ANALYSIS OF IRRIGATION WATER POLICIES IN SYRIA: CURRENT DEVELOPMENTS AND FUTURE OPTIONS

Consuelo Varela-Ortega and Juan A. Sagardoy

a) Department of Agricultural Economics. Polytechnic University of Madrid, Spain. email: cvarela@eco.etsia.upm.es (corresponding author)
b) Irrigation management specialist. Via Apelle 77, 00124 Rome, Italy. email: j.sagardoy@flashnet.it

Abstract

Water scarcity in Syria is becoming an increasingly serious concern for public authorities as future demand of water is surpassing available resources. The agricultural sector in Syria consumes up to 85% of all available hydric resources in the country, hence the need to increase water use efficiency in agriculture is at the center of the nation’s water policy discussions. Therefore the criteria, objectives and implementation of water policies demand important changes and a careful assessment. As agriculture is a key sector in the Syrian economy, irrigation expansion has mounted over the last decades to comply with the nation’s food security objectives and to satisfy food production needs. At present, water policies in Syria are designed to combine the expansion of irrigation and to attain a sustainable use of water by increasing technical efficiency and by reducing future consumption. One of the pillars of this policy is the adoption of modern irrigation technologies at farm level that is already profiting from considerable government support. In this context, the objective of this study is to analyze the irrigation water sector in Syria and its related water policies. The methodology includes two major parts at different levels of aggregation, a national and basin’s level and a farm level analysis. In both cases simulations of different scenarios have been carried out to permit short and long term assessments of different policy alternatives for conserving water resources. Results show that current water policies in Syria may not be sustainable and that sustainability will be reached in the medium term only if irrigation modernization is coupled with a limited and selective expansion of irrigated areas. Water policies in Syria will have to rely progressively on demand management and the introduction of incentives, such as water-crop quotas or tariffs, to attain water conservation objectives.

1. Introduction

In Syria as in many other countries in the region, water is becoming progressively scarce as future demand is coming close or even surpassing available resources. Hence water use efficiency in all sectors is becoming a matter of economic, social and political concern and water polices are at the core of the

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nation’s economic policy discussions. This crucial issue is particularly relevant for the agricultural sector in Syria, which uses up to 85% of all the available water resources in the country (FAO-MAAR, 1999).

Irrigated agriculture has increased steadily in Syria over the last decades, almost doubling since 1985. This mounting pace has responded to the nation’s food security policy objectives to satisfy the food production needs of an increasing population that features one of the largest growth rates in the world (3.50% in 1985 and still 2.54% from 1995-2000) (FAO-MAAR, 1999, 2001). Recently, the notion of food security, formerly assimilated to food self-sufficiency, has been redefined into a more flexible concept oriented to increase production of certain crops that profit from comparative advantage. Consequently, exports of these products can counterbalance the need to import other commodities (Sarris, 2001).

As the economy in Syria has been primarily based on agriculture, agricultural policies have been shaped by the general state-led import substitution development policies that have prevailed for the last decades and are currently being liberalized. The major strategy for agricultural production has been self-sufficiency in the principal food staples instrumented through the government’s annual agricultural production plan. Despite of significant liberalization in the last years, the introduction of incentives to stimulate private sector exports and to liberalize imports, the state still plays a major role in production and trade. At present the state maintains a heavy intervention in the purchasing and marketing of the strategic agricultural products (cotton, tobacco, sugar beet, wheat, barley, lentils and chickpeas) as the private sector trades in fruit and vegetables and livestock products. The government grants crop licenses to the farmers which entitles them to obtain subsidized loans and inputs and to sell the produce to the state agencies at the government’s support prices. Therefore the agricultural sector benefits form considerable protection which implies a large share of the public budget. Total expenditures for irrigated agriculture accounted for almost 70% of all expenditures in agriculture (Sarris, 2001).

In this context, the main purpose of this study is to analyze water management policies in Syria in the framework of the recent developments towards more market-oriented agricultural policies. A growing preoccupation in Syria is the design and implementation of sustainable irrigation water policies aimed at increasing the efficiency of water use in agriculture and at conserving water resources by reducing future consumption. Of major importance in this context is the adoption of modern irrigation technologies at farm level that is already profiting from considerable support by the government agencies implicated. However, its wider adoption may require additional incentives and other supporting measures. On-farm improvements must be accompanied by similar policies at network level to increase their efficiency and such measures need to be evaluated in technical and economic terms at national and system’s level.
The study consists on the analysis of the irrigation water sector in Syria and its related water policies for which an explicit methodology has been developed. The investigation includes two major parts at different levels of aggregation. One is devoted to analyzing the irrigation water sector in Syria at national aggregated level and at regional basin’s level. The other part is a disaggregated farm level analysis. In both cases simulations of different scenarios have been carried out to permit short and long term assessments of different policy alternatives for conserving water resources in Syria and their effects at national, regional and farm levels.

2. Structure and performance of the irrigation sector

2.1 Irrigated lands and irrigation techniques
From the 18,5 million ha of total lands of the Syrian Arab Republic, cultivated land extends over an area of 5,484,000 ha of which 1,213,000 is irrigated land (22%), 3,655,000 ha is rain-fed land (67%) and 616,000 ha is fallow land (11%) (FAO-MAAR, 2001). Irrigated lands are not distributed evenly across the country and most concentrate along the Euphrates river, in the coastal areas and in the central regions. The size of the irrigated holdings is substantially smaller than the size of the rain-fed holdings and varies distinctively across regions (governorates). At nations’ level, the average holding size is 9.2 ha and for irrigated farms is 3.6 ha (Figure 1). Larger holdings grow mostly extensive crops such as wheat and cotton, as more intensive crops such as sugar beet, potato, tomato and maize are grown predominantly in medium size farms. Vineyards are basically grown in reclaimed mountain and hill areas whereas intensive corps such as vegetables are grown primarily in the coastal smaller farms and in the outskirts of the urban districts. Fruit trees are planted largely in rainfed lands in newly reclaimed territories in the central regions and also in the coastal areas. The distribution of the irrigated areas by basins is reflected in Table 1.

