# Water use efficiency and economic approach

## National study Syria

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# I. Context

## 1. Improvement of water use efficiency in the Mediterranean

In its report entitled "Mediterranean: the Blue Plan's environment and development outlook" (2005), the Blue Plan endeavoured to evaluate the extent of water loss and "misuse" for each sector (losses which artificially inflate water demand in the various national planning documents) and on the basis of a set of ambitious albeit "feasible" hypotheses to estimate recoverable losses per sector and per Mediterranean basin sub-region. Potential achievable savings were thus estimated at around a quarter of current water demand, in other words 70 $km^3$ for a total demand of 282 $km^3$ for the Mediterranean states as a whole in 2000. In 2025 it would be about 85 $km^3$ /yr (for total water demand of some 330 $km^3$/yr).

**Table 1 - Estimate recoverable losses by Mediterranean sub-regions in 2000**

| Sub-regions of Mediterranean basin (Countries) | Drinking water Networks efficiency raised to 85% and users efficiency raised to 90% | Irrigation Networks efficiency raised to 90% and plot efficiency raised to 80% | Industries Recycling generalized to 50% | Total |
|---|---|---|---|---|
| North | 4,4 | 15,7 | 9,5 | 29,6 |
| East | 1,8 | 12,2 | 2,2 | 16,2 |
| South | 2,5 | 17,9 | 4,1 | 24,5 |
| Total | 8,7 | 45,8 | 15,8 | 70,3 |

Source: Blue Plan, J. Margat

Note: They are the "recoverable losses" from the only point of view of the techniques available, without prejudging social resistances and difficulties.

It was retained the "desirable objectives" following as regards improving water physical efficiencies at regional level and by 2025 (These "desirable" objectives correspond to the efficiency improvement hypotheses in the Blue Plan's alternative scenario):

- For drinking water in the Municipalities: rates of distribution losses reduced to 15% and user leaks reduced to 10%;
- For irrigation: transport and distribution losses reduced to 10% and raised irrigation plot efficiency to 80%;
- For industry: recycling generalized to 50%.

However, up to each individual country to set its own efficiency improvement objectives. Efficiency plans (or plans for the rational use of water resources), the principle of which was adopted at the Johannesburg Summit, can be drawn up and implemented at various levels (country, basin, tables, city or irrigated area).

## 2. Priority indicators of water chapter of Mediterranean Strategy for Sustainable Development

The Contracting Parties to the Barcelona Convention adopted, in November 2005, the Mediterranean Strategy for Sustainable Development (MSSD). The first priority field of action of the Strategy is "integrated water resources and demand management", the key aims of which are:

- Strengthening of WDM policies to stabilize water demand by reducing losses and wasteful use, and increasing the added value per $m^3$ of water used (efficiencies improvement);
- to promote the integrated management of catchment's areas including underground and surface water, ecosystems and depollution objectives;
- Access to drinking water and sanitation to deliver the "Millennium Development Goals";
- to promote participation, partnership, and co-operation.

5 priority indicators adopted to regularly follow the progress made by the countries in terms of water management, namely:

**Table 2 – Priority indicators of MSSD**

| Number | Indicator | Code |
|---|---|---|
| 1 | Index of water efficiency (total and per sector) | WAT-P01 |
| 2 | Water demand (total and per sector), and compared to the GDP (total and per sector) | WAT-P02 |
| 3 | Exploitation index of renewable natural resources | WAT-P03 |
| 4 | Share of the population with access to an improved water source (total, urban, rural) | WAT-P04 |
| 5 | Share of the population with access to an improved sanitation system (total, urban, rural) | WAT-P05 |

Source: Plan Bleu, 2005

# II. Water efficiency index (total and per sector)

## 1. Definition

This index measures progress in water savings through demand management, by reducing losses and wasteful use during transport and distribution. It covers total and sectoral efficiency (drinking water, agriculture and industry).

### 1.1. Sectoral efficiencies

#### *1.1.1. Drinking water efficiency*

This is the share of drinking water produced, distributed, and paid by consumers.

Epot = V1 / V2 where V1 = drinking water volume invoiced and paid by consumer in $km^3$/year.

V2 = total drinking water volume produced and distributed in $km^3$/year (drinking water demand).

The indicator measures both the physical efficiency of drinking water distribution networks (loss rates or yield) and economic efficiency, e.g. the capacity of network managers to cover costs through consumer payments.

#### *1.1.2. Irrigation water efficiency*

The physical efficiency of irrigation water is the product of "network for irrigation water transport and distribution" efficiency by plot efficiency:

**Eirr = E1 x E2**

E1: efficiency of irrigation water transport and distribution networks, upstream from agricultural plots, measured as the ratio between water volumes actually distributed to plots (V3) and the total volume of water for irrigation (V4), upstream of networks, including losses in networks;

**E1 = V3 / V4**

E2: plot irrigation efficiency is defined as the sum of efficiencies (per plot) of all irrigation modes (surface irrigation, sprinkler irrigation, micro-irrigation, others), weighted by the respective proportions of all local modes and estimated as the ratio between water volumes actually consumed by plants and volumes delivered to plots:

$$\mathbf{E2} = \sum_{1}^{n} \frac{Sm \times Em}{S}$$

n: number of irrigation modes used

Sm: surfaces irrigated using modes: m

Em: method efficiency: m

S: total local irrigated surface according to different modes

#### *1.1.3. Water industrial efficiency*

The volume of recycled industrial water (recycling index)

**Eind= V5 / V6**

V5 = Recycled water volumes in $km^3$/year.

V6 = Gross volume consumed for industrial processes which is equal to the volume incoming for the first-time to the industrial plant + recycled volume in $km^3$/year.

### 1.2. Total efficiency

Total physical efficiency of water consumption is defined as the sum of used water quantity ratios per sector (demand-losses) over sector demand, weighted by the share of sectoral requirements (drinking water, irrigation and industry).

$$E = \frac{(Epot \times Dpot + Eirr \times Dirr + Eind \times Dind)}{D}$$

Dpot: domestic demand (drinking water)

Dirr: irrigation water demand

Dind: industrial water demand

D: total water demand

Water demand is defined as the sum of water volumes dedicated to satisfying needs (excluding "green" water[1] and "virtual" water[2], including volumes losses in production, transport and consumption. This corresponds to the sum of water volumes abstracted, non-traditional water production (desalination and imports), and water reuse, minus export volumes.

## 2. Unit

Percentage (%)

## 3. Precautions / Notes

The economic efficiency of drinking water is dependent on invoicing modes (subscription, meters) and meter malfunction can yield biased results.

In situ measurements of actual average plot irrigation efficiency (E2) are more complex, in view of the difficulty in precisely assessing volumes consumed by plants, and in view of the high number of plots. Each country has national estimates of the average efficiency of all systems, based on pilot experiments. The value of E2 in fact highlights the distribution of irrigation per major modes of irrigation at national level (theoretical average efficiency estimated from 40 to 60% for surface irrigation from 70 to 80% for sprinkler irrigation and from 80 to 90% for localized irrigation).

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[1] Green water is the transpiration which rises directly from precipitations; it is about rain agriculture, pastures, forests, etc.

[2] Virtual water corresponds to the volume of water consumed during the production of o good (not to be confused with the water content in this good). It is usually expressed in litres of water per kilo. For example, in Italy, approximately 2 400 litres of water is needed to produce one kilo of corn, 2 500 litres for one kg of rice and 21 000 litres for one kilo of Beef meat.

# III. Determination of efficiencies

## 1. Drinking water

### 1.1.1. Drinking water invoiced and paid by customer

**Table 3 - Drinking water volume invoiced and paid by consumer (V1) ($km^3$/year)**

| Year | | Values | Source |
|---|---|---|---|
| 1995 | | 0.340 | 1 |
| 2000 | | 0.608 | 2 |
| 2005 | | 0.781 | 3 |
| 2010 | 1st Scenario | 0.954 | 4 |
| | 2nd Scenario | 0.864 | 5 |
| | Average | 0.909 | 6 |
| 2015 | | 0.925 | 7 |
| 2020 | | 1.071 | 8 |
| 2025 | | 1.226 | 9 |
| 2030 | | 1.336 | 10 |

Source: El-Azmeh, 2008

### 1.1.2. Drinking water produced and distributed

**Table 4 - Total drinking water volume produced and distributed (V2) ($km^3$/year)**

| Year | | Values | Source |
|---|---|---|---|
| 1995 | | 0.609 | 1 |
| 2000 | | 0.984 | 2 |
| 2005 | | 1.298 | 3 |
| 2010 | 1st Scenario | 1.612 | 11 |
| | 2nd Scenario | 1.259 | 12 |
| | 3rd Scenario | 1.140 | 13 |
| | Average | 1.337 | 14 |
| 2015 | | 1.156 | 15 |
| 2020 | | 1.260 | 16 |
| 2025 | | 1.393 | 17 |
| 2030 | | 1.484 | 18 |

Source: El-Azmeh, 2008

### 1.1.3. Drinking water efficiency

**Table 5 - Drinking water efficiency (Epot = V1 / V2 in %)**

| Year | Values | Source |
|---|---|---|
| 1995 | 55.8% | Expert's calculation |
| 2000 | 61.8% | |
| 2005 | 60.2% | |
| 2010 | 68.0% | Expert's prospects |
| 2015 | 80.0% | Set target |
| 2020 | 85.0% | Expert's prospects |
| 2025 | 88.0% | |
| 2030 | 90.0% | |

Source: El-Azmeh, 2008

### *1.1.4. Sources and Remarks - Drinking water section*

1) Central Bureau of Statistics, Statistical Abstract 1996, table 8/5
2) Central Bureau of Statistics, Statistical Abstract 2001, table 8/5
3) Central Bureau of Statistics, Statistical Abstract 2006, table 8/5
4) Proposed by the expert as a simple linear extension of the increase in drinking water volume invoiced and paid by consumer as recorded for the preceding period 2000-2005:

   **V1 2010 1st scenario = V1 2005 + (V1 2005 – V1 2000)**

5) Proposed by the expert on basis of the following data/assumptions:
   - The average population projection for the year 2010 (20.5 millions) which is the one-decimal rounded average of the high and low projections reported in the 1st National Population Report, 2008.
   - The anticipated urban/rural composition of population in the year 2010 (54.5% urban / 45.5% rural), calculated from 2007 composition (53.5% urban / 46.5% rural) and the current average urbanization rate (0.33% per annum, or 1% every 3 years). Both as reported in the 1st National Population Report, 2008.
   - Coverage with drinking water supply in the year 2010 for residents of urban and rural areas (99% urban and 93% rural), as targeted by the 10th 5-year national development plan (2006-2010).
   - The current average consumption (invoiced and paid) 120 l/day per individual served with piped drinking water (from available statistics).

