The possible effects of irrigation schemes and irrigation methods on water budget and economy in Atatürk dam of South-Eastern Anatolia region of Turkey

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The possible effects of irrigation schemes and irrigation methods on water budget and economy in Atatürk dam of south-eastern Anatolia region of Turkey

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Abstract. The South-eastern Anatolia Project (GAP) has been implemented in the southeast part of Turkey, covering 9 provinces and the two most important rivers of Turkey. The main purpose of this gorgeous project is to uplift the income level and living standards of people in the region, to remove the inter-regional development disparities and to contribute to the national goals of economic development and social stability. The cost of the project is 32 billion USD consisting of 13 sub-projects in the river basins of Euphrates and Tigris. The project has evolved over time and has become multi sectoral, integrated and human based on the sustainable regional development. Upon the fully completion of the project, 1.8 Million hectares of land will be able to be irrigated in Euphrates and Tigris Basins through surface and underground water resources. From 1995 until now, 273.000 ha. of land have already been irrigated within the GAP Project. Roughly 739,000 ha. of this land will be irrigated from Atatürk Dam, the largest dam of GAP Project. At present, nearly ¼ of this area is under irrigation. Some technological developments have been experienced in the Project area, ranging from upstream controlled schemes having trapezoidal section, lined or unlined, to upstream controlled schemes having high pressurized piped system; and from conventional methods to drip irrigation method. The effects of those kinds of developments over water budget of irrigation schemes from Atatürk Dam have been studied. The data gathering from both 472,000 ha. of pumping irrigation and 267.000 ha. of gravity irrigation area is used in this study. Monthly plant water consumptions are determined through referenced plant water consumption gathered by GIS in association with plant growth index acquired from regional research studies. Irrigation module and annual total irrigation requirement are determined under different schemes and methods by means of monthly estimated plant water consumption rates. The contribution to the cost of energy generated by Atatürk Dam and to the cost of energy under pumping irrigation is determined.

Keywords. Water Budget – Atatürk Dam – GAP Region – Irrigation – Efficiency.

Les effets possibles des périmètres et des méthodes d'irrigation sur le bilan hydrique et l'économie d'eau du barrage d'Atatürk dans l'Anatolie du sud-est en Turquie

Résumé. *Le Projet de l'Anatolie du Sud-Est (GAP) a été mis en place dans la région sud-orientale de la Turquie, qui inclut 9 provinces et deux des principaux fleuves de la Turquie, dans le but d'élever le niveau du revenu et le standard de vie des habitants, de réduire les disparités dans le développement et contribuer à la réalisation des objectifs nationaux de développement économique et stabilité sociale. Le projet, dont le coût s'élève à 32 milliards de dollars, comprend 13 sous-projets des bassins hydrographiques de l'Euphrate et du Tigre. Après une certaine évolution dans le temps, le projet et actuellement multisectoriel, intégré et axé sur l'objectif d'un développement durable. Au terme du projet, 1,8 millions d'hectares de terres pourront être irrigués dans les bassin de l'Euphrate et du Tigre, en exploitant des ressources en eau superficielles et souterraines. A partir de 1995, 273.000 ha de terres ont déjà été irrigués dans le cadre du projet GAP. Approximativement, 739.000 ha de ces terres seront irrigués en exploitant le barrage d'Atatürk, qui est le plus grand du projet GAP. A l'heure actuelle, presque ¼ de cette région est irrigué. Dans la zone du projet, des innovations techniques intéressantes ont été testées, depuis les périmètres contrôlés en amont avec des canaux de section trapézoïdale, revêtus ou non, aux périmètres contrôlés en amont, avec un système de canalisation à haute pression, depuis les méthodes conventionnelles à l'irrigation au goutte-à-goutte. En plus, on a évalué les effets de ces développements sur le bilan hydrique des périmètres d'irrigation du barrage d'Atatürk. Les données obtenues sur 472,000 ha soumis à l'irrigation par pompage et 267.000 ha soumis à l'irrigation gravitaire ont été utilisées dans cette étude. La consommation mensuelle d'eau de la culture est déterminée sur la base de la consommation d'eau des plantes de référence, estimée par le SIG et associée*

à l'indice de croissance de la plante repéré dans des études régionales. Le module d'irrigation et le besoins d'irrigation annuels totaux sont déterminés compte tenu des différents périmètres et méthodes, sur la base des taux mensuels de consommation d'eau de la plante estimés. On considère également la contribution au coût de l'énergie générée par le barrage d'Atatürk et le coût de l'énergie dans le cas de l'irrigation par pompage.