Surface irrigation is the prevailing irrigation system in Syria covering 95% of the irrigated area. Basin irrigation is the predominant technique used in surface irrigation and most of the irrigated wheat and barley are irrigated by this method. Irrigation field efficiency is reportedly low, often around 40% in the old networks (50 years) and around 60% in the more recent ones (15 years). Furthermore the construction of ridges for the basins implies a loss of productive land which could be assessed between 5 and 10% reducing further the productivity of the land. Cotton and vegetables are irrigated by furrows but because the land is rarely leveled the efficiency of such technique is also low.
Figure 1 - Average size of irrigated holdings by governorate (ha)


Table 1 - Irrigated Area by basin (1999-2000)

<table>
<thead>
<tr>
<th>Basin</th>
<th>Source/Governorate</th>
<th>Wells</th>
<th>Rivers &amp; Springs</th>
<th>Regular Irrigation Networks</th>
<th>Total 99-2000</th>
<th>Total of the Basin</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euphrates</td>
<td>Raqqa</td>
<td>69 073</td>
<td>38 129</td>
<td>76 245</td>
<td>183 447</td>
<td>432 835</td>
<td>Over exploited</td>
</tr>
<tr>
<td></td>
<td>Aleppo</td>
<td>79 118</td>
<td>3 875</td>
<td>41 622</td>
<td>124 615</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Assad Establishment</td>
<td>-</td>
<td>-</td>
<td>16 927</td>
<td>16 927</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Deir Ezzor</td>
<td>42 504</td>
<td>53 240</td>
<td>12 103</td>
<td>107 846</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coastal</td>
<td>Lattakia</td>
<td>4 295</td>
<td>2 270</td>
<td>37 309</td>
<td>43 874</td>
<td>72 132</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tartous</td>
<td>8 701</td>
<td>3 592</td>
<td>15 965</td>
<td>28 258</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Khabour</td>
<td>Al Hasakeh</td>
<td>314 050</td>
<td>29 073</td>
<td>60 952</td>
<td>404 075</td>
<td>404 075</td>
<td>Over exploited</td>
</tr>
<tr>
<td>Yarmouk</td>
<td>Daraa</td>
<td>8 308</td>
<td>455</td>
<td>20 000</td>
<td>28 673</td>
<td>34 299</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quneitra</td>
<td>1 938</td>
<td>92</td>
<td>2 485</td>
<td>4 515</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Al Sweida</td>
<td>391</td>
<td>-</td>
<td>630</td>
<td>1 021</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orontos + Al Badia</td>
<td>Homs</td>
<td>24 751</td>
<td>6 623</td>
<td>22 932</td>
<td>54 306</td>
<td>257 298</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hama</td>
<td>47 245</td>
<td>4 849</td>
<td>7 679</td>
<td>59 773</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Idlib</td>
<td>35 558</td>
<td>1 897</td>
<td>6 854</td>
<td>44 309</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Al Ghab</td>
<td>16 040</td>
<td>93</td>
<td>58 858</td>
<td>74 991</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aleppo</td>
<td>5 783</td>
<td>2 179</td>
<td>15 957</td>
<td>23 919</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barada &amp; Awag</td>
<td>Rural Damascus</td>
<td>57 282</td>
<td>16 685</td>
<td>-</td>
<td>75 967</td>
<td>75 429</td>
<td>Over exploited</td>
</tr>
<tr>
<td></td>
<td>Damascus</td>
<td>473</td>
<td>989</td>
<td>-</td>
<td>1 462</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>715 509</td>
<td>164 041</td>
<td>396 518</td>
<td>1 276 068</td>
<td>1 276 068</td>
<td></td>
</tr>
</tbody>
</table>

Table 3 indicates that the average consumption of the irrigated hectare is 12,434 cubic meters per year and that the average consumption of the irrigated hectare in the Euphrates basin is 16,750 cubic meters per year. This is a significantly huge quantity that necessitates a serious reconsideration of the irrigation methods and shifting to modern irrigation systems. In response to these needs, the Government of Syria has taken several actions to insure water conservation. These actions have been implemented by a number of legal decisions enacted along 2000 and 2001 that concern the rehabilitation of old irrigation systems and the conversion to modern irrigation in a four year period. (see Policy matrix in heading 3). The main objective of these decisions is to reduce the annual water consumption from 12,434 to 7,000 cubic meters per ha. At present only 10% of the total irrigated surface (127,000 ha) is equipped with modern irrigation techniques such as sprinkler or drip irrigation (MAAR, 2001)

2.2 Management of irrigation systems
The Ministry of Irrigation is responsible for the planning, design and management of dams and public irrigation systems that cover about 400,000 ha. There are also numerous small and medium size irrigation networks that operate with waters coming from rivers or springs and that are managed by cooperatives. In these irrigation systems land holdings tend to be very small and the cooperative is responsible for providing a large number of services to their associates, such as the maintenance of the irrigation system, the distribution of water, the provision of inputs and the sale of produce. Water distribution is normally organized by groups of farmers that receive water from the same canal. The water in the main canal and pumping station is managed by a hired person or sometimes by the leaders of the cooperative. Water in the lateral canals is generally distributed on an established rotation.

Total irrigated area by wells is 715,509 ha of which 44% are in Al Hassakeh (Khabour basin). The total number of wells is 201,259 out of which about one forth were not licensed in 1999 (MAAR, 2001, Munther, 2001). This situation provoked the enacting of a special decree stating the obligation of licensing all wells by 2001 alongside the government’s decision to encourage the adoption of modern irrigation technologies by the farmers. About ¾ of the wells use fuel as primary energy and only the remaining ¼ use electricity. Wells depth and discharge rates are quite variable. In groundwater areas most of the wells are private and water is used in the farm of the owner of the well and sometimes it includes those plots of farmers located nearby. According to field survey’s data, farmers that have excess water capacity in their wells sell some of the extra water to neighbors².