   With the application of the following formula:

   **V1 2010 2nd scenario = 20.5 [(0.545*0.99) + (0.455*0.93)] x 0.120 x 365 x 10-3**

6) The average of the two scenarios for V1 in 2010 is assessed by the expert to be more reasonable and likely realizable, thus would be the input for use in computing the Water Efficiency Index.
7) Proposed by the expert on basis of the following data/assumptions:
   - The average population projection for the year 2015 (23.0 millions) which is the one-decimal rounded average of the high and low projections reported in the 1st National Population Report, 2008.
   - Coverage with drinking water supply in the year 2015 to reach 91.8% of whole population, as targeted by the 2nd National Report on Millennium Goals, September 2005.
   - A continued average consumption (invoiced and paid) 120 l/day per individual served with piped drinking water.

   With the application of the following formula:

   **V1 2015 = 23.0 x 0.918 x 0.120 x 365 x 10-3**

8) Proposed by the expert on basis of the following data/assumptions:
   - The average population projection for the year 2020 (25.5 millions) which is the one-decimal rounded average of the high and low projections reported in the 1st National Population Report, 2008.
   - Coverage with drinking water supply in the year 2020 to reach 95.9% of whole population, which is the average of targeted coverage of years 2015 and 2025 (91.8 and 100% respectively).
   - A continued average consumption (invoiced and paid) 120 l/day per individual served with piped drinking water.

   With the application of the following formula:

   **V1 2020 = 25.5 x 0.959 x 0.120 x 365 x 10-3**

9) Proposed by the expert on basis of the following data/assumptions:

- The average population projection for the year 2025 (28.0 millions) which is the one-decimal rounded average of the high and low projections reported in the 1st National Population Report, 2008.
- The targeted full coverage with piped drinking water service for all urban and rural residents.
- A continued average consumption (invoiced and paid) 120 l/day per individual.

With the application of the following formula:

**V1 2025 = 28.0 x 0.120 x 365 x 10-3**

10) Proposed by the expert on basis of the following data/assumptions:
   - A population projection for the year 2030 (30.5 millions) as proposed by the expert on basis of continuing growth in population size at the average of about 0.5 million/year till the year 2035 at least.
   - A continued full coverage with piped drinking water service for all urban and rural residents.
   - A continued average consumption (invoiced and paid) 120 l/day per individual.

   With the application of the following formula:

**V1 2030 = 30.5 x 0.120 x 365 x 10-3**

11) Proposed by the expert as a simple linear extension of the increase in Total drinking water volume produced and distributed as recorded for the preceding period 2000-2005:

**V2 2010 1st scenario = V2 2005 + (V2 2005 – V2 2000)**

12) Proposed by the expert on basis of the following data/assumptions:
   - The results of the 1st Scenario for (V1) calculation (the previous table).
   - The targeted reduction of water losses (sum of physical and administrative losses) as set in the 10th 5-year development plan (2006-2010), i.e. to reach average losses 22% for urban areas and 27% for rural areas.
   - An anticipated 2010 urban/rural composition of piped drinking water beneficiaries; 56% urban and 44% rural. Calculated from anticipated urban/rural composition of population in the same year (54.5% urban / 45.5% rural), and targeted coverage with piped drinking water supply in the year 2010 for residents of urban and rural areas (99% urban and 93% rural, please refer to the 3rd point of above source No.5), by use of following formulas.
     - **Urban beneficiaries % = 100 (0.545*0.99) / [(0.545*0.99) + (0.455*0.93)]**
     - **Rural beneficiaries % = 100 (0.455*0.93) / [(0.545*0.99) + (0.455*0.93)]**

   With the application of the following formula;

**V2 2010 2nd scenario = V1 2010 1st scenario / {1- [(0.56*0.22) + (0.44*0.27)]}**

13) Proposed by the expert on basis the following data/assumptions:
   - The results of the 2nd Scenario for (V1) calculation (the previous table).
   - The targeted reduction of water losses (sum of physical and administrative losses) as set in the 10th 5-year development plan (2006-2010), i.e. to reach average losses 22% for urban areas and 27% for rural areas.
   - An anticipated 2010 urban/rural composition of piped drinking water beneficiaries; 56% urban and 44% rural (as explained in the previous source).

   With the application of the following formula:

**V2 2010 3rd scenario = V1 2010 2nd scenario / {1- [(0.56*0.22) + (0.44*0.27)]}**

14) The average of the three scenarios for V2 in 2010 is assessed by the expert to be more reasonable and likely realizable, thus would be the input for use in computing the Water Efficiency Index.

15) Proposed by the expert on basis of government's targeted efficiency 80%:

**V2 2015 = V1 2015 x 100/80**

16) Proposed by the expert on basis of a higher target efficiency 85% for 2020:

**V2 2020 = V1 2020 x 100/85**

This efficiency is prospected taking into consideration the following trends:

- The increasing pressures on potable water in result of Syria's high population growth, and
- The increasing scarcity of potable water in result of accumulated and continuing depletion and pollution of its resources, added to the anticipated decrease of renewable water resources in general due to anticipated adverse climatic changes in the east-Mediterranean region as a result of the global warming phenomenon.

A matter which will most likely bring the drinking water to become a national critical and first priority issue, forcing anticipatively the government to seek higher attainable target for drinking water efficiency by that time.

It is worthy to indicate that the realization of 85% target efficiency in 2020 is dependent on the achievement of 80% in 2015.

This judgment falls under futurity concepts and rules, and presented here for prospective purposes only, without any assumption of a planning role.

17) Proposed by the expert on basis of a higher target efficiency 88% for 2025:

**V2 2025 = V1 2025 x 100/88**

While the trends described in the preceding remark (source 16) are prospected to continue and magnify, forcing the government to seek higher and higher targets for drinking water efficiency, the technical (and perhaps socio-cultural) limitations will most probably prevent attaining the same improvement of efficiency as proposed for the preceding quinquennium 2016-2020 (5%). For the period 2021-2025 a 3% attainment is prospected by the expert to be a reasonable (though hardly attainable) target.

It is worthy to indicate that the realization of 88% target efficiency in 2025 is dependent on the achievement of 85% in 2020.

This judgment falls under futurity concepts and rules, and presented here for prospective purposes only, without any assumption of a planning role.

18) Proposed by the expert on basis of a higher target efficiency 90% for 2030:

**V2 2030 = V1 2030 x 100/90**

While the trends described in the preceding remark (source 16) are prospected to continue and magnify in the quinquennium 2026-2030 (perhaps except of some improvement with regards to pollution of drinking water resources in result of prospected increasing enforcement of pollution prevention measures), the shrinking margins for improvement of efficiency, with a relatively low organizational and technical capacities which anticipated to continue in a way or another, will make it extremely difficult for drinking water providers to attain further 2 points of efficiency (from proposed 88% in 2025 to proposed 90% in 2030) comparing to 5 and 3 points as proposed for the preceding two quinquenniums 2016-2020 and 2021-2025 respectively. However such attainment is prospected by the expert to be a reasonable target for the government at that time, being forced by increasing severity and high priority of drinking water issue in the country.

It is worthy to indicate that the realization of 90% target efficiency in 2030 is dependent on the achievement of 88% in 2025.

This judgment falls under futurity concepts and rules, and presented here for prospective purposes only, without any assumption of a planning role.

# 2. Irrigation water

## 2.1. Transport and distribution networks

### *2.1.1. Water distribution to plots (upstream of plots)*

**Table 6 - Volumes actually distributed to plots (V3) ($km^3$/year)**

| Year | | Values | Source |
|---|---|---|---|
| 1995 | | 12.043 | 19 |
| 2000 | | 13.188 | 20 |
| 2005 | | 16.616 | 21 |
| 2010 | 1st Scenario | 17.796 | 22 |
| | 2nd Scenario | 14.837 | 23 |
| | Average | 16.317 | 24 |
| 2015 | | 13.192 | 25 |
| 2020 | | 12.573 | 26 |
| 2025 | | 12.000 | 27 |
| 2030 | | 12.000 | 28 |

Source: El-Azmeh, 2008

### *2.1.2. Total water for irrigation (upstream of networks)*

**Table 7 - Total volume of water for irrigation, including losses in networks (V4) ($km^3$/year)**

| Year | Values | Source |
|---|---|---|
| 1995 | 13.992 | 33 |
| 2000 | 15.137 | 34 |
| 2005 | 18.565 | 35 |
| 2010 | 18.266 | 36 |
| 2015 | 14.723 | 37 |
| 2020 | 13.986 | |
| 2025 | 13.304 | |
| 2030 | 13.260 | |

Source: El-Azmeh, 2008

### *2.1.3. Transport and distribution efficiency*

**Table 8 - Transport and distribution efficiency (E1 = V3 / V4 in %)**

| Year | Values | Source |
|---|---|---|
| 1995 | 86.1% | Expert's calculations |
| 2000 | 87.1% | |
| 2005 | 89.5% | |
| 2010 | 89.3% | Expert's prospects |
| 2015 | 89.6% | |
| 2020 | 89.9% | |
| 2025 | 90.2% | |
| 2030 | 90.5% | |

