (The Syrian *Badia*) is the most environmentally vulnerable to drought, the country is lacking any strategy for drought monitoring or mitigation plans .Moreover, the country does not have socioeconomic drought monitoring focal points or institutions that could act as a central coordination unit for data collection, analysis and dissemination. Drought vulnerability assessments are not conducted, nor there is any early warning bulletin issued to vulnerable communities. It is well established now, after the different climatic change scenarios produced by the Intergovernmental Panel for Climate Change (IPCC) report 2007, that the Eastern Mediterranean region including Syria and even most of the Southern Mediterranean countries will be exposed to more frequent drought events and even reduction in precipitation of about 25 % within the 50 coming years. Such results prove the necessity for the country to start taking some actions for alleviating the impacts of climate change in the future.
Recently, within the Ministry of Agriculture and Agrarian Reform, the Agricultural Policy Center has been created with the assistance of FAO and the Italian Government, and deals at limited level with drought monitoring.
There is no national strategy to deal with natural disasters. A commission has been recently formed under the Auspices of the Prime Minister for dealing with these issues (but mainly focusing on earthquakes as a natural disaster). There are no serious actions taken regarding the climate change impacts, yet.

3) **Regional cooperation**: Coordination and exchange of data and information within the region can be of great help for the country for complementing the existing data and filling the gaps and even exchange the experience. There are some regional networks such as the Network coordinating by International

Center for Agricultural Research in Dry Areas (ICARDA), but the cooperation or the involvement of the country in different existing networks are limited due to the fact that the climatic or any water data and information are classified confidential and need a lot of efforts to be realized. Networking provides opportunities to share experiences and lesson learned and even help in predicting the climate change events, since all the region (for example the Eastern Mediterranean countries) usually face the same climatic events.

4) **Research on climate change:** Usually, research has no significant impacts on policy development in developing countries. The existing national research centers are mainly dealing with how to save water in agriculture. There is need to develop research programs to deal with the impacts of climate change, however. The major constraint is the access to data and information.
The scientific research in this field constitute a basic element for defining water policy and strategy which can be harmonized with climate change issues. It is widely recognized that dissemination of research results to policy makers in the appropriate formats is a factor in successful policies. Developing scenarios about the impacts of climate change on food, water, environment, poverty would certainly help decision makers develop solid national policies.

5) **Legislation enforcement:** One of the major elements which prove the capacity and efficiency of the national institutions for implementing adopted water policy is the enforcement of legislation. Water legislation is not well applied regarding the drilling of boreholes of which about 50 % is illegal, and it seems that the control of well drilling is not at the same level of challenges that the country is facing regarding the water scarcity. Recently, a new legislation has been adopted for drilling wells as well as water quality, however its full application is still questionable. Due to many factors including lack of awareness about the threats that the country is facing in case of shortage of water.

6) **Socioeconomic vulnerability:** Half of the Syrian population live in rural areas and largely dependent on agriculture for their livelihood. The agricultural sector is the main water consumer (more than 80 %) and is contributing 30 to 32 % of the GDP, providing works to about 50 % of the population and employs 32 % of the Syrian labor force of the rural population which is depending the most on natural resources such as water and vegetation which are the most vulnerable to climate change. Herders in Badia are most vulnerable to climate change and were severely affected by drought events.. During the season 1998-1999 drought, the mortality rates for ewes and lambs were 10 % and 25 %, respectively (ESCWA, 2005). Despite these facts, no assessment has been conducted to define the magnitude of vulnerability to climate change.

7) **Lack of final agreement for shared rivers:** Syria is depending on attaining more than 75 % of the total water resources on five main rivers shared between neighboring countries (Euphrates, Tigris, *Yarmouk*, Orontes and *Nahr El Kabir Janobi*). There is only one official agreement regarding Orontes basin (between Lebanon and Syria).

As climate change impacts increase, challenges in managing shared waters will increase as demand for the scarce water develop. Climate change preparedness urge the concerned countries for finalizing agreements regarding the sharing water from rivers to become a component as a national integrated water resources management.