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² Prices quoted were in the range of 6 SP/m³. Exchange rate: 1 US $ = 50 SP (Syrian Pounds) (2001)
2.3 Water fees and recovery of irrigation costs

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

2.4 Water resources

The water resources of Syria are very limited compared to the needs of the country and estimations show that available resources amount to 16,058 million m3/year as total uses reach 19,162 million m3/year (tables 2 and 3). In consequence, the water balance for Syria is negative with a deficit of 3,104 million m3/year varying distinctively across basins. In fact, only three basins have a positive balance and the remaining have considerable negative balances. Deficits ranged between 94 million m³ in Al Yarmouk basin and 3,106 million m³ in Al Khabour basin due to the expansion of the irrigated area, a disproportionate and often uncontrolled development of wells and the severe drought. The magnitude of the deficit in Al Khabour indicates that it will be difficult to correct it without special strict measures.

Table 2 - Available Water Resources by basin

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>Barada &amp; Awag</th>
<th>Yarmouk</th>
<th>Al Badia</th>
<th>Orontos (Al Asi)</th>
<th>Coastal</th>
<th>Al Khabour</th>
<th>Euphrates and Tigris</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rain fall (Actual/average)</td>
<td>%</td>
<td>59</td>
<td>49</td>
<td>30</td>
<td>60</td>
<td>80</td>
<td>40</td>
<td>100-40</td>
<td></td>
</tr>
<tr>
<td>Water resources (surface)</td>
<td>Million m³</td>
<td>12</td>
<td>88</td>
<td>49</td>
<td>666</td>
<td>1246</td>
<td>315</td>
<td>6818</td>
<td>9194</td>
</tr>
<tr>
<td>Water resources (underground)</td>
<td>Million m³</td>
<td>490</td>
<td>131</td>
<td>54</td>
<td>964</td>
<td>622</td>
<td>640</td>
<td>2494</td>
<td>5395</td>
</tr>
<tr>
<td>Water resources (total)</td>
<td>Million m³</td>
<td>502</td>
<td>219</td>
<td>103</td>
<td>1630</td>
<td>1868</td>
<td>955</td>
<td>9312</td>
<td>14589</td>
</tr>
<tr>
<td>Utilization rate</td>
<td>%</td>
<td>0,90</td>
<td>0,85</td>
<td>0,60</td>
<td>0,85</td>
<td>0,65</td>
<td>0,95</td>
<td>0,98</td>
<td>-</td>
</tr>
<tr>
<td>Actually available</td>
<td>Million m³</td>
<td>452</td>
<td>186</td>
<td>62</td>
<td>1386</td>
<td>1214</td>
<td>907</td>
<td>9126</td>
<td>13332</td>
</tr>
<tr>
<td>Domestic &amp; Industrial</td>
<td>Million m³</td>
<td>257</td>
<td>50</td>
<td>8</td>
<td>214</td>
<td>0</td>
<td>36</td>
<td>130</td>
<td>695</td>
</tr>
<tr>
<td>waste water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agricultural drainage</td>
<td>Million m³</td>
<td>568</td>
<td>36</td>
<td>-</td>
<td>231</td>
<td>43</td>
<td>428</td>
<td>725</td>
<td>2031</td>
</tr>
<tr>
<td>Total available for use</td>
<td>Million m³</td>
<td>1277</td>
<td>272</td>
<td>70</td>
<td>1831</td>
<td>1257</td>
<td>1371</td>
<td>9981</td>
<td>16058</td>
</tr>
</tbody>
</table>

Source: Ministry of Agriculture and Agrarian Reform, Arab Republic of Syria (MAAR a, 2001)
Table 3 - Present water uses and Water Balances

<table>
<thead>
<tr>
<th>Water use</th>
<th>unit</th>
<th>Barada &amp; Awag</th>
<th>Yarmouk</th>
<th>Al Badia</th>
<th>Orontos (Al Asi)</th>
<th>Coastal</th>
<th>Al Khabour</th>
<th>Euphrates &amp; Tigris</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated area</td>
<td>Ha</td>
<td>75429</td>
<td>34299</td>
<td>3871</td>
<td>253427</td>
<td>72132</td>
<td>404075</td>
<td>432835</td>
<td>1276068</td>
</tr>
<tr>
<td>Irrigation requirements</td>
<td>m3/ha</td>
<td>16000</td>
<td>10500</td>
<td>11000</td>
<td>9100</td>
<td>6000</td>
<td>10600</td>
<td>16700</td>
<td>12429</td>
</tr>
<tr>
<td>Irrigation water use</td>
<td>million m3</td>
<td>1207</td>
<td>360</td>
<td>43</td>
<td>2306</td>
<td>433</td>
<td>4283</td>
<td>7228</td>
<td>15860</td>
</tr>
<tr>
<td>Population</td>
<td>million persons</td>
<td>4.0890</td>
<td>0.9430</td>
<td>0.1130</td>
<td>2.5280</td>
<td>1.8290</td>
<td>0.6690</td>
<td>4.1050</td>
<td>14,2760</td>
</tr>
<tr>
<td>Domestic water use</td>
<td>million m3</td>
<td>298</td>
<td>69</td>
<td>8</td>
<td>185</td>
<td>134</td>
<td>49</td>
<td>300</td>
<td>1,042</td>
</tr>
<tr>
<td>Industry water use</td>
<td>million m3</td>
<td>77</td>
<td>18</td>
<td>2</td>
<td>48</td>
<td>35</td>
<td>13</td>
<td>78</td>
<td>315</td>
</tr>
<tr>
<td>Evaporation</td>
<td>million m3</td>
<td>5</td>
<td>31</td>
<td>15</td>
<td>148</td>
<td>16</td>
<td>132</td>
<td>1643</td>
<td>1,990</td>
</tr>
<tr>
<td>Total uses</td>
<td>million m3</td>
<td>1588</td>
<td>478</td>
<td>68</td>
<td>2687</td>
<td>617</td>
<td>4477</td>
<td>9249</td>
<td>19162</td>
</tr>
<tr>
<td>WATER BALANCE</td>
<td>million m3</td>
<td>-311</td>
<td>-206</td>
<td>2</td>
<td>-856</td>
<td>640</td>
<td>-3105</td>
<td>732</td>
<td>-3104</td>
</tr>
</tbody>
</table>