Source: El-Azmeh, 2008

## 2.2. Plot irrigation efficiency

**Table 9 - Irrigated surfaces in the country according to modes of irrigation (Sm in 1000 ha)**

| Year | | Value | | | Source |
|---|---|---|---|---|---|
| | | Surface (Ssur) | Sprinkler (Sspr) | Localized (Sloc) | |
| 1995 | | 1,089 | Negligible | Negligible | 38 |
| 2000 | | 1,123 | 58 | 30 | 39 |
| 2005 | | 1,182 | 160 | 84 | 40 |
| 2010 | 1st Scenario | 1,100 | 262 | 138 | 41 |
| | 2nd Scenario | 681 | 554 | 265 | 42 |
| | Average | 890 | 408 | 202 | 43 |
| 2015 | | 315 | 840 | 395 | 44 |
| 2020 | | 215 | 928 | 437 | 45 |
| 2025 | | 150 | 986 | 464 | 46 |
| 2030 | | 150 | 986 | 464 | 47 |

Source: El-Azmeh, 2008

**Table 10 - Total surfaces irrigated in the country according to the whole modes (S in 1000 ha)**

| Year | Values | Source |
|---|---|---|
| 1995 | 1,089 | 38 |
| 2000 | 1,211 | 29 |
| 2005 | 1,426 | 30 |
| 2010 | 1,500 | 31 |
| 2015 | 1,550 | 49 |
| 2020 | 1,580 | |
| 2025 | 1,600 | |
| 2030 | 1,600 | |

Source: El-Azmeh, 2008

For information, theoretical efficiencies are as follows:

**Table 11 – Theoretical efficiencies of each irrigation mode**

| Irrigation mode practiced | Theoretical efficiency (%) | Efficiency measured or estimated in the country (%) | | | |
|---|---|---|---|---|---|
| | | Em | Year | Values | Source |
| Surface | 40 - 60 | Esur | 1995-2005 | 45% | 50 |
| | | | 2010 | 48% | 51 |
| | | | 2015 | 54% | |
| | | | 2020 | 58% | |
| | | | 2025 | 64% | |
| | | | 2030 | 65% | |
| Sprinkler | 70 - 80 | Espr | 1995-2005 | 70% | 52 |
| | | | 2010 | 71% | 53 |
| | | | 2015 | 72% | |
| | | | 2020 | 73% | |
| | | | 2025 | 74% | |
| | | | 2030 | 75% | |
| Localized | 80 - 90 | Eloc | 1995-2005 | 80% | 54 |
| | | | 2010 | 82% | 55 |
| | | | 2015 | 84% | |
| | | | 2020 | 85% | |
| | | | 2025 | 86% | |
| | | | 2030 | 87% | |

Source: El-Azmeh, 2008

Table 12 - Plot water use efficiency - E2 = (Ssur*Esur+Sspr*Espr+Sloc*Eloc)/S (in %)

| Year | Values | Source |
|---|---|---|
| 1995 | 45.0% | Expert's calculations |
| 2000 | 47.1% | |
| 2005 | 49.9% | |
| 2010 | 58.8% | Expert's prospects |
| 2015 | 71.4% | |
| 2020 | 74.3% | |
| 2025 | 76.5% | |
| 2030 | 77.5% | |

Source: El-Azmeh, 2008

## 2.3. Water irrigation efficiency

Table 13 - Water irrigation efficiency (Eirr = E1 x E2 in %)

| Year | Values | Source |
|---|---|---|
| 1995 | 38.7% | Expert's calculations |
| 2000 | 41.0% | |
| 2005 | 44.7% | |
| 2010 | 52.5% | Expert's prospects |
| 2015 | 64.0% | |
| 2020 | 66.8% | |
| 2025 | 69.0% | |
| 2030 | 70.1% | |

Source: El-Azmeh, 2008

## 2.4. Sources and Remarks - Irrigation water section

19) Ministry of Irrigation, Actual Water Balance - Hydrological Year 1994-1995 (Figure refers to the hydrological year from 01/10/1994 till 30/09/1995)

20) Ministry of Irrigation, Actual Water Balance - Hydrological Year 1999-2000 (Figure refers to the hydrological year from 01/10/1999 till 30/09/2000)

21) Ministry of Irrigation, Actual Water Balance - Hydrological Year 2004-2005 (Figure refers to the hydrological year from 01/10/2004 till 30/09/2005)

22) Proposed by the expert as a simple linear extension of the increase in water volume actually distributed to plots, quenched by the shrinking margins for converting non-irrigated lands into irrigated ones as remarkable from the prospected slow-down of expansion in irrigated surfaces in the country:

Table 14 – Total irrigated surfaces in Syria

| Year | Total irrigated surfaces S (1,000 ha) | Source |
|---|---|---|
| 2000 | 1,211 | 29 |
| 2005 | 1,426 (Increase 2000-2005: 215) | 30 |
| 2010 | 1,500 (Increase 2005-2010: 74) | 31 |

Source: El-Azmeh, 2008

This quenching action is introduced to the linear extension of the increase in water volume through the following formula:

**V3 2010 1st scenario = V3 2005 + [(V3 2005 – V3 2000) (S 2010 – S 2005) / (S 2005 – S 2000)]**

23) Proposed by the expert on basis of the following data/assumptions:

- The targets of the 10th 5-year National Development Plan (2006-2010); to convert about 50% of 2005 conventional surface-irrigated lands into modern irrigation (sprinkler – localized – modified surface irrigation), thus lowering the annual water demand for a one ha of these converted lands from 12,800 $m^3$ (as generalized in the Plan for conventional irrigation per national average crops' composition) to 8,000 $m^3$ (as targeted in the Plan for modern irrigation per same crops' composition).
- The non-irrigated areas that are prospected during the quinquennium 2006-2010 to be converted into irrigated ones (about 74,000 ha, source 31) are assumingly irrigated by modern systems, applying to them the same average water demand of 8,000 $m^3$/ha/annum.
- The same average water demand is also applied for areas already irrigated by modern systems up to 2005 (244,000 ha, source 30).

Calculations relevant to this scenario are summarized in the table 15:

**Table 15 – Evolution of irrigated areas by modern systems**

| | 2005 | 2010 | | |
|---|---|---|---|---|
| | Irrigated area (1,000 ha) | Irrigated area (1,000 ha) | Generalized Water Demand per ha ($m^3$/year) | Total Water Demand ($km^3$/year) |
| Conventional | 1,182 | 591 | 12,800 | 7.565 |
| Modern | 244 | 909 | 8,000 | 7.272 |
| Totals | 1,426 | 1,500 | | 14.837 |
| Source | 30 | 32 | | |

Source: Al-Azmeh, 2008

24) The average of the tow scenarios for V3 2010 is assessed by the expert to be more reasonable and likely realizable, thus would be the input for use in computing the Water Efficiency Index.

25) Proposed by the expert on basis of the following data/assumptions:

- The target of the National Program for Conversion to Modern Irrigation (February, 2005); to convert in 10 years (i.e. till 2015) all irrigated lands into modern modes (sprinkler – localized – modified surface irrigation), except of 165,000 ha excluded for being unconvertible within Program's timeframe due to non-suitability of existing networks.
- Average water demands 8,000 $m^3$ /year for a modern-irrigated one ha, as targeted in the 10th 5-year National Development Plan (2006-2010).
- Average water demands 12,800$m^3$/year for a conventional-irrigated 1 ha of the unconvertible areas.
- Total irrigated surfaces 1,550 thousand ha. Prospected by the expert on basis of 2010 total irrigated areas 1,500 thousand ha (source 31) and a "net" conversion of non-irrigated lands into irrigated ones at about +10,000 ha/year in average for the period 2011-2015, resulting in total to about 50,000 ha additional irrigated areas (refer to source 49).

Accordingly, the total volume of water actually distributed to plots in the year 2015 could be prospected as follows:

**V3 2015 = [8,000 (1,550-165) + (12,800 x 165)] 10-6**

This judgment falls under futurity concepts and rules, and presented here for prospective purposes only, without any assumption of a planning role.

26) Proposed by the expert on basis of the following data/assumptions:

- About 60% of the areas excluded from the National Program for Conversion to Modern Irrigation of 2006-2015, due to non-suitability of existing networks, are prospected for rehabilitation of networks and conversion to modern irrigation during the period 2016-2020. This makes about

100,000 out of the initially excluded 165,000 ha. Consequently at the level of the year 2020 there will remain about 65,000 ha prospected to still irrigate by conventional surface irrigation with an average plot water demand no much less than before (12,800 $m^3$/ha/year).

- Average plot water demand per modern-irrigated ha to slightly decrease from 8,000 $m^3$/ha/year (2015) to 7,750 $m^3$/ha/year (2020). This is prospected by the expert as a net resultant of the following two contradictory factors, the second of which is assessed to be more powerful, at least in the stage of this quinquennium:
  a) "Negative" factor: anticipated increasing demand on irrigation water per ha, in order to balance the likely decrease and imbalance of precipitation (including increasing frequency of drought years) resulting from the anticipated adverse climatic changes in the east-Mediterranean region due to global warming phenomenon.
  b) "Positive" factor: a general improvement in irrigation techniques and experience, on the one hand, and changes in crops' composition towards less water consuming and drought-resistant cultivars, on the other hand, both actuated by increasing pressures on water resources in result of Syria's high population growth and priority of allocating water resources for non-agricultural uses, increasing scarcity of water and anticipated decrease of renewable water resources due to the anticipated adverse climatic changes in the east-Mediterranean region, again in result of global warming.
- Total irrigated surfaces 1,580 thousand ha. Prospected by the expert on basis of 2015 total irrigated areas 1,550 thousand ha (source 25) and a "net" conversion of non-irrigated lands into irrigated ones at about +6,000 ha/year in average for the period 2016-2020, resulting in total to about 30,000 ha additional irrigated areas (refer to source 49).

Accordingly, the total volume of water actually distributed to plots in the year 2020 could be prospected as follows:

$$V3\ 2020 = [7{,}750\ (1{,}580-65) + (12{,}800 \times 65)]\ 10^{-6}$$

This judgment falls under futurity concepts and rules, and presented here for prospective purposes only, without any assumption of a planning role.