Mots-clés. *Bilan hydrique – Barrage d'Atatürk – Région du GAP –Irrigation – Efficience.*

I – Introduction

1. South-eastern Anatolia Project (GAP) and Atatürk Dam Irrigations

The South-eastern Anatolia Project, aiming at increasing the income and raising the standard of living of the population of this region by utilizing its natural resources, eliminating interregional disparities and contributing to the objective of restoring an economic development at national level and social stability and becoming a trademark of Turkey, is a multi - sector, integrated attempt for development, based on soil and water resources with the human being at its focal point (Akçakoca, 1997).

Previously, GAP had been planned as a bundle of 13 projects, with the objective of irrigation and hydroelectric power generation on the Rivers Euphrates and Tigris. The building of 22 dams and 19 hydroelectric power plants were envisaged within its scope. Today, beyond dams, hydraulic power plants and irrigation facilities on the Euphrates and the Tigris, the South-eastern Anatolia Project represents a comprehensive regional development effort based on a multi - sector, integrated and sustainable development approach targeting the full - fledged development not only of the region, but also of entire Turkey and its neighbouring areas, including investments and services in urban and rural infrastructure, agricultural infrastructure, transportation, industry, education, health, housing, tourism and various other sectors.

The surface area of the region, covering the provinces of Adiyaman, Batman, Diyarbakir, Gaziantep, Kilis, Mardin, Siirt, Sanliurfa and Sirnak, constitutes approximately 10% of the total surface area of Turkey (75,193 km²). According to the 2007 census, the population of the GAP Region provinces was 7.6 millions, constituting approximately 10.2% of the country's total population. The urban population of the region is 66%; the rural population 34%.

Upon the completion of the GAP, the irrigation of 1.8 million hectares of land, generation of 27 billion kWh hydraulic energy annually, 209% income increase per capita and employment opportunities for approximately 3.8 million people are targeted. Stated in figures, upon the completion of GAP, 2.1 billion dollars of agricultural benefit and a benefit of 2.2 billion dollars in terms of energy will be achieved, thus having a contribution of 4.3 billion dollars to the national economy.

Of the installed capacity of the 7476 MW hydroelectric power plant within the scope of GAP, 5513 MW have been materialized and 18.3 billion kWh energy have been generated in 2007. As of the end of the year 2007, the irrigation of 273,000 ha of land is in operation, and additional irrigation facilities for 100.000 ha of land are under construction.

The Atatürk Dam, which is the biggest and the key construction of the project, is the third dam built on the River Euphrates. With an active capacity of 19 billion m³ within a total capacity of 49 billion m³ and an installed capacity of 2,400 MW, it is Turkey's largest dam ranking 6th in the world, considering the capacity of rock-filled dams. An area of 739,323 ha will be irrigated from the waters of the Atatürk Dam. 472,000 ha of this land will be irrigated by electric - pump irrigation (Table 1).By the end of 2007, 190,000 ha of land are irrigated by Lake Atatürk Dam, of which 161,000 ha are irrigated by way of surface irrigation and the remaining 29,000 ha by pump irrigation. Presently surface irrigation facilities for 10,862 ha of land and pump irrigation facilities for 1,846 ha of land are under construction (Figure 1).