Source: Ministry of Agriculture and Agrarian Reform, Arab Republic of Syria (MAAR a, 2001).

Syria has important groundwater resources estimated at 5,395 million m³ which represents 37% of the total water resources of the country. The best aquifers concentrate in the western and northern regions but most have been overexploited except for the Coastal and Al Badia basins. Water tables have decreased enormously in many areas, up to 57 meters in the Orontos basin during the period 1990-1999, which has led to the prohibition for drilling new wells by recently enacted legal decisions.

Considering the severe water scarcity in Syria, the adoption of modern irrigation techniques is crucial for the country’s development of irrigated agriculture. In fact, the related authorities such as the Ministry of Agriculture and the Ministry of Irrigation, are actively encouraging irrigation modernization policies. According to the statistics available average water use in irrigation is 12,434 m³/ha and the adoption of modern technologies should reduce it to 8,000 m³/ha. The area equipped with modern irrigation techniques in year 2000 was 126,719 ha, of which 88% was under sprinkler irrigation and 12% under drip irrigation. Most of these techniques (95%) were installed in areas irrigated by wells. The rate of adoption of modern irrigation techniques from 1999 to 2000 was 37,686 ha as compared to 19,641 ha for the period 1998-1999. (MAAR a, MAAR b, 2001, Somi et al, 2001). However, interviews with manufacturers of irrigation equipment indicated that they are operating below installed capacity. Quality control does not take place systematically and prices of irrigation equipment at present are comparable to international prices and their imports are liberalized.

3 The policy framework

The Government of Syria has enacted in the last years a considerable amount of legal regulations and decrees that relate to irrigation water. This active legislation development evidences the importance that water resources have for the Syrian economy. From 1999 to 2001 the legal framework that affects
irrigation water has been thoroughly modified and strict measures have been taken into action (Varela and Sagardoy, 2001, annex 1).

The policy matrix below summarizes the policies related to irrigation water in Syria according to policy objectives, policy strategies and policy measures. The legal regulations developed recently in Syria respond to specific policy objectives that are namely: (1) Conservation of water resources, (2) Food security and food production targets, (3) Settlement of nomad population. Each policy objective includes several policy strategies that are implemented by different policy measures.

With the objective of reducing water use, the Government of Syria (GOS) has decided that all irrigated areas will be equipped with modern irrigation techniques in 4 years. This means that 287,337 ha will be adopted annually. Alongside, as a way to control water use, the GOS has decided to promote the installation of measuring devices in all existing wells and is requiring that all wells must be licensed by July 2001. The Co-operative Bank is providing loans to the farmers to purchase modern irrigation equipment at subsidized interest rates, with higher subsidies for cooperatives. The development of new irrigation in the public sector has been important increasing from 219,273 ha in 1993 ha to 396,518 in 2000 at a rate of 25,000 ha/year (MAAR b, 2001). Most of the new systems are of line canals from the headwork to the farm gate. Unfortunately the use of pressurized networks is still rather infrequent.
## POLICY MATRIX FOR IRRIGATION WATER IN SYRIA

<table>
<thead>
<tr>
<th>POLICY OBJECTIVES</th>
<th>POLICY STRATEGIES</th>
<th>MEASURES</th>
</tr>
</thead>
</table>
| **CONSERVATION OF WATER RESOURCES** | Sustainable use of groundwater aquifers | • Well drilling is banned in the cretassic layer  
• Only public Ministries are allowed to drill wells for domestic water use  
• Forbidding cultivation of summer crops in the steppe areas to preserve unrenewable groundwater reserves  
• Obligation to license all unlicensed wells by July 1 2001  
• Well drilling licensing is banned  
• Well deepening licenses are subject to the conditions of the irrigation department in the Governorates  
• Pumping system installation is not permitted unless renewable water is available  
• Installation of flow meters in wells  
• Grant irrigation license to farmers investing in the installation of flow meters |
| Cost recovery in public irrigation schemes | • O&M costs: Irrigation fee of 3500 SP/ha for spring irrigation and 600 SP/ha for winter irrigation  
• Capital costs: Establish a land reclamation fee from 2000 – 7000 SP/ha |
| Irrigation rehabilitation and modernization | • Submit studies for adoption of pressurized pipe irrigation systems  
• Rehabilitation of public irrigation schemes within a specific schedule  
• Supply to farmers with the required equipment and inputs  
• Agricultural Credit Bank will finance modern irrigation networks and pumping sets  
• Rehabilitation of the Al Manajeer irrigation projects in the Tigris and Al Khabour basins  
• Already implemented projects should be rehabilitated to adapt to modern irrigation techniques |
| Adoption of modern irrigation technologies at farm level | • Submit studies for adopting modern irrigation techniques for strategic crops according to basins’ capacity  
• Allocate annual budgets and provide necessary loans. Perform quality control of equipment  
• Conversion from traditional irrigation methods to modern irrigation techniques in 4 years  
• Start conversion in public sector systems  
• Financing of adoption of modern irrigation by the Agriculture Cooperative Bank  
• Give priority for financing the projects located in the water-deficit basins  
• Licenses will be granted to unlicensed wells provided that modern irrigation (sprinklers, drip) is installed |
| **FOOD SECURITY: MEET FOOD PRODUCTION TARGETS** | Coordinate Agricultural Plan with irrig. water availability | • Establishment of crop rotations and cropping patterns of strategic crops according to the renewable water resources, dams and reservoirs allocated for irrigation |
| Development of new irrigation areas | • Allow farmers in Raqqa Governorate to cultivate 1400 ha with summer crops and 2800 ha with winter crops  
• All irrigation and land reclamation projects should consider the adoption of modern irrigation techniques |
| **SETTLEMENT OF NOMAD POPULATION** | Development of new irrigation areas | • To ensure settlement of population in specific areas it is permitted to cultivate pastoral shrubs and fodder barley not exceeding use of 1500 million m³/year for all uses,  
• summer crops are forbidden to preserve unrenewable ground water reserves  
• investment in new irrigated lands by wells in the steppe trying to preserve water & settlement of population |
4 Macro level analysis: current and projected balance of water resources