27) Proposed by the expert on basis of the following data/assumptions:

- The remainder conventional-irrigated 65,000 ha (previous source 26) are prospected for rehabilitation of networks and conversion to modern irrigation during the quinquennium 2021-2025, i.e. no areas in 2025 still irrigate with conventional surface irrigation.
- Average plot water demand per irrigated ha to slightly decrease from 7,750 $m^3$/ha/year (2020) to 7,500 $m^3$/ha/year (2025). This is prospected by the expert as a net resultant of the following two contradictory factors, the second of which is assessed to be more powerful, at least in the stage of this quinquennium:
  a) "Negative" factor: anticipated increasing demand on irrigation water per ha, in order to balance the likely decrease and imbalance of precipitation (including increasing frequency of drought years) resulting from the anticipated adverse climatic changes in the east-Mediterranean region due to global warming phenomenon.
  b) "Positive" factor: a general improvement in irrigation techniques and experience, on the one hand, and changes in crops' composition towards less water consuming and drought-resistant cultivars, on the other hand, both actuated by increasing pressures on water resources in result of Syria's high population growth and priority of allocating water resources for non-agricultural uses, increasing scarcity of water and anticipated decrease of renewable water resources due to the anticipated adverse climatic changes in the east-Mediterranean region, again in result of global warming.

- Total irrigated surfaces 1,600 thousand ha. Prospected by the expert on basis of 2020 total irrigated areas 1,580 thousand ha (source 26) and a "net" conversion of non-irrigated lands into irrigated ones at about +4,000 ha/year in average for the period 2021-2025, resulting in total to about 20,000 ha additional irrigated areas, totalling to 1,600 thousand ha which considered by the National Basic Prospective Report "Towards a Vision for Development Prospects - Syria 2025" (Damascus, 2007) as the maximum irrigateable area in the country in view of maximum renewable water resources (refer to source 49).

Accordingly, the total volume of water actually distributed to plots in the year 2025 could be generalized as follows:

**V3 2025 = 1,600 x 7,500 x 10-6**

This judgment falls under futurity concepts and rules, and presented here for prospective purposes only, without any assumption of a planning role.

28) There is high uncertainty with regards to the long term future of agricultural irrigation, however it could be prospected that unless new major water resources are added to the national water balance, enabling further expansion in the irrigated areas (e.g. from desalination of seawater or saline groundwater, higher shares for Syria from Euphrates and Tigris, etc.), and/or more water-saving agricultural practices are applied, it is proposed by the expert that the total water distributed to plots (V3) will remain in 2030 more or less similar to 2025.

29) Central Bureau of Statistics, Statistical Abstract 2001, table 8/4.

30) Central Bureau of Statistics, Statistical Abstract 2006, table 9/4.

31) Estimation based on 2005 total irrigated areas 1,426 thousand ha (above source 30) and the current "net" rates of converting non-irrigated lands into irrigated ones (about +15,000 ha/year).

32) Calculated by the expert on basis of estimated 2010 total irrigated areas 1,500 thousand ha (above source 31) and the target of the 10th 5-year national development plan (2006-2010) to convert about 50% of 2005 conventional surface-irrigated lands into modern irrigation.

33) Ministry of Irrigation, Actual Water Balance - Hydrological Year 1994-1995. Figure refers to the hydrological year from 01/10/1994 till 30/09/1995, obtained as the sum of volume actually distributed to plots (V3) and reported evaporative losses from water surfaces. No estimations available for losses due to potential leaks/overflows ex distribution networks, but the magnitude of these losses is assessed to be relatively low in view of the fact that about 63% of irrigated areas in this hydrological year were groundwater-irrigated ex local (dominantly plot individual) wells, where actually no distribution networks "upstream of plots" are involved, and in-plot distribution losses could be attributed to plot irrigation inefficiency rather than transport and distribution inefficiency.

34) Ministry of Irrigation, Actual Water Balance - Hydrological Year 1999-2000. Figure refers to the hydrological year from 01/10/1999 till 30/09/2000, obtained as the sum of volume actually distributed to plots (V3) and reported evaporative losses from water surfaces. No estimations available for losses due to potential leaks/overflows ex distribution networks, but the magnitude of these losses is assessed to be relatively low in view of the fact that about 58% of irrigated areas in this hydrological year were groundwater-irrigated ex local (dominantly plot individual) wells, where actually no distribution networks "upstream of plots" are involved, and in-plot distribution losses could be attributed to plot irrigation inefficiency rather than transport and distribution inefficiency.

35) Ministry of Irrigation, Actual Water Balance - Hydrological Year 2004-2005. Figure refers to the hydrological year from 01/10/2004 till 30/09/2005, obtained as the sum of volume actually distributed to plots (V3) and reported evaporative losses from water surfaces. No estimations available for losses due to potential leaks/overflows ex distribution networks, but the magnitude of these losses is assessed to be relatively low in view of the fact that about 61% of irrigated areas in this hydrological year were groundwater-irrigated ex local (dominantly plot individual) wells, where actually no distribution

networks "upstream of plots" are involved, and in-plot distribution losses could be attributed to plot irrigation inefficiency rather than transport and distribution inefficiency.

36) Proposed by the expert as the sum of the average volume anticipated for actual distribution to plots in the year 2010 (source 24) and the volume represents evaporative losses from water surfaces as reported in all recent national water balances issued by the Ministry of Irrigation:

**V4 2010 = V3 2010 Average + 1.949 (km$^3$/year)**

This method is lacking accuracy due to the following two reasons:

– A fixed volume is used for evaporative losses regardless of varying climate conditions and volumes of stored and distributed water.

– Losses due to potential leaks/overflows ex distribution networks are not considered.

However, any other method will be lacking compatibility with V4 reported for previous years (1995, 2000 &2005) since they have the same built-in inaccuracy.

37) For the chain of quinquenniums 2015-2020-2025-2030, it was proposed by the expert that an estimated gradual improvement in transport and distribution efficiency (E1) of 0.3% per each quinquennium would be achievable, mainly in result of implementing evaporation control measures including underground storage of seasonal surplus of surface water by artificial recharging (infiltration or injection) into the aquifers, conversion of opened distribution systems into piped or covered ones, etc.

This improvement is conversely quantified into total volume of water for irrigation by the application of the following general formula;

**V4 20XY = V3 20XY x 100/ (E1 20XY-5 +0.3)**

This judgment falls under futurity concepts and rules, and presented here for prospective purposes only, without any assumption of a planning role.

38) Central Bureau of Statistics, Statistical Abstract 1996, table 8/4. Neither this source nor other sources indicated the areas according to mode of irrigation, but it is commonly accepted that conventional surface irrigation was dominant at the level of 1995, while sprinkler and localized irrigated areas were practically negligible.

39) For total irrigated area; Central Bureau of Statistics, Statistical Abstract 2001, table 8/4. Distribution of this area according to irrigation modes is proposed by the expert on the basis of the total areas already converted to "modern irrigation" prior to the year 2000; 88,000 ha, as stated in the National Program for Conversion to Modern Irrigation (February, 2005), and since no details are given in the source on these areas according to their mode of irrigation (sprinkler / localized / modified surface irrigation), the aforementioned area was prorated according to the general ratio between these modes as noticed from data relevant to the year 2005 (sprinkler 66%, localized 34%, modified surface negligible).

40) Central Bureau of Statistics, Statistical Abstract 2006, table 10/4. It should be noted in this connection that the relevant Water Balance of the Ministry of Irrigation for the same year has stated a different total irrigated area (1,464 thousand ha).

41) Proposed by the expert as a simple linear extension of the increase in areas irrigated by sprinkler (Sspr) and localized (Sloc) modes as recorded for the preceding period 2000-2005:

**Sspr 2010 1st scenario = Sspr 2005 + (Sspr 2005 – Sspr 2000)**

**Sloc 2010 1st scenario = Sloc 2005 + (Sloc 2005 – Sloc 2000)**

Then surface irrigated areas (Ssur) were the balance from 1,500 thousand ha, the estimated total irrigated areas in the year 2010 (source 31):

**Ssur 2010 1st scenario = 1,500 – (Sspr 2010 1st scenario + Sloc 2010 1st scenario)**

In depth this scenario represents the continuation of the current slow-rate conversion to sprinkler and localized irrigation modes.

42) Proposed by the expert on basis of the following data/assumptions:

- Estimated 2010 total irrigated areas 1,500 thousand ha (source 31)
- The target set by the 10th 5-year national development plan (2006-2010); to convert about 50% of 2005 conventional surface-irrigated lands into modern irrigation (sprinkler – localized – modified surface irrigation)
- The non-irrigated areas that are prospected during the quinquennium 2006-2010 to be converted into irrigated ones are assumingly irrigated by the modern systems
- The total "modern irrigated" areas at 2010 (909,000 ha) has been distributed according to irrigation modes taking into consideration:
    - ♦ 2005 status, and
    - ♦ 2015 final targets of the National Program for Conversion to Modern Irrigation (February, 2005), as detailed in source 48.
- The areas planned for irrigation by modified surface irrigation (estimated for 2010 at about 90,000 ha) are added in this calculation to surface mode areas (Ssur), however they still playing an efficiency-modifying role through improving the efficiency of surface irrigation (Esur) itself (refer to source 51).

43) The average of the two scenarios for Sm in 2010 is assessed by the expert to be more reasonable and likely realizable, thus would be the input for use in computing the Water Efficiency Index.

44) Proposed by the expert on basis of the following data/assumptions:

- Total irrigated areas 1,550 thousand ha (source 25). The prospected additional 50,000 ha irrigated area (than 2010) is irrigated assumingly by sprinkler or localized modes, thus has been distributed according to these two modes taking into consideration the 2015 final targets of the National Program for Conversion to Modern Irrigation (February, 2005), as detailed in source 48. However, it should be noted that the actual distribution will be dependent not only on the nature of these areas, their water sources and crops planted thereat, but also on wider factors acting at national level including inevitable changes in the national crops' composition and development in irrigation techniques.
- The achievement of the final targets of the 10-year National Program for Conversion to Modern Irrigation (February, 2005) as detailed in source 48, i.e. conversion of all irrigated areas to sprinkler/localized irrigation, excluding of:
    - ♦ 165,000 ha which considered unconvertible to any mode of "modern irrigation" within the timeframe of the Program due to non-suitability of existing networks, and
    - ♦ 150,000 ha to be converted to modified surface irrigation, which included in the table within the surface mode areas (Ssur). However this area still playing an efficiency-modifying role through improving the efficiency of surface irrigation (Esur) itself (refer to source 51).