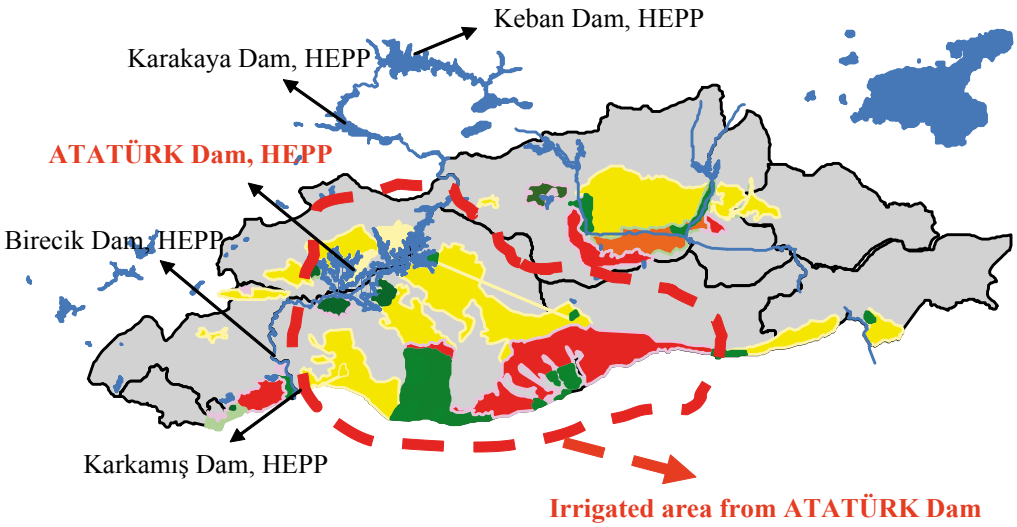

Figure 1. GAP Irrigation Projects.

Table 1. Atatürk Dam's Irrigation Projects.

Irrigation Projects	Units		Gross Area	Operation Area	Under Construction Area	Stage of Planning and Tender Area
Urfa Tunnel Irrigations (385,190 Ha)	Mardin	Gravity	108,384	10,597	2,888	94,899
	Ceylanpınar+Yukarı Harran	Pumping	118,264	0	0	118,264
	Ş.Urfa Harran		147,887	139,913	7,974	0
	Akçakale		10,255	10,255	10,255 (Renewal)	
	Groundwater Irrig. Paşabağı		400	400	0	0
Siverek Hilvan Pumping			156,373	0	0	156,373
Bozova Pumping			48,414	8,669	0	39,745
Bozova Merkez Pumping			1,080	1,080	0	0
Yaylak Pumping			18,322	18,322	0	0
Suruç Pumping			94,814	0	0	94,814
Atatürk Pumping			26,793	0	0	26,793
Samsat Pumping			8,337	960	1,846	5,531
Total			739,323	190,196	12,708	530,888

In this study, the impact of water savings achieved by converting the planned surface irrigation system at the Atatürk Dam into pressure irrigation systems, on the national income and income of the farmers will be discussed.

II – Materials and Methods

The GAP region consists of 7.5 million ha of land in total, 3.2 million ha of which is arable land. On 1.8 million ha of this agricultural area, irrigated agriculture will be carried out. In the GAP Region, the size of an average agricultural holding is about 1.1 ha.

The climate of the GAP Region is separated into two parts (northern and southern GAP), considering temperature and precipitation regime (Anonymous, 1990). In the northern GAP Region, with an annual precipitation of over 600 mm and temperature of less than 2.5 ºC in February, pump irrigation from the Atatürk and Samsat dams is carried out. In the southern GAP Region, with an annual precipitation of less than 400 mm and temperature of over 5 ºC in February, the related irrigation systems are the Suruç and Urfa tunnel irrigations within the Mardin-Ceylanpınar, Upper Harran, Şanlıurfa-Harran, Paşabağı and Akçakale YAS projects. For regions with a temperature of over 5 ºC in February and precipitation level between 400-600 mm, Yaylak, Bozova, Bozova Merkez and Siverek - Hilvan irrigation projects have been designed. Regarding soil classification, the main part of the irrigable soil in the GAP Region, consists of class 1 and 2 land. Yaylak, Bozova and Bozova Merkez irrigations consist of class 2 and 3 land; Siverek - Hilvan, Samsat and Atatürk irrigations are considered within class 2 and 3 land. As references for the crop pattern within the project area, studies by (Koç, 2001), who evaluated the crop pattern for the GAP Region taking into account the country's needs and market conditions, and studies by (Demir *et al.* 2001a), based on the report by Yıldırım 2002, who determined the ecological requirements of plants in his study called 'Irrigation Conditions, Climate, Plants and Homogeneous Areas' (Table 2) have been taken into account.