8) **Water Management:** The sustainable development and management of water resources needs that coordinated efforts should be established among the different stakeholders, since a water resource is considered as the pivot for all economic activities mainly agriculture. Even if there is some evidence of coordination between the water and agricultural policies in allocating water for different crops (reduction of cotton cultivated areas for saving water),but in other domain coordination is not well defined (for example creation of industrial zones in areas lacking water resources,such as Adra, Hesia industrial zones and new population settlements without any investigation regarding water availability in these areas). The mechanism of consultation and coordination is lacking.
The agricultural sector is using about 80 % of the total water used in the country, but the low water use efficiency (more than 80 % of all irrigated areas are still using traditional flood irrigation) and water productivity in this sector presents an enormous challenge to sustainable water management. The country has launched a very optimistic program for introducing the modern irrigation techniques but the results of these efforts is still very limited (does not exceed 27 % after 8 years of application of the prime ministry decision for converting tradional to new irrigation systems). Major causes behind the delay is the low water tariffs applied for water irrigation which do not provides incentives for water saving, in addition to technical constraints and lack of awareness.
Demand management requires major improvement in the agricultural water productivity. The integration approach of land and water management across different economic sectors in the country is a pre requisite for ensuring cooperation between the different ministries, authorities, research and other concerned institutions.

## 5. Adaptation policies and measures to lessen the effect of climate change on water resources:

Water scarcity induces competition for water among sectors of the economy and among countries and regions sharing common resources.
Many different interests are at stake and equitable solutions must be found among different water stakeholders. Climate change is projected to increase water stress and environment degradation in the Eastern Mediterranean region (including Syria) compounding other pressures as demographic growth and economic development and urbanization. All predictions indicate that climate change will reduce the overall amount of rain by 20% and will increase variability making it much harder to manage. For example climate change may reduce the Euphrates and Tigris flow by as much as 30-50 % (ESCWA, 2008).
West Asia countries experienced extreme weather events. Changes in precipitation, combined with rising temperature and reduced snow cover, will have impacts on

water quality and quantity, requiring water managers to include climate change in their planning and investment decisions.

The poor are the most vulnerable to the impacts of climate change and have the least means to adapt. Therefore, the top priority for adaptation in the water sector would be the reduction in the vulnerabilities of people (particularly the poor and disadvantaged) living mainly in rural areas (about 50 % of the Syrian population) and have agriculture as main activity. This means that this sector will be the most vulnerable to climate change. Even in urban areas, the poor live in marginal settlements whichlack in most cases the necessary infrastructure (such as sewage system and drinking water networks, which expose them to floods. Adaptation measures should also take into consideration livelihood needs of the poor in these areas.

Any adaptation measures to alleviate the effect of climate change on water resources should focus on the two main issues: sustaining the agricultural production and conserving the environment. Coping with the most severe consequences of climate change would require major changes in water management policy and infrastructure.

## *The adaptation policies and measures can be summarized as follow:*

- **Water policy:** According to the recent national water strategy adopted for the country water security is of major concerns. The main driving force is water scarcity that the country is facing and it is expected to aggravate more in the future. Climate change which is now considered a fact is a newly introduced driver in water resources management which should be taken also into consideration in the national water security strategy. Therefore, adaptation strategies need to be embedded within existing national policies, legislative and institutional frameworks. Water scarcity and the growing population's demand for water has promoted the Government to take two important steps to improve the use and management of water in agriculture. These include: (i) modernization of on-farm irrigation systems to improve irrigation efficiency and conserve water (Irrigation field efficiency is reportedly low, often below 50 %.); and (ii) enhancement of regulatory measures to improve water management and to empower private water users' organizations to take a more active role in irrigation water management. The ministry of irrigation has started recently a new water policy which is mainly based on water demand management rather on water supply management. This means increasing productivity and reducing unproductive losses (mainly in irrigation).It is now adopted that there will not be any extension in irrigated areas up to the year 2027. Water allocated to the agricultural sector will be maintained at a certain volume and the efforts would focus on vertical development of this sector by changing crop pattern, introducing modern irrigation techniques reducing water loss and reallocating water to crops with higher economic value . A national program to promote modern irrigation and assist irrigation water users to convert their inefficient traditional on-farm irrigation systems to advanced modern systems has been launched. Only 27 % of the traditional systems have been converted to modern irrigation since 2001, despite extensive efforts over the last decade (Fig. 16).