As water resources vary greatly across basins in Syria, it can be expected that water policies will have distinct effects on the different basins. Therefore we have analyzed in this study four different policy scenarios to assess the effect of water development and water conservation policies at country level and at basins’ level. These policy scenarios have been simulated along the years 2000-2015 horizon to evaluate the effects of several policy alternatives on the short, medium and long-term availability of water resources in Syria. The analysis at basin’s level was performed to permit to assess the diverse impacts that those policies may produce on critical high-water-deficit basins with respect to water-surplus basins. This distinction is crucial for water policy analysis and policy recommendations. Figures 2-5 show the results of the policy scenarios at aggregate level and for the most critical basin.

Scenario 1: Present policy: Combination of irrigation modernization (4 years) and irrigation expansion (15 years)

This scenario represents the official government policy (Presidency of the Ministers Council, 2001) consisting in the modernization of the irrigation techniques and the development of an area compatible with the requirements created by the increasing population. The area to be modernized is 31,9017 ha/year (for a period of 4 years) and those to be developed are 27,800 ha/year (15 years). The evolution of the deficit for the whole country evidences that during the four initial years a large reduction of the deficit is achieved but from the 5th year onwards the deficit starts to increase due to the development of the new areas. At the end of the period the deficit reaches 2,469 Mm3 which is only 635 Mm3 smaller than the initial value. This shows clearly that in spite of the substantial impact that could be obtained with the modernization program, the expansion of the irrigated area has a marked counterbalancing effect. The Al Khabour basin recovers and its deficit decreases to nearly 2000 Mm3 but it declines later on to values close to the initial ones. This is an indication that in this basin the development of new irrigation should not be promoted if the equilibrium between demand and supply is to be restored. A similar conclusion applies to the Orontes basin.

Scenario 2: Modernization policy: Modernization of existing irrigation schemes with no expansion of irrigation

This scenario permits to visualize the effect of a gradual modernization policy whereby the whole irrigated area (1,149,349 ha) will be modernized over a period of 15 years at the rate of 80,000 ha per year approximately. This scenario permits to reach a positive balance by the 12th year and by the year 15th the balance reaches a positive value of 857 Mm3. Unfortunately this scenario will not permit to cover the needs of the growing population and some commodities will have to be imported. The reduction of the
deficit in the critical basins (Al Khabour and Orontes) are close to 40% of the initial values, which is substantial for a 15 year period, but it also indicates that even if the whole area is modernized these basins will continue to have an important deficit. Therefore stronger measures will be required to achieve a positive balance in these critical basins such as water consumption limitations per well, closing of wells, reduction of irrigated area, limiting the cropping pattern to crops with relative small water requirements or any combination of these measures.

Scenario 3. Long-term combined policy: Combination of irrigation modernization and irrigation expansion (15 years both processes)

This scenario assumes that modernization will be undertaken in the whole irrigated area but at the rate of 80,000 ha/year, in accordance to other international experiences. Expansion of irrigated area will take place at the same rate as in Scenario 1. At national level, deficit is reduced from -3,104 Mm³ to -2,753 Mm³, as the annual balance between the modernized areas and the newly irrigated areas is positive. This permits the reduction of the deficit but after year 15 the trend will reverse as all the existing irrigated area will have been modernized and only new areas will be added. The critical Al Khabour basin follows a similar pattern until year 11 where all the area to be modernized is covered and from that year on only new area is added producing a reversal of the trend.

Scenario 4. Differentiated policy: Modernization in critical basins and limited irrigation expansion in selected basins.

This scenario simulates different irrigation policies for the high-deficit critical basins and for the positive-balance basins. For the critical Al Khabour and Orontes basins a special five year modernization plan will be developed assuming that all the irrigated area will be modernized in this period no new lands will be transformed into irrigation. For the remaining basins the existing area will be modernized over a longer period of 15 years. New irrigation areas will be developed only in the positive-balance basins (Euphrates and Coastal, 120,000 ha and 45,000 ha respectively). The effect of this hypothesis is quite positive as it will permit to reduce the national deficit from -3104 to -451 Mm³ (Figure 5). A total of 165,000 ha of newly irrigated lands will be developed over the 15 year period representing approximately one third of the present Government plans. For the Al Khabour basin the effect is also quite remarkable reducing the deficit from -3,105 to -1845 Mm³ in a period of 5 years and practically stabilizing onwards. This again shows that even if the whole area is modernized in a short period of time, the basin still has a high negative balance that will eventually lead to the depletion of the aquifers.
Water Balance Scenarios

Figure 2- Scenario 1: Current policy. Modernization (4 years) and irrigation expansion (15 years)

Figure 3: Scenario 2: Modernization policy with no irrigation expansion

Figure 4: Scenario 3: Long term policy. Modernization and irrigation expansion (15 years)

Figure 5- Scenario 4: Differentiated policy. Modernization in all basins, no expansion in critical basins
Results of the analysis show that when modernization policies are combined with the expansion of irrigated areas to reach the projected goal of 420,000 ha for the 15 year period, water balances tend to revert to the initial values (Scenario 1) or produce only a moderate reduction of the deficit (Scenario 3). The fact that some basins have quite large deficits while others have positive balances indicates the need for a differentiated policy to attain a national positive balance. Modernization will concentrate in the high-deficit basins while development of new areas will be permitted only in the basins that have positive balances (Scenario 4), although the expansion of the irrigated area will reach only one forth of the projected objectives.