Table 2. The Crop Pattern by Atatürk Dam's Irrigations with (%).

Crop	GAP Average	Ş.Urfa-Harran, Akçakale YAS and Paşabağı	Mardin-Ceylanpınar	Siverek-Hilvan Pumping	Bozova Merkez, Bozova and Yaylak Pumping	Suruç	Samsat and Atatürk Pumping
Wheat	23.20	22.40	22.58	23.20	23.20	28.00	23.50
Cotton	45.60	46.40	47.30	47.00	47.00	49.70	47.60
Melon & Watermelon	5.30	5.30	4.88	5.00	0.00	0.00	0.00
Bean	1.20	1.20	1.18	1.20	1.20	4.00	1.20
Vegetables	6.40	6.40	6.45	5.30	0.00	0.00	0.00
Sunflower	0.80	0.80	0.78	0.80	0.80	0.80	0.80
Alfalfa	2.90	2.90	2.68	2.90	2.90	2.90	2.00
Fruit	8.30	8.30	8.23	8.30	8.30	8.30	8.30
Maize	4.50	4.50	4.15	4.50	14.80	4.50	14.80
Lentil &Chickpea	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Onion	0.80	0.80	0.80	0.80	0.80	0.80	0.80
I. Crop Total	**100**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Soybean II. Crop	2.40	1.00	2.20	2.40	0.00	0.00	0.00
II. Crop Maize	5.60	8.82	6.31	5.60	9.00	8.50	8.00
II Crop Maize Slag	3.70	3.00	3.35	3.70	3.70	3.70	3.70
Vegetable II.Crop	2.80	2.00	2.80	2.80	2.80	2.80	2.80
II. Crop Vetches	2.32	2.00	2.16	2.32	1.32	1.82	2.32
II. Crop Total	**16.82**	**16.82**	**16.82**	**16.82**	**16.82**	**16.82**	**16.82**
General Total	**116.82**	**116.82**	**116.82**	**116.82**	**116.82**	**116.82**	**116.82**

Source: Demir et al., 2001.

The evaporation and precipitation values have been taken from Demir and others, who have utilized figures of the last 30 years, obtained by 112 meteorological stations, consisting of 27 large climate and 85 precipitation stations and the GAP Region and its surroundings and have been calculated with the help of geographical information system by the FAO Penman method for each irrigation (Table 3 and 4).

Table 3. Monthly evapotranspiration values defined by the GIS.

Project Names	Month ETo Value (mm/mount)												Annual
	1	2	3	4	5	6	7	8	9	10	11	12	
Atatürk	31	42	69	97	144	181	193	173	126	81	42	28	1212
Bozova ve Bozova Merkez	33	44	75	112	164	205	179	170	135	92	47	29	1291
Samsat Pumping	29	39	67	96	141	176	191	170	124	78	40	27	1185
Akçakale Yas	31	45	78	121	183	230	231	211	153	95	45	28	1451
Ş.Urfa-Harran ve Paşabağıı	31	43	75	115	173	220	215	198	146	92	43	27	1383
Mardin-Ceylanpınar	39	49	81	116	175	224	244	218	160	99	50	35	1497
Siverek-Hilvan	40	49	82	115	167	216	234	210	157	99	49	34	1457
Suruç	33	47	81	120	175	210	199	184	139	88	44	29	1356
Yaylak	31	43	72	103	151	184	180	164	125	81	42	28	1212
GAP Region Average	34	46	80	118	175	222	238	213	156	97	47	31	1463

Source: Demir et al., 2001b

Table 4. Monthly Total Precipitation values defined by the GIS.