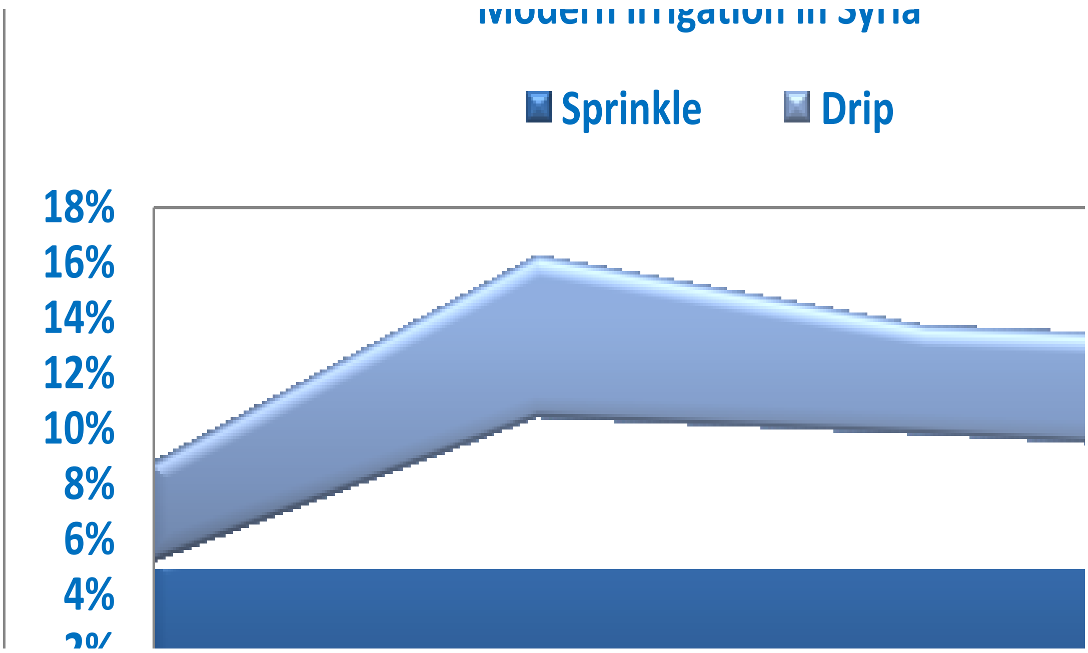


**Fig. (16):** Trends in development of Modern irrigation in Syria (MAAR and IFAD, 2004 )

This low rate of development of modern irrigation should be analyzed in depth for identifying the constraints behind this result. Since food security policy is adopted as a basic strategy for the country, this means that the agricultural sector from all point of view (economic, politics and socioeconomic) will be continuously privileged by the government. More efforts and measures should be taken urgently for increasing this rate for saving more water and reducing water withdrawal for agricultural purposes.

***Most probably, the reasons behind the low rate of converting to modern irrigation are:***

- The low water tariff for water used in irrigation and weakness for the enforcement of water legislation, mainly for extracting groundwater.

- Lack of awareness, Limited knowledge of the farmers on advantages of modern on-farm irrigation techniques and inadequate access to information and technical support services to assist with planning, design, and operation and maintenance of the on-farm irrigation system as well as for the respective irrigation practices would remain a major constraint.

- Shortages of qualified technical staff specialized in modern on-farm irrigation techniques in relevant agencies and institutions, particularly at the Governorate, District and local levels, resulting in inability to prepare plans, designs and training the needed staff.

- The small holdings of the poor farmers and increasing fragmentation of their land due to inheritance would not be the optimal size which would enable the efficient layout and design of an advanced distribution and on-farm irrigation system.

- The quality of the locally manufactured as well as imported irrigation equipments is highly unreliable. National production is suffering from improper products design, low quality of imported raw material, age or poor maintenance of production tools. Import equipment is not considered to be of highest quality due to the lack of quality and performance control in Syria

- The poverty level of farmers for purchasing such costly equipment , lack of education, weakness of enforcement of legislation can play a role for the low rate of converting traditional to new irrigation systems. Farmers usually prefer the cheapest equipment, while manufacturers tend to decrease the prices of equipment through using lower quality production lines and raw materials.

Since the agricultural sector would be most vulnerable to any climate change impacts, more attention should be given to water management policy for sustaining the agricultural development of the country through the acceleration of introduction of modern irrigation equipments where appropriate.