5. Micro level analysis: adoption of modern irrigation technologies

The assessment of the effects of the adoption of modern irrigation technologies requires a disaggregated farm level analysis that will complete the analysis at aggregated and basins’ levels that was presented in the previous section. For this purpose different policy scenarios have been simulated that correspond to the adoption of different irrigation techniques under various types of water sources and farms that respond to the structural and agronomic characteristics of the irrigation agriculture in several regions in Syria. Thus, a typology of farms has been built to represent the Syrian irrigated agriculture in different regional environments. Representative farms were selected based upon the statistical data available, according to farm size, production potential, factor allocation, cropping pattern and type of water source. Different alternatives for adopting modern irrigation techniques were considered to permit to evaluate the effects that the investments in new irrigation equipment will have on the financial results of different farm types. As shown in Figure 6, land sizes are not extremely dispersed in Syria. Small irrigated farms are numerous, they account for 30% of all farms and occupy 15% of the total irrigated surface in the country. The average irrigated farm in Syria is 3.6 ha and it represents the most balanced farm size class. In fact, farms of around 3 ha in size represent approximately one forth of all irrigated lands and all holdings in Syria.
Selection of representative farms:

Table 5.2 shows the aggregated strata that were selected to define the representative farms with an adequate level of representativity. These strata include roughly 80% of the irrigated area and 70% of the irrigated holdings.

Table 4 - Selection of representative farms by area and number of holdings

<table>
<thead>
<tr>
<th>farm size strata (ha)</th>
<th>average farm size (ha)</th>
<th>%area</th>
<th>%holdings</th>
<th>representative farms (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;1 - &lt;2</td>
<td>1,52</td>
<td>16,08</td>
<td>38,18</td>
<td>1,5</td>
</tr>
<tr>
<td>&gt;4 - &lt;8</td>
<td>5,43</td>
<td>32,66</td>
<td>21,78</td>
<td>5</td>
</tr>
<tr>
<td>&gt;10 - &lt;25</td>
<td>13,73</td>
<td>33,50</td>
<td>8,84</td>
<td>14</td>
</tr>
<tr>
<td>total</td>
<td></td>
<td>82,24</td>
<td>68,80</td>
<td></td>
</tr>
</tbody>
</table>

Source: Own elaboration based on data of the Bureau of Statistics (1994 census)

A field survey was conducted in set of 48 irrigated farms which permitted to accede to direct farm-based information that was used for the definition of the technical parameters, cropping pattern, farm size, water use and irrigation techniques in the farm models. Field survey data provided also the data base for obtaining the irrigation cost parameters in all the irrigation techniques alternatives in the farm models.

The farm typology is intended to represent the irrigation agriculture in Syria and features the characteristics of distinctive agricultural regions in the country. It consists on three selected representative farms according to the data available of size and number of irrigated holdings as defined in table 4. These
farms are a large extensive farm of 14ha, a medium size semi-intensive farm of 5 ha and a small intensive farm of 1.5 ha, which together represent 77% of all irrigated holdings and 64% of the irrigated surface. Water sources in the different types of farms include surface water from rivers and underground water from wells of 200 m, 100 m and 50m. depth. Irrigation costs were calculated for all the different alternatives using field data information. Irrigation techniques include traditional surface irrigation and modern sprinkler and drip irrigation. The combination of farm types, water sources and irrigation techniques has resulted in an ample number of farm models which has permitted to compare the effects of the adoption of modern technologies for irrigation across farm structures and water sources. The general characteristics of the farms are the following:

Table 5 - General characteristics of the representative farms

<table>
<thead>
<tr>
<th>Farm type</th>
<th>Size (ha)</th>
<th>Cropping pattern</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large farm</td>
<td>14</td>
<td>Wheat, Cotton</td>
<td>70%, 30%</td>
</tr>
<tr>
<td>Medium size farm</td>
<td>5</td>
<td>Wheat, Cotton, Potato, Sugar Beet</td>
<td>50%, 20%, 15%, 15%</td>
</tr>
<tr>
<td>Small farm</td>
<td>1.5</td>
<td>Tomato, Potato, Oranges</td>
<td>50%, 25%, 25%</td>
</tr>
</tbody>
</table>

Comparative effects by farm types

Results of the analysis are shown in Figure 7 which depicts the profit attained by each farm type as modern irrigation techniques are adopted. Figure 8 shows, equivalently, the financial returns of water.

The effects of the adoption of modern irrigation on farm profit can be substantially different in the large, medium and small farms evidencing that structural parameters and cropping patterns are determinant and hence regional characteristics. The results on financial returns of water (net margin/m3) show that for all farm types, the adoption of modern irrigation techniques increases substantially. However, differences between these two techniques are evidenced, and in the case of sprinklers increases range from 55 to 125% as in the case of drip irrigation these figures double ranging from 116 to 218%. Across all farm types, the kind of water source (surface or underground water) determines also the profitability of adopting modern irrigation methods. The adoption of water-saving modern irrigation technologies results in larger increases in farm profits when water is extracted from wells as volumetric water costs are substantially reduced.