Project names	Monthly rainfall values (mm/month)												Annual
	1	2	3	4	5	6	7	8	9	10	11	12	
Akçakale Yas	51	46	47	35	24	2	1	0	0	16	34	46	308
Atatürk	96	86	86	63	36	7	1	0	2	30	60	105	577
Bozova ve Bozova Merkez	43	52	56	41	35	3	0	0	0	14	41	66	355
Samsat Pumping	105	100	88	58	38	6	1	0	1	26	75	108	611
Ş.Urfa-Harran ve Paşabağıı	54	50	58	32	32	4	1	0	0	17	42	57	353
Mardin-Ceylanpınar	45	54	55	45	30	3	0	0	0	12	42	56	346
Siverek-Hilvan	48	61	59	50	38	6	0	0	0	19	46	60	393
Suruç	67	54	21	53	32	7	1	0	2	23	54	29	347
Yaylak	44	79	132	26	29	0	0	0	0	18	38	124	492
GAP Region Average	62	70	70	54	38	6	0	0	1	22	56	68	452

Source: Demir et al., 2001b

Considering the plant growth coefficients, values of Ilbeyi, who calculated plant growth coefficients (kc) (8) by utilizing studies on plant water consumption in the Region and throughout Turkey, and figures obtained by Allen (5), have been taken into consideration (Table 5).The entire transmission canals and canalette networks of Akçakale YAS, Paşabağı and Bozova Merkez irrigations are equipped with low and high pressure pipes. The conveyance canals of the other irrigations consist of concrete lined canals and distribution networks equipped with low and high pressure pipes. Eighty percent of the Harran Plain irrigation consists of canalette system and 20% of low pipe networks. For networks with a pipe diameter of up to 400 mm, high density polyethylene (HDPE) pipes have been used; for networks of a greater diameter, glass reinforced plastic pipes (GRP) have been used. The technical peculiarities and net areas of irrigation are detailed in table 6. In order to convert gross areas into net areas, the coefficient 0.93, which resulted from the Şanlıurfa - Harran Plain Irrigation, has been utilized. The last column of the table reports the mean pressure, enabling sprinkling irrigation for each irrigation and energy consumption for 1 m^3. As a sample for gradual pumping for irrigation, the Siverek - Hilvan Pump Irrigation Scheme is shown in Figure 2. In order to provide additional pressure to be required apart from the State Hydraulic Works (DSI), necessarily energy amounts for elevating water to 35m, including head losses, have been taken into consideration.

Table 5. Calculated Plant Growth Coefficient for the GAP Region by FAO Penman methodology.

Crop	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
Cereal	0.67	0.63	1.20	1.35	0.97	0.18					0.35	0.58
Cotton				0.22	0.78	1.25	1.09	1.24	0.88	0.25		
Sugar beet			0.16	0.35	0.85	1.03	1.12	0.95	0.20			
Potato				0.22	0.38	0.69	0.96	0.20	0.35			
Melon & Watermelon				0.13	0.38	0.82	0.91	0.77	0.47			
Bean				0.14	0.50	1.05	1.15	0.33				
Vegetable				0.13	0.92	1.48	1.72	1.87	1.87	1.26	0.66	
Sunflower				0.19	0.45	0.85	1.15	0.77	0.68			
Alfalfa			0.96	1.19	1.47	1.76	1.76	2.22	2.20	1.72		
Fruit			0.30	0.70	0.92	1.05	1.05	1.05	0.95	0.40		
Pomegranate			0.30	0.70	0.92	1.05	1.05	1.05	0.95	0.40		
Olive				0.50	0.55	0.60	0.65	0.65	0.65	0.60	0.25	
Pepper				0.13	0.92	1.48	1.72	1.87	1.87			
II. Crop Soy bean							0.50	0.90	1.15	0.32		
II. Crop Sesame						0.12	0.40	0.95	1.10	0.19		
II. Crop Maize							0.68	1.90	2.26	0.45		
II. Crop Peanut						0.14	0.45	0.90	1.15	0.40		
II. Crop Vegetable									0.70	0.85	1.05	0.50

Source: İlbeyi, 2001 and Allen et al., 1998.

Table 6. The technical aspects of Irrigations.