Results from agricultural research in *Deir El Zore* and elsewhere have proven that using modern on-farm irrigation techniques such as sprinkler and drip for cotton cultivation would result in water savings up to 58 %, increased yields up to 35 % and reduced the labor requirement between 50 % and 85 % depending on the type of system. Similar results are indicated for wheat, sugar beet and maize (MAAR and IFAD, 2004).

Since climate change is a multidisciplinary issue by nature, strategies should be integrated into national policies affecting water supply, water use, land use agriculture and environmental policies. The implementation of the integrated water resources management concept (IWRM) which was recently developed as an approach for ensuring optimal management of water resources can help for defining a new water policy for climate change preparedness and mitigation.

IWRM is a process that promotes the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystem. It is a framework for the sustainable development and management of water resources for the whole society. Effective IWRM must include (a) policies to improve water use efficiency ,particularly in irrigation (b) give the water its real economic value (c) education of policy makers on the importance of climate change preparedness as part of the IWRM (d) rationing water if necessary (e) developing nontraditional water sources as water reuse, water harvesting, desalinization.

**Build institutional and technical capacity:** The country has worked during the last years to enhance the technical capacity of different institutions involved in water management mainly meteorological and hydrological monitoring networks (systematic collection and data processing). But coordination a cooperation among different water stakeholders is still lacking.

There is also an urgent need to create a central institutions or task forces at the national level charged with assessing, monitoring, supervising a climate change early warning system and developing a climate change preparedness plan. This central unite should have the access to different source of water information (different water monitoring and data bases systems and other related sectors) and has the technical capacity (in both qualified human resources and modern equipments) for conducting studies, research, synthesize existing information (previous and actual), developing long term climate change planning, preparing scenario, developing indicators to assess various characteristics of climate change, assess vulnerability of national economy at different levels including the poor, and defining national strategy and priorities for mitigating climate change. For example developing indicators for assessing different characteristics of drought, such as intensity, frequency, spatial extent and socioeconomic impacts.

- **Information exchange and multidisciplinary linkages:** Since climate change affects all the socioeconomic sectors its preparedness action plan necessitate a multidisciplinary approach, institutional arrangements and interagency communication and information exchange. Decision makers should have in hand on a regular basis the reliable data and the results regarding different scenarios to accord priorities for their actions. This issue requires institutional linkages between monitoring and rapid response action plan at different decision making level partnerships between different disciplines and institutions will further strengthen cooperation and enhance information exchange mechanism.

- **Regional cooperation:** Mitigating climate change impacts necessitate the enhancement of regional cooperation, since this phenomenon will have impacts on all the countries of the Eastern Mediterranean region. Cooperation with other countries through bi-lateral or regional cooperation by establishing a regional networks with the assistance of regional and international organizations would help to streamline the information, and increasing capacity building. The regional cooperation provides also opportunities to share data, information, experience and lesson learned.

## 6. General conclusions and recommendations

- ✓ All predictions indicate that climate change will reduce the overall amount of rain by 20 % and will increase variability.
- ✓ -Climate change studies indicate that Syria and Eastern Mediterranean countries will experience extreme weather events. Changes in precipitation, combined with rising atmospheric temperature and reduced snow cover, will have impacts on water quality and quantity, requiring water managers to incorporate climate change in water policies.
- ✓ Limited water supplies due to climate change would restrict present agricultural productivity and threaten the food security in Syria. Changing crop types and introducing more efficient irrigation systems can provide significant win-win options for water conservation to offset the projected impacts of climate change in the country.
- ✓ Water policy should focus on demand management rather on supply management. This means more efforts are needed regarding the enforcement of water legislation, awareness, integration of land and water management through the implementation of integrated water resources management concept (IWRM).
- ✓ Implementation of climate change adaptation strategies within national water resources strategic plans will require interaction and horizontal coordination

between multiple levels of government institutions and the involvement of stakeholders, civil societies, private and public sectors.

- ✓ Development of cooperation with the other countries of the region of similar natural and climatic conditions will facilitate exchange of data, experiences, lesson learned and helping in capacity building of national institutions.
- ✓ A national water strategy depends heavily on data and information sharing. The establishment of an early warning system is urgently needed for the country. It will aid in supervising and managing the water data collection, data processing, assessment of climate change impacts and vulnerability. Dissemination of early warning findings to key policy and decision makers is critical to effective climate change preparedness.

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