3 Exchange rate: 1 US $ = 50 SP (Syrian Pounds) (2001)
Adoption of modern irrigation techniques in the large farm
In the large farm irrigated by river water, farm profits increase moderately when modern irrigation techniques are adopted. From a net margin per ha of 18,683 Sp/ha in surface irrigation to 23,395 SP/ha in the case of sprinkler irrigation and 22,387 SP/ha in drip irrigation. If water is extracted from wells of 100 m. depth, modern irrigation results in higher farm profit increases, passing from 10,752 SP/ha in surface irrigation to 29,127 SP/ha in sprinklers and 28,212 SP/ha in drip irrigation. This is due to the decrease in irrigation costs inbuilt in the modern water saving techniques as water costs depend on the volumes of extracted water. This tendency is reinforced as water becomes more expensive in deep wells of 200 m. depth. These results show that in this type of extensive farm sprinkler irrigation is more suitable than drip irrigation although sprinklers cannot be used along the whole growth period of cotton.

Adoption of modern irrigation in the medium size farm
Medium size semi-intensive farms irrigated by river water increase farm profits by 33% when sprinkler irrigation is adopted (from 41,911 SP/ha to 55,797 SP/ha) and by 36% when drip irrigation is adopted (to 56,949 SP/ha). These results evidence that this modern technology is more suited for a more intensive cropping pattern (that includes potato). In medium size farms irrigated by wells, the adoption of sprinkler or drip irrigation results in a double increase in farm profits (64% and 67% respectively) than in the case of river water (from 35,627 to 58,477 SP/ha for sprinklers and 59,628 SP/ha for drip). The advantages of drip irrigation are reinforced as volumetric water savings are greater in this type of technology.

Adoption of modern irrigation in the small farm
In the case of the small intensive farm, that grows mainly fruits and vegetables, the comparative efficiency of adopting drip irrigation is further evidenced both for surface river water and for underground water. For surface water, farm profits increase by 38% if sprinkler irrigation is adopted and 67% if drip irrigation is selected (from 153,087 SP/ha to respectively 210,985 and 255,962 SP/ha). If irrigation water is extracted from shallow 50 m wells farm profits increase by a double amount, 67% in the case of sprinkler irrigation and 111 % in drip irrigation (from 119,164 SP/ha to respectively 206,304 and 251,478 SP/ha).
Figure 7 - Financial effects of modern irrigation technologies by farm type

Net Margin/ha

LF: large farm; MF: Medium farm; SF: small farm

Figure 8 - Financial returns of water by type of farm, irrigation technique and water source

Net Margin/m3 of water

LF: large farm; MF: Medium farm; SF: small farm
5. Concluding reflections

On water resources policies

From the results of our analysis, we have evidenced that the present water balance in Syria is negative and a fast-rate growing population is putting additional pressure on the existing resources which are not enough to satisfy existing demand. The development of new water resources seems very limited considering that Syria has developed a fair number of dams and reservoirs. As it has been often argued, further investments in new public-funded irrigation networks are extensively questioned worldwide due to increasing costs and environmental damage (Rosegrant 1997, FAO 1997). An alternative will be to invest in improving the efficiency of existing irrigation systems and to provide incentives to private investments (Rosegrant and Svendsen 1993, Seckler 1996, Badaragoda 1998) which will conform with Syria’s new trends in agricultural policies. This seems especially crucial as, on the whole, restoring a positive water balance in the future appears as an important policy objective in Syria that will require some drastic measures in some of the existing basins where the deficit has reached alarming proportions. However, the nation-wide projected water policies in Syria have proven to be non-sustainable and a positive water balance will not be reached in the country, even less so in the critical high-deficit basins. Therefore much of the present and future water policy will have to rely on demand management.

As some basins have positive balances while others have quite large deficits, a differentiated water basin policy would offer the best opportunity to reduce water imbalances among basins and reach a moderate overall positive balance. This policy will consist in coupling a modernization policy with a moderate and selective expansion of irrigation. That is, an intensive plan of modernization directed to the most critical basins with a lower rate of implementation in those basins where the deficit is smaller. New irrigation areas should be developed exclusively on the basins with positive water balances and will meet about one forth of the projected policy targets. This implies that Syria will have to rely on the imports of some produce in accordance with the recent trend towards more market oriented agricultural policies and a more flexible concept of food security (responding to the recent joining the WTO and a trade agreement with the EU). A possible agreement with Turkey regarding the flow available at the border could provide the basis for additional expansions of the irrigated area in the Euphrates basin.

On the adoption of modern irrigation techniques

The policy directed to substitute traditional irrigation systems with modern water-saving techniques seems very appropriate in Syria, considering that farmers are operating under an area-based administered water pricing system and are not charged for the actual use of water. This system does not ensure an efficient use of water. In fact, farmers benefit from subsidies for irrigation water as well as for strategic
products and inputs which characterize the basis of the government’s agricultural production plan. Currently, irrigators use large volumes of water well above what will be considered the optimal crop irrigation requirements without any penalty.

On the other hand, the adoption of modern irrigation technologies poses some technological problems. Firstly, these modern technologies are better suited for holdings irrigated by private wells due to the certainty of having a continuous water flow available when necessary. Secondly, adoption of modern irrigation in public surface irrigation systems will present technological problems as most of the irrigation networks work in a rotation system that makes water available to the farm on turns of variable duration. Such modality is not compatible with the use of sprinkler and drip irrigation systems that require a frequent water supply. Therefore the existing irrigation networks will have to be adapted to this technical requisite.