45) Proposed by the expert on basis of the following data/assumptions:

- Total irrigated areas 1,580 thousand ha with additional 30,000 ha irrigated area than 2015 (source 26). In addition, it is prospected that about 100,000 ha (out of the excluded 165 thousand ha) will be converted from conventional surface irrigation to sprinkler/localized modes (same source); making the sum of 130,000 ha new areas irrigated by sprinkler and localized modes.
- This sum 130 thousand ha has been distributed according to irrigation modes taking into consideration the 2015 status with regards to sprinkler/localized ratio. However, it should be noted that the actual distribution will be dependent not only on the nature of these areas, their water

sources and crops planted thereat, but also on wider factors acting at national level including inevitable changes in the national crops' composition and development in irrigation techniques.

This judgment falls under futurity concepts and rules, and presented here for prospective purposes only, without any assumption of a planning role.

46) Proposed by the expert on basis of the following data/assumptions:

- Total irrigated areas 1,600 thousand ha with additional 20,000 ha irrigated area than 2020 (source 27). Whilst the remainder 65 thousand ha of the excluded conventional irrigated areas are prospected to be converted to sprinkler/localized modes (same source); making the sum of 85,000 ha new areas irrigated by sprinkler and localized modes.
- This sum 85,000 ha has been distributed according to irrigation modes taking into consideration the 2020 status with regards to sprinkler/localized ratio. However, it should be noted that the actual distribution will be dependent not only on the nature of these areas, their water sources and crops planted thereat, but also on wider factors acting at national level including inevitable changes in the national crops' composition and development in irrigation techniques.

This judgment falls under futurity concepts and rules, and presented here for prospective purposes only, without any assumption of a planning role.

47) There is high uncertainty with regards to the long term future of agricultural irrigation, however it could be prospected that, unless major developments or changes happen, the areas and irrigation modes of irrigated surfaces in the country (Sm) will remain in 2030 more or less similar to 2025.

48) M.D. Daoud, About the Progress in the National Program for Rationalizing Water Use in the Agricultural Sector (August 2006).

49) Proposed by the expert on basis of the following data/assumptions:

- 2010 estimated total irrigated areas 1,500 thousand ha (source 31)
- 2025 maximum irrigateable areas in the country (in view of maximum renewable water resources) 1,600 thousand ha, as considered by the National Basic Prospective Report "Towards a Vision for Development Prospects - Syria 2025" (Damascus, 2007).
- "Net" conversion of non-irrigated lands into irrigated ones is prospected to slow-down due to shrinking margins for expansion in irrigation, water availability limitations, increasing control on groundwater extraction, and priority of allocating water resources for other uses, as follows:
    - From about +15,000 ha/year in average for 2006-2010, to
    - about +10,000 ha/year in average for 2011-2015, to
    - about +6,000 ha/year in average for 2016-2020, to
    - about +4,000 ha/year in average for 2021-2025, to
    - around zero in average for 2026-2030

In general, the issue of prospecting the expansion in irrigated areas is a complex and critical issue in Syria, ruled by contradictory forces:

a) Expanding forces; the high population growth results in higher needs for national foodstuff security and increasing demand on foodstuff and other agricultural products, increasing demand on job opportunities including farming sector as the major profession in rural areas, etc.

b) Shrinking forces; increasing scarcity of irrigation water in result of accumulated and continuing depletion and pollution of water resources, anticipated decrease of its renewable resources due to anticipated adverse climatic changes in the east-Mediterranean region as a result of the global warming phenomenon, soil pollution, salinization, erosion and land desertification, expansion of cities, residential agglomerations, industrial and infrastructure installations on behalf of fertile and irrigated lands, etc.

In this context the expression "net conversion" has been used in this report to describe the resultant of lands converted from non-irrigated into irrigated, minus lands converted from irrigated into non-irrigated. This resultant is prospected to quench gradually from some positive-sign areas to around zero in the last quinquennium of this prospect.

This judgment falls under futurity concepts and rules, and presented here for prospective purposes only, without any assumption of a planning role.

50) Estimate of the National Program for Conversion to Modern Irrigation

51) Proposed by the expert on basis of the following data/assumptions:

- Prospected changes in the composition of surface irrigated areas (conventional/modified surface irrigation) over the period from 2005 (≈100% of surface irrigation is conventional) till 2025 (when conventional surface irrigation no longer exist and 100% of surface irrigated areas are modified as described in sources 44, 45 & 46).
- Attaining a gradual improvement of efficiency over the period 2005-2030 by 1% every five years for both conventional and modified surface irrigation, starting from 45% for the conventional mode (source 50), and 60% for the modified mode which is the minimum efficiency of this mode according to M.D. Daoud (source 48).

This improvement is prospected by the expert in result of increasing water scarcity and raise of farmers' awareness on the necessity of self irrigation rationalization at plot level, leading them to improve their irrigation practices.

Calculations relevant to this scenario are summarized in the table 16:

**Table 16 – Improving surface irrigation**

| Year | Total surface irrigated areas 1,000 ha | Conventional surface irrigation | | Modified surface irrigation | | Weighted average efficiency |
|---|---|---|---|---|---|---|
| | | Area | Efficiency | Area | Efficiency | |
| 2005 | 1,182 | 1,182 | 45% | Negligible | 60% | 45% |
| 2010 | 890 | 800 | 46% | 90 | 61% | 48% |
| 2015 | 315 | 165 | 47% | 150 | 62% | 54% |
| 2020 | 215 | 65 | 48% | 150 | 63% | 58% |
| 2025 | 150 | None | - | 150 | 64% | 64% |
| 2030 | 150 | None | - | 150 | 65% | 65% |

Source: Al-Azmeh, 2008

This judgment falls under futurity concepts and rules, and presented here for prospective purposes only, without any assumption of a planning role.

52) Minimum efficiency of sprinkler mode according to M.D. Daoud (source 48).

53) Proposed by the expert assuming the attainment of a gradual improvement of efficiency over the whole period 2005-2030 by 1% every five years. This improvement is prospected in result of the following actuating factors:

- Improving quality of sprinkler equipment and quality control on same
- Farmers' improved experience on using sprinkler
- Increasing water scarcity and raise of farmers' awareness on the necessity of self irrigation rationalization at plot level

According to M.D. Daoud (source 48) the efficiency range of sprinkler mode is 70-81%. However, the less optimistic prospects in this report are based upon the inevitable deviation between pilot experiences and real farming conditions on the one hand, and the high evaporative loss that accompany sprinkler irrigation in dry and hot weather conditions on the other hand.

This judgment falls under futurity concepts and rules, and presented here for prospective purposes only, without any assumption of a planning role.

54) Minimum efficiency of localized mode according to M.D. Daoud (source 48).

55) Proposed by the expert assuming the attainment of a gradual improvement of efficiency over the period 2005-2015 by 2% every five years, followed by a lower rate improvement over the period 2015-2030 of 1% every five years. This is prospected by the expert as a result of the following actuating factors:

- Improving quality localized irrigation equipment (stricter quality control)
- Farmers' improved experience on this mode of irrigation
- Increasing water scarcity and raise of farmers' awareness on the necessity of self irrigation rationalization at plot level
- The space for efficiency improvement would anticipatively allow higher rates of improvement at the beginning

According to M.D. Daoud (source 48) the efficiency range of localized mode is 80-94%. However, the less optimistic prospects in this report are based upon the inevitable deviation between pilot experiences and real farming conditions.

This judgment falls under futurity concepts and rules, and presented here for prospective purposes only, without any assumption of a planning role.

# 3. Industrial water

## 3.1. Recycled water volumes

**Table 17 - Recycled water volumes (V5) ($km^3$/year)**

| Year | Values | Source |
|---|---|---|
| 1995 | Negligible | No data is available.<br>Values were inversely calculated from the estimates given in the next two tables (3.2 & 3.3) |
| 2000 | 0.006 | |
| 2005 | 0.018 | |
| 2010 | 0.040 | |
| 2015 | 0.067 | |
| 2020 | 0.108 | |
| 2025 | 0.160 | |
| 2030 | 0.230 | |

Source: Al-Azmeh, 2008

## 3.2. Gross volumes consumed for industrial processes

**Table 18 - Gross volume consumed for industrial processes (volume incoming for the first-time to the industrial plant + recycled volume) (V6) ($km^3$/year)**

| Year | Values | Source |
|---|---|---|
| 1995 | 0.285 | In the absence of reliable data, estimates of M.D. Daoud (source 48, subsection 2.4 of this report) were utilized. It should be noted that the estimates presented in this source for the past years widely disagree with the estimates given in the yearly Water Balances of the Ministry of Irrigation, which have estimated the industrial water consumption for 1995, 2000 & 2005 at 0.358, 0.510 & 0.766$km^3$/year respectively. However, both are estimations but with different base of assumptions. Daoud's figures were preferred since having future prospects and seemed to be of more convincing augmentation. |
| 2000 | 0.315 | |
| 2005 | 0.356 | |
| 2010 | 0.400 | |
| 2015 | 0.445 | |
| 2020 | 0.490 | |
| 2025 | 0.533 | |
| 2030 | 0.575 | |

Source: Al-Azmeh, 2008

## 3.3. Industrial water efficiency

Table 19 - Industrial water efficiency (Eind= V5/V6 in %)

| Year | Values | Source |
|---|---|---|
| 1995 | Negligible | Very rough estimates based upon expert's personal observations and consultations with sectoral industrial experts. |
| 2000 | 2% | |
| 2005 | 5% | |
| 2010 | 10% | Very rough expectations based upon anticipated gradually increasing control by installations and public authorities on industrial water usage in response to increasing concerns on water saving issues at both industry/economic and legislative/regulatory levels. |
| 2015 | 15% | |
| 2020 | 22% | |
| 2025 | 30% | |
| 2030 | 40% | |