Irrigation Name	Net Area	Irrigation methods	Main canal	System	Total Efficiency of conveyance and distribution	Demand for Pumping energy (kWh/m^3)	Additional energy for Pressurized irrigation (kWh/m^3)
Akçakale	9,537	Gravity	CCC	PLP	0.92	0.000	0.137
Atatürk Pumping	24,917	Gravity	CCC	PLP	0.92	0.225	0.137
Bozova Pumping	45,025	Pressurized	CCC	PHP	0.92	0.247	0.000
Bozova Merkez Pumping	1,004	Pressurized	PHP	PHP	0.99	0.230	0.000
Mardin-Ceylanpınar (Gravity+Pumping)	210,782	Gravity	CCC	PLP	0.92	0.183	0.137
Paşabağı	400	Gravity	PLP	PLP	0.96	0.000	0.137
Samsat Pumping	7,753	Gravity	CCC	PLP	0.93	0.230	0.137
Siverek-Hilvan Pumping	145,427	Gravity	CCC	PLP	0.92	0.222	0.137
Suruç Pumping	88,177	%60 Gravity, %40 Pressurized	CCC	%60 PLP, %40 PHP	0.92	0.235	0.070
Ş.Urfa-Harran	137,535	Gravity	CCC	%80 CCC, %20 PLP	0.89	0.000	0.137
Yaylak Pumping	17,039	Pressurized	CCC	PHP	0.92	0.195	0.000

CCC: Canal with Cement Concrete lining, PLP: Pipe with Low Pressurized (California), PHP: Pipe with High Pressurized

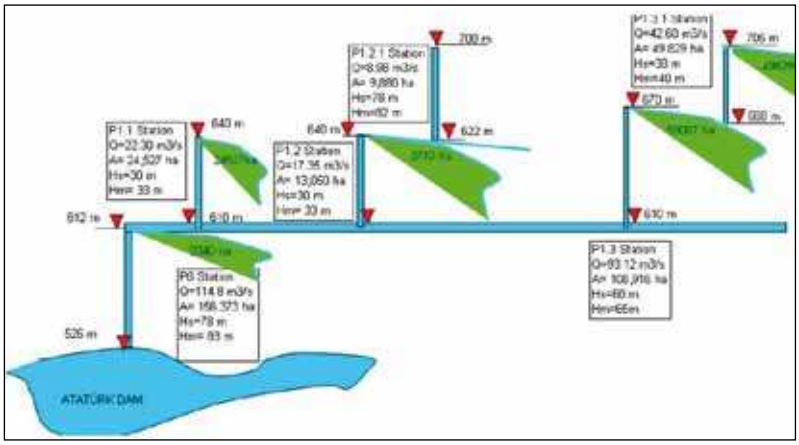

Figure 2. Siverek-Hilvan Pumping Irrigation Scheme.

Irrigation modules and annual water requirements have been calculated by the General Directorate of the State Hydraulic Works (DSI), with two alternatives, under pressure and surface irrigation conditions taking into regard water transmission, distribution and application outputs. Apart from the State Hydraulic Works, wetting rates at drip irrigations have been taken into account. In table 7, criteria used by the State Hydraulic Works and in this study have been displayed in detail.

Table 7. Criteria used by DSİ and this study.

Crop	DSI Criteria				Criteria for this study			
	Method of Irrigation	Irrigation efficiency	Wetting Ratio	Total Irrigation efficiency	Method of Irrigation	Irrigation efficiency	Wetting Ratio	Total Irrigation efficiency
Cereal	Border	0.61	1.00	0.61	Sprn.	0.70	1.00	0.70
Cotton	Furrow	0.61	1.00	0.61	Drip	0.85	0.75	1.13
Melon & Watermelon	Furrow	0.61	1.00	0.61	Drip	0.85	0.50	1.70
Bean	Furrow	0.61	1.00	0.61	Sprn.	0.70	1.00	0.70
Vegetables	Furrow	0.61	1.00	0.61	Drip	0.90	0.75	1.20
Sunflower	Furrow	0.61	1.00	0.61	Sprn