The analysis made at farm level shows that the adoption of modern irrigation is financially attractive in most cases in Syria. However, the adoption of modern water-saving irrigation techniques will not necessarily imply that water savings will take place unless equipment is properly used. But even if the equipment is used properly farmers may wish to cultivate a larger proportion of their lands or plant more water consuming crops if they do not find incentives to do otherwise. Therefore whether water is actually saved by increasing on-farm irrigation efficiency needs careful evaluation. In fact, as technical efficiency increases on-farm water consumption is expected to decrease as a mean to attain overall water conservation strategies. However, in Syria or elsewhere, it cannot be generally affirmed that irrigation modernization polices will induce, unambiguously, an increase in water savings and actual outcomes of these policies are frequently misleading (Huffaker and Whittlesey 1995, Garrido et al 1997, Seckler 1996).

Thus, for the design of demand-management water policies, it has to be recalled that the mere technical conception of irrigation modernization does not necessarily induce a reduction in water consumption in spite of ameliorating technical efficiency, as it has often been argued (Huffaker and Whittlesey 1995, Rosegrant et al 1995, Garrido et al 1997). Consequently, to resort to incentive structures (e.g. volumetric water pricing) for complementing technological solutions will be a foreseeable policy for attaining a more efficient use of irrigation water and increase water saving. (Rosegrant et al 1995, Facon 1997, Varela-Ortega et al, 2000). In fact, it has been experienced worldwide that no water conservation strategies can be expected from the irrigators in the absence of appropriate incentives (such as water tariffs, water quotas of market-based mechanisms). Subsidies for irrigation modernization will benefit exclusively the private farmer by increasing farm income gains but will not induce water saving and thus will not be consistent with water conservation objectives (Varela-Ortega et al 2000)
Along these lines of argument, the most likely solutions for a better demand-management water policy in Syria will be the following:

- Limiting the amount of water/ha that can be used in every well considering the aquifer’s recharge rate and penalizing those that exceed it with a penalty fee. However, the implementation of this measure is not easy and requires the installation of flow meters. In fact, a water policy based on quantitative limitations of water use has important monitoring and control requirements and therefore these policies have proven to be difficult to implement due to high enforcement costs (Varela-Ortega et al., 2002).

- Establish the equivalence between the maximum permitted water quantity per ha and the area that can be planted of different crops according to different technologies. This is referred to as a water/crop quota system and it will permit the farmers to chose their cropping pattern within an established quota of water and have it approved by the government authorities. In order not to distort the national objectives of strategic crops’ production, the government can establish support prices for selective strategic crops to achieve those objectives. This water/crop quota system could be implemented gradually over a 5 years period. An example of the water/crop quota system is illustrated below:

**Table 6** - Example of a water/crop quota system for a water allocation of 4000 m3/ha (first year)

<table>
<thead>
<tr>
<th>Irrigation Technique</th>
<th>Wheat</th>
<th>Cotton</th>
<th>Sugar beet</th>
<th>Sunflower</th>
<th>Barley</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional irrigation</td>
<td>0,9ha</td>
<td>0,25 ha</td>
<td>0,6</td>
<td>0,9 ha</td>
<td>0,90 ha</td>
</tr>
<tr>
<td>Sprinkler irrigation</td>
<td>1,20 ha</td>
<td>0,35 ha</td>
<td>1,0</td>
<td>1,20 ha</td>
<td>1,20 ha</td>
</tr>
<tr>
<td>Drip irrigation</td>
<td>1,20 ha</td>
<td>0,45 ha</td>
<td>1,1</td>
<td>1,30 ha</td>
<td>1,20 ha</td>
</tr>
</tbody>
</table>

**Table 7** - Example of a water/crop quota system for a water allocation of 2700 m3/ha (fifth year)

<table>
<thead>
<tr>
<th>Irrigation Technique</th>
<th>Wheat</th>
<th>Cotton</th>
<th>Sugar beet</th>
<th>Sunflower seeds</th>
<th>Barley</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional irrigation</td>
<td>0,60ha</td>
<td>0,15 ha</td>
<td>0,5</td>
<td>0,6 ha</td>
<td>0,60 ha</td>
</tr>
<tr>
<td>Sprinkler irrigation</td>
<td>0,90 ha</td>
<td>0,25 ha</td>
<td>0,70</td>
<td>0,74 ha</td>
<td>0,84 ha</td>
</tr>
<tr>
<td>Drip irrigation</td>
<td>0,90 ha</td>
<td>0,40 ha</td>
<td>0,77</td>
<td>0,90 ha</td>
<td>0,84 ha</td>
</tr>
</tbody>
</table>

Modernization of farms where wheat and cotton are traditionally grown present the technical problem that sprinkler irrigation is suitable for wheat but not adequate for all phases of crop development of cotton. The inverse applies for drip irrigation. The water/crop quota system provides a good basis for solving this serious technical limitation as farmers can choose the most suitable cropping pattern to their irrigation techniques.

- The adoption of modern water-saving technologies may not be sufficient to ensure their rapid adoption in the critical basins where water balances are highly negative. Therefore the GOS should adopt some measures that will contribute to accelerate the rate of adoption in these basins. Experience
worldwide indicate that subsidies of different kind are practiced in many countries for the adoption of these techniques. Justification of this ‘water conservation subsidy’ will be of environmental nature like the replenishing of the aquifers. Furthermore, this subsidy will put groundwater farmers in a similar situation to the farmers using surface waters who have enjoyed traditionally a certain level of subsidies for the provision of water to their farms.

- Choosing the right combination of measures will require more detailed information about the hydrological characteristics of the basins and the present use of the water (inventory of the existing wells) but considering that installation of flow meters may take some time to implement the most feasible alternative in the short run would be to control the permitted quantity of water as indicated before.

None of these measures will be easily accepted by the farmers as they will perceive them as a reduction of their income. Enforcement of some of them may cause social unrest and result in limited implementation. Any such measure should be accompanied by some financial incentives to decrease the resistance for their adoption as well as by setting-up participatory mechanisms that will permit the farmers to get involved in the policy decisions before arriving to their implementation.

5 References


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