Source: Al-Azmeh, 2008

# 4. Total physical efficiency of water use

Table 20 - Total physical efficiency of water use (E) in %

| Year | Values | Source |
|---|---|---|
| 1995 | 39.44 % | Program's outputs |
| 2000 | 41.53 % | |
| 2005 | 44.96 % | |
| 2010 | 52.71 % | |
| 2015 | 63.78 % | |
| 2020 | 66.86 % | |
| 2025 | 69.38 % | |
| 2030 | 70.93 % | |

Source: Al-Azmeh, 2008

# 5. Observations

Table 21 - Observations

| Variables | Sources, Access URL | Frequency and Availability of data | Comments (geographic coverage, accessibility, production mode etc.) |
|---|---|---|---|
| V1 | sources 1-10, subsection 3.1.4 of this report, of which 1-3 URL is www.cbssyr.org | official data relevant to every past year available at about 1 year delay | national level data past years data: direct fm source Future values: expert scenarios |
| V2 | sources 1-3 (URL www.cbssyr.org) & 11-18, subsection.1.4 of this report | | |
| Epot | - | - | 1995-2005: calculated fm available data 2015: set target other years: prospects |
| V3 | sources 19-32, subsection 2.4 of this report, of which 29 & 30 URL is www.cbssyr.org | official data relevant to every past year available at about 1 year delay | national level data past years: direct/calculated fm source data future: expert scenarios |
| V4 | sources 33-37, subsection 2.4 of this report | | |
| E1 | - | - | 1995-2005: calculated fm available data 2010-2030: prospects |
| E2 | - | - | |
| Sm | sources 38-47, subsection 2.4 of this report | official data relevant to every past year available at about 1 year delay | national level data past years: direct/calculated fm source data future: expert scenarios |
| S | sources 38, 29-31 (URL www.cbssyr.org) & 49, subsection 2.4 of this report | | |
| Eirr | - | - | 1995-2005: calculated fm available data 2010-2030: prospects |
| V5 | - | no reliable data on this issue | national level estimates and prospects |
| V6 | estimates/prospects of source 48, subsection 2.4 of this report | | |
| Eind | - | - | Presumptive |
| E | program's outputs | - | based upon calculated Epot & Eirr (for Dpot+Dirr averaging 97.5% of D over the whole period 1995-2030), and presumptive Eind (for Dind averaging only 2.5% of D over the whole period 1995-2030) |

Source: Al-Azmeh, 2008

# IV. General remarks and discussion

It is noticeable from the previous section No.3 that the lack of firm and compatible data on many components needed for calculating the Water Efficiency Index, has lead in many cases to utilize the available data from this or that source, sometimes by very indirect courses, to obtain the required inputs to the best possible satisfaction of requirements and adherence to definitions of the methodology of water efficiency index calculation as adopted by the Mediterranean Strategy for Sustainable Development. Now, after withdrawal from that area where complicated assumptions, scenario building and futurity prospects were inevitable to produce numerical inputs for computing the sectoral and total Water Efficiency Indexes, the focus in this section of the report will be mostly on a panoramic view of water efficiency status and progress in the Syrian Arab Republic, presenting a brief analysis on their trends in connection with the overall resources/uses water balance, starting from a generalized evaluation of the efficiency results produced in the previous section No.3, passing through the approaches, values and timeframes of the set national objectives for water efficiency improvement, and major policies, plans, measures and project adopted for achieving same, closing with an overview of the status of and process towards attaining a meaningful physical water saving, as a crucial issue for the country, through the replacement of the classic Water Supply Management by a modern and well-tailored Water Demand Management.

## 1. Compatibility and reliability

It is clear enough from section 3 of this report that the national statistical data and future objectives/targets doesn't allow in many cases a smooth and direct obtainment of basic data needed for calculating the sectoral and total water efficiency indexes, the matter which obliged report preparer to utilize and elaborate scattered data and various assumptions.

In order to identify areas where improvements are needed for future better collection of basic data and more reliable production of efficiency index's various components, the following table summarizes expert's assessment of the:

- degree of compatibility of the national data, directly or indirectly utilized for obtaining the inputs used in computing water efficiency indexes, with the methodology and definitions adopted by the Blue Plan and the Mediterranean Strategy for Sustainable Development, and
- estimated level of reliability or weakness points of the values of inputs themselves, either weakness is attributed to the utilized data or to the assumptions made by the expert to obtain the inputs.

**Table 22 – Compatibility & reliability**

| Sector | Input | Compatibility with MSSD definitions | Reliability of values | Remarks |
|---|---|---|---|---|
| Drinking | V1 | High | likely biased values due to old meters malfunction & non-metered subscriptions | V2-V1 includes some legally free of charge distributed waters (to public schools, departments, religious places etc.), anyhow this doesn't affect V1 compatibility in its definite function |
| | V2 | High | likely biased values due to inaccurate outlet meters or bulk water measurements | |
| Irrigation | V3 | Moderate | low reliability in the absence of plot water metering/measurement systems | In the absence of reliable data on the loss on transportation (leaks & overflows), only the loss on evaporation is considered in V4-V3 values, accordingly in E1 (=V3/V4) values |
| | V4 | High | doubtful reliability particularly because of the low control on actual groundwater extraction which represents (so far) the source for irrigating about 60% of total irrigated area | |
| | Sm | Moderate | Moderate to High | in addition to the 3 irrigation modes recognized in BP & MSSD methodology, the national approach considers the modified surface irrigation as a different mode with a distinctive efficiency, this inconsistency was overcame in this report by raising the surface mode efficiency proportional to the area portion of modified surface irrigation from total surface irrigated areas |
| | S | High | | - |
| Industrial | V5 | No data | - | water-uses-wise, the current level of control on industrial activities could be assessed as too low |
| | V6 | Doubtful | Low (rough estimates) | |

Source: Al-Azmeh, 2008

It could be concluded from the above table that there are two major areas, i.e. irrigation distribution efficiency (E1) and industrial efficiency (Eind), in which the national basic data is more or less incompatible with the methodology and definitions adopted by MSSD for calculating water uses efficiency. Priority actions are needed in these two areas, not only to overcome this incompatibility but also to enable a sound basis for further efficiency improvement that is most needed for the country. These proposed actions are:

1) Identify irrigation distribution efficiency related to water losses in distribution networks - upstream of plots

   Unlike Blue Plan's and MSSD's methodology and definitions, and apart from a general indication in the National Program for Conversion to Modern Irrigation (February, 2005) to plot losses as being responsible for more than 70% of total irrigation losses, the various Syria's plans and reference documents on irrigation water efficiency are lacking a clear distinction between distribution and plot irrigation efficiencies.

   Yet, in the opinion of report preparer, the loss-on-distribution, in its definite meaning, is applicable in Syria only to about 20-25% of the total irrigated areas in the country that are irrigated via public projects networks sourcing mainly ex dam lakes, whilst about 15% of irrigated areas sourcing directly ex rivers and springs, and the balance areas (about 60%) sourcing ex groundwater, dominantly by in-plot wells, where in both later cases the "loss-on-distribution" could be attributed to in-plot irrigation inefficiency rather than transport and distribution inefficiency.

   However, the relative significance of irrigation distribution efficiency will be increasing in future proportional to the planned expansion of irrigation via public (and local collective) networks on account of groundwater plot wells.

   As far as these public and collective projects' networks are concerned, the current water balance system of the Ministry of Irrigation doesn't recognize the physical losses between networks' inlets (i.e. ex water resource) and outlets (points of delivery to the plots). This means that said losses are statistically attributed, indirectly, to plot irrigation inefficiency instead of distribution inefficiency, causing some misleading in this respect.

   The establishment of a distribution efficiency index at the level of each irrigation network and, consequently, at national level, will not only erase this discrepancy but will also help in prioritizing networks' rehabilitation programmes in a manner that substantially contribute in the national efforts for improving the water use efficiency.

2) Identify industrial water efficiency (industrial demand and recycling ratio)

   In the absence of reliable data on the industrial water use in general, report preparer see the need for a national process that may last 1-2 years to cover with qualified inspection missions all large- and medium-scales public or private industrial plants which use water in industrial processes (away from drinking, sanitary and green surfaces needs), whether these plants belongs to extractive industries (managed by the Ministry of Oil and Mineral Resources) or manufacturing industries (managed by the Ministry of Industry, or other ministries).

   The purpose of such a process is to identify for each plant its:

- maximum (nominal) industrial water demand, pursuant to plant's industrial processes and production capacity
- nature of source water (wells, river, lake, public network)
- reliability of actual intake measuring system (if exist), and equipment needed to be mounted to enable the water authority verifying it (meters, proof systems for large consumers etc)
- industrial water effluents; quantity, pollution, treatment, disposal, segregation from sanitation system etc.
- status of recycling, if any

- identify the opportunity for recycling, if any, in quantity and percentage of demand, as well as opportunity to utilize BAT

This process is proposed to establish a reliable national record on industrial water demand and recycling ratio that helps in effecting control measures under the two overlapping frameworks of water saving (water demand management) and pollution prevention. Then the aforementioned concerned ministries shall keep this record updated and its file activated in the competency of their central environmental directorates, in close cooperation with the environmental authority (the General Commission for Environmental Affairs, under the Ministry of Local Administration and Environment) and the water resources authority (Ministry of Irrigation), probably in the form of a permanent committee for rationalization of industrial water uses, following the matter up to the step of proposing an adequate and applicable legal and financial framework that can ensure for each concerned plant the integration of 3 water-related objectives:

a) to retain actual water intake within the determined nominal demand

b) to recycle used industrial water up to the determined opportunity

c) to ensure the long-term conformity of final effluents with the allowable discharging specifications

A preliminary estimated cost of this process could be ranging at 700-850 thousand Euros (office, expertise, training, manpower, laboratory testing, field equipment, transportation and accommodation etc.).

## 2. National efficiency improvement objectives

In the Water Strategy of the Syrian Arab Republic (March 2003), a general statement related to improving water use efficiency was adopted, that is to achieve "the highest possible efficiency in the conveyance, distribution and use according to water demand management procedures".

Afterwards, other reference documents and plans have set numerical target for some sectoral efficiencies, with or without definite deadline for achievement, which are considered as national objectives in this respect. These are summarized in the following table:

**Table 23 – National efficiency improvement objectives**

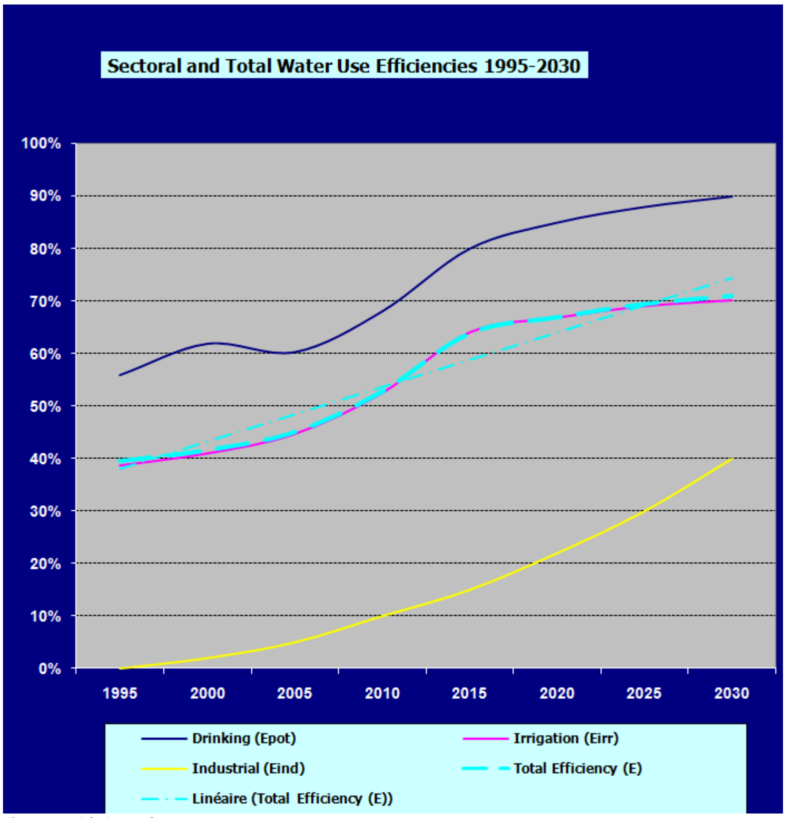
<table>
<tr><th>Sector</th><th>Index</th><th>Objective</th><th>Timeframe</th><th>Remarks</th></tr>
<tr><td>Drinking</td><td>Epot</td><td>80%+</td><td>2015+</td><td>-</td></tr>
<tr><td rowspan="3">Irrigation</td><td>E1</td><td>≥70% for canal networks<br>≥85% for piped networks</td><td>N/A</td><td>project's level indicators applicable to public irrigation projects only</td></tr>
<tr><td>E2</td><td>72-78%</td><td>2015+</td><td rowspan="2">There is a possible mix-up between E2 & Eirr in result of the low recognition of E1 (refer to point "a" subsection 1 of this section)</td></tr>
<tr><td>Eirr</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Industrial</td><td>Eind</td><td>N/A</td><td>N/A</td><td>besides lacking the relevant basic data, there is a low concern on the concept itself (refer to point "b" subsection 1 of this section)</td></tr>
<tr><td>Total</td><td>E</td><td>N/A</td><td>N/A</td><td>there is a low concern on the concept itself, most probably due to the overwhelming share of irrigation use & marginal shares of drinking & industrial water uses (refer to the next subsection 3 of this section)</td></tr>
</table>

Source: Al-Azmeh, 2008

## 3. Efficiency improvement in process

Drawing curves of sectoral and total efficiencies over the whole period under consideration (as obtained in section 3 of this report) will clearly show the past-present-future continuous overwhelming effect in Syria of irrigation efficiency on the total efficiency, and the marginal effect of drinking and industrial efficiencies.

**Figure 1 – Efficiency index (total & per sector)**




Source: Al-Azmeh, 2008

Thus, examining efficiency improvement process means, overwhelmingly, examining the process of rationalizing irrigation uses, the title of which in Syria is the National Program for Conversion to Modern Irrigation (February, 2005).

At planning level, the Program starts from the year 2004 status quo of conventional surface irrigated areas, classifying them according to water source (groundwater wells, rivers and springs, or public irrigation projects), then reclassify each into sub-classes according to the desired mode of irrigation appropriate to land features and planted crops, and then estimate the total cost of conversion by multiplying the area of each sub-class by an average cost for converting 1 ha to the desired irrigation mode. The total cost obtained by this method was 43.6 milliard Syrian Liras (equivalent to about 700 million Euros at 2004 exchange rate) distributed as follows:

- 12.7 milliard for converting 160,820 ha sourcing ex wells to localized mode
- 15.2 milliard for converting 434,808 ha sourcing ex wells to sprinkler mode
- 0.35 milliard for converting 50,000 ha sourcing ex Euphrates river to modified surface mode
- 6.3 milliard for converting 86,459 ha sourcing ex rivers/springs to localized
- 3.0 milliard for converting 85,950 ha sourcing ex rivers/springs to sprinkler
- 0.7 milliard for converting 100,000 ha sourcing ex public projects to modified surface mode
- 2.4 milliard for converting 53,106 ha sourcing ex public projects to localized

- 2.9 milliard for converting 83,344 ha sourcing ex public projects to sprinkler

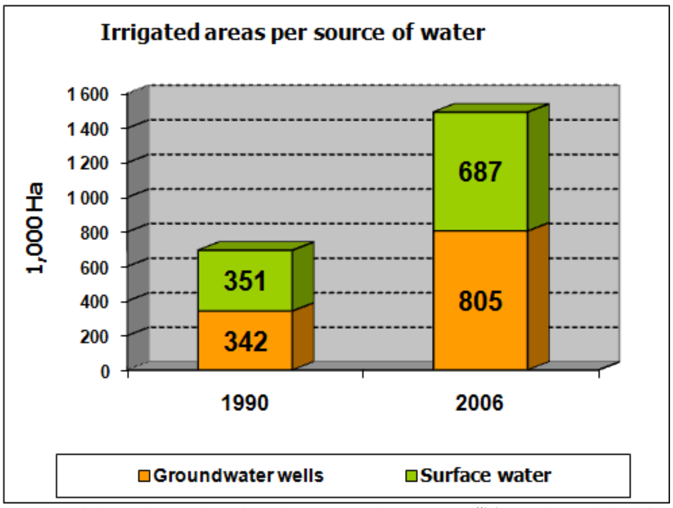
This estimated monetary cost of the Program, that to be spent over a period of implementation of 10 years or 2 successive 5-year national development plans, was allocated (along with an extra inflation reserve) by establishing a special fund, feed by public treasury, General Union of Peasants, and international donors, the function of which is to loan peasants medium-term and interest-free loans to be used in converting the a/m conventionally irrigated properties to the a/m water-saving irrigation modes.

Apart from funding issues, the Program tackles a variety of legal, organizational, land property and technical dimensions that supposed to smooth and boost its implementation.

The main objective of the program is not saving water to use the savings as water resource for further expansion in irrigated areas, though this could be the case in some hydrological basins or sub-basins in the country. Indeed the objective is to safeguard groundwater reservoirs from depletion, the risk that became of utmost concern in the last two decades.

The following chart compares the expansion occurred between 1990 and 2006 in irrigated areas from groundwater wells and irrigated areas from surface water sources including rivers, springs and public irrigation projects, showing clearly the huge expansion in total (215%), and the greater expansion occurred account groundwater wells (235%) compared to the one occurred account surface sources (196%).

**Figure 2 – Irrigated areas per source of water**




Source of data: the National Basic Prospective Report "Towards a Vision for Development Prospects - Syria 2025" (Damascus, 2007)

Consequently, the yearly extraction, countrywide, from groundwater reservoirs has exceeded by far the groundwater renewal rate. According to the National Basic Prospective Report "Towards a Vision for Development Prospects - Syria 2025" (Damascus, 2007), the current extraction has exceeded 8.5 $km^3$/year against an average of 2.7 $km^3$/year considered extractible without permanent negative effects on natural springs' flows. Here is the great challenge stands in front of the National Program for Conversion to Modern Irrigation, in particular, and the whole water demand management of the country towards improving water use efficiency, in general.

## 4. Water Demand Management; a must to Syria rather than a choice

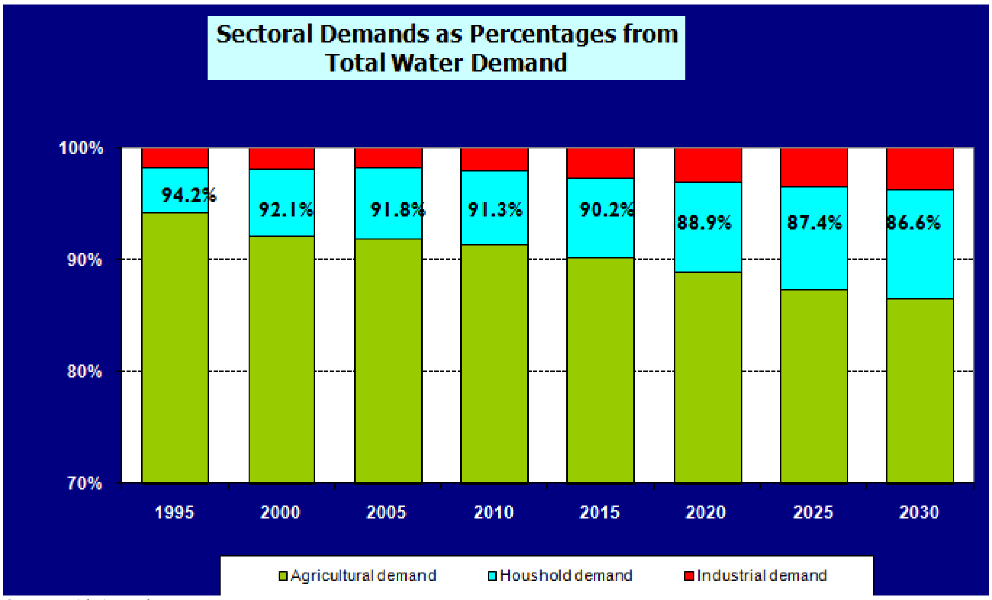
The Water Strategy of the Syrian Arab Republic, adopted by the Government in March 2003, has clearly prioritized water resources allocation for potential conflicting uses as follows:

- 1st priority: potable (household) water
- 2nd priority: industry, including tourism
- 3rd priority: modern irrigated agriculture

Thus, in view of total water shortage already suffered in some hydrological basins of the country, particularly in Damascus area (Barada & Al-Awaj basin) and the far north-east region (Al-Khabour basin), and the shrinking surplus in the other basins, along with the continuing increase of potable and industrial demands pursuant to population growth, increasing coverage with piped water services, and industrialization, a realistic reaction to such a worsening situation is to restructure the allocation of water resources among sectors, enabling a room for sufficing the increasing household and industrial demands by decreasing agriculture share of water, mainly through irrigation rationalization tools.

The following chart shows the structure of water allocation in the near past, then how may change until 2030 if the prospects detailed in section 3 of this report (which involve the scenario of successful implementation of the National Program for Conversion to Modern Irrigation) are realized.

**Figure 3 – Sectoral demands as percentage from total water demands**




Source: Al-Azmeh, 2008

Anyhow, the matter could not be reduced to just a process aiming at reallocating water resources. It is also (and mainly) a vital matter of saving unrenewable resources from depletion since a huge volume of water (about 5.3 $km^3$) would be annually saved in the agriculture sector according to the prospects obtained in this report, from 18.565 $km^3$/year irrigation demand in 2005 down to 13.260 $km^3$/year in 2030. The question with this 5.3 $km^3$ is not a slack cost comparison between two alternatives:

- securing it under water supply management framework
- or saving it under water demand management framework

The question is rather the absolute long-term physical unavailability of this quantity of water. Certainly there is no exaggeration if the question of sustainable use of the limited water resources of Syria is considered the most crucial question amongst the wide variety of sustainable development questions arising in front of the country. The water question is anticipated to acquire increasing importance in the light of the rapidly increasing population and the consequent increasing economic pressures on water demand added to increasing scarcity of water in result of accumulated and continuing depletion and pollution of water resources, all against a likely decrease of precipitation and renewable water resources due to anticipated adverse climatic changes in the east-Mediterranean region as a result of the global warming phenomenon.

Anyhow, with excluding the following two contradictory factors:

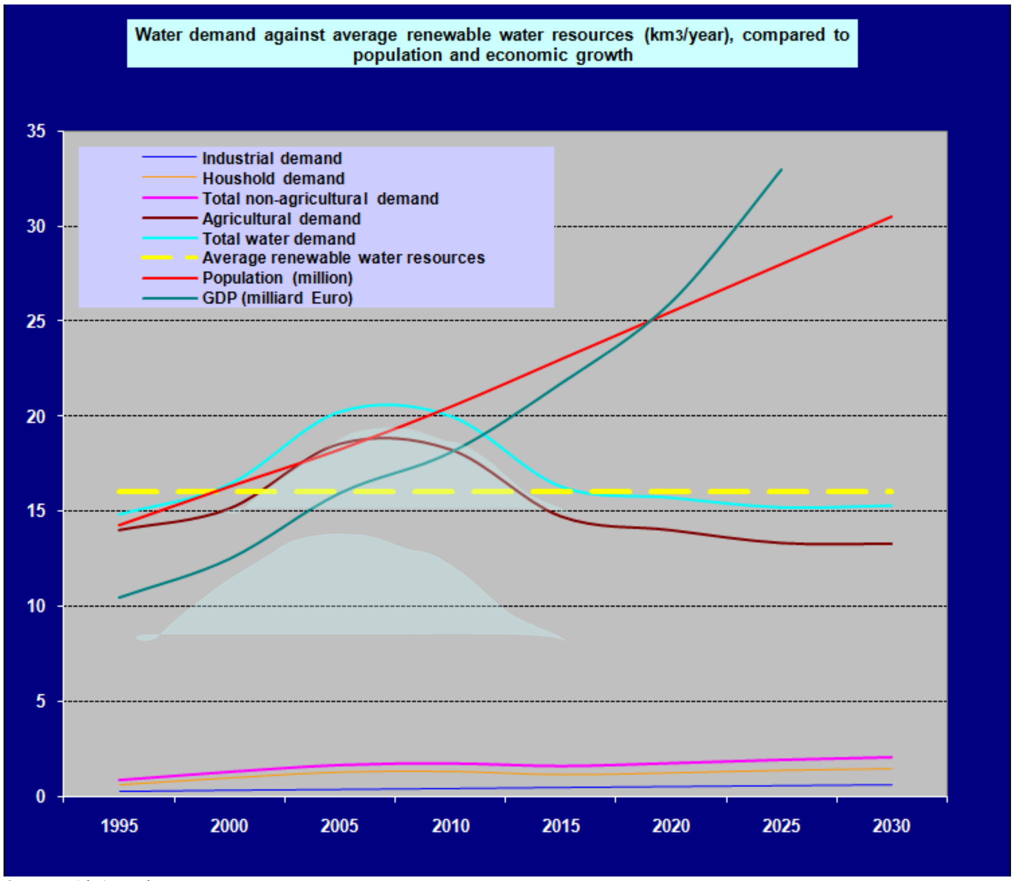
1) the anticipated decrease of renewable water resources due to climatic changes (since this factor is still unquantifiable), and

2) a possible increase of resources that might result from adding major new resources to the national water balance, either conventional (e.g. utilizing Syria's share from the Tigris, bordering Syria territories along 44 km. This share is currently agreed with Iraq at about 1.25 km³/year to be utilized for converting some 150,000 ha in the far north-east region from wells to networks), or unconventional resources (e.g. by costly seawater or saline groundwater desalinization).

The following multi-purpose chart will show, over the whole period under consideration in this report (1995-2030):

- the sectoral and total water demand trends (as per the results obtained in section 3 of this report), against country's average renewable water resources of about 16 km³/year (as obtainable from various national water reports and studies, including Syria's current share from the Euphrates about 6.6 km³/year as agreed with Turkey and Iraq), and
- compare water demand trends to:
  - population growth trends (Central Bureau of Statistics, Statistical Abstracts 1996, 2001 & 2006 for past years, and average projections reported in the 1st National Population Report, 2008, for upcoming years), and;
  - economic growth trends expressed as the national Gross Domestic Product at market price and constant prices of the year 2000 (Central Bureau of Statistics, Statistical Abstract 2006 table 9/16 for past years, and the prospects reported in the National Basic Prospective Report "Towards a Vision for Development Prospects - Syria 2025", Damascus 2007, for upcoming years), converted to Euros applying a constant exchange rate 72.5 Syrian Liras per Euro (2008 average exchange rate).

**Figure 4 – Water demand against average renewable water resources (km³/year), compared to population and economic growth**




Source: Al-Azmeh, 2008

The most important points that could be concluded from above chart are:

1) The non-agricultural water demand (industrial + household) steadily increase with population and economic growth.
2) The agricultural water demand has dramatically increased over the last ten years. This is mainly attributed to the expansion in irrigated areas that sourcing water either ex dams (public irrigation projects) or ex groundwater by drilling licensed or unlicensed wells.
3) The curve of agricultural water demand has most probably reached its peak now years and expected to turn down now on. However, this trend is still uncertain enough since largely dependent on the level of success in implementing the National Program for Conversion to Modern Irrigation.
4) Seizing the overwhelming share of water uses, the agricultural sector is well shaping the curve of total water demand, up and down.
5) Sometime during the 2nd half of 1990s, following the dramatic increase in agricultural water demand, the national water uses have exceeded in value the national renewable water resources. Obviously the shortage is being compensated from reserve stock, i.e. extracting unrenewable groundwater, resulting into lower-flow or even dry-out of many natural springs and significant sink-down of groundwater levels in many hydrological basins in the country, causing increasing economic losses including high costs for wells' deepening and increasing consumption of power for pumping.
6) The current shortage gap between the national water uses and resources (represented by the light-coloured area in the chart) is expected to shrink down, then eliminate sometime during the 2nd half of 2010s, pursuant to the prospected progress in improving sectoral water uses efficiencies and particularly in implementing the National Program for Conversion to Modern Irrigation.
7) Accordingly, the national water balance could be expected to re-equalize, and even gaining some positive margin, then after. In a general term this is translated into prospected halt of depleting unrenewable stock of groundwater, however this is at national level and will not be to equal extents for all hydrological basins of the country.
8) It is noticeable from the chart that there was over the period 1995-2005 a type of parallelism between the growth of total water demand and the growth of population and GDP. As appears from the chart this is attributed mainly not to the growth of potable and industrial water demands but to agricultural demand due to horizontal expansion in irrigated farming as to satisfy the increasing foodstuff needs and to improve the status of national foodstuff self-sufficiency and security. Unfavourably, this type of expansion has reached to a point where foodstuff security started to threat the water security of the country, a matter that may badly return on foodstuff security itself.
9) But with the prospected improvement of water uses efficiencies, particularly in agriculture through the National Program for Conversion to Modern Irrigation, it appears from the future trends in the chart that the Syrian Arab Republic has a very good opportunity to "detach" (say; de-parallelize) the growth of total water demand from the growth of population and GDP. Nevertheless, this may not adversely affect the national foodstuff security and self-sufficiency if accompanied with a "vertical expansion" in agriculture, i.e. raising the productivity through increasing the yields of land unit and water unit in agrarian practice. In fact the results of the national researches and pilot experiences in this domain have proved enough that the conversion to sprinkler, localized and modified surface irrigation modes is accompanied for all major national crops not only by high water savings (higher water unit yields) but also higher land unit yields.

In few words, the sustainability of human wellbeing, economic growth and social development in the Syrian Arab Republic became increasingly dependent on a meaningful water saving through raising water uses efficiency and strict application of the approach and rules of Water Demand Management, otherwise the country will be facing a critical water crises in a not too far future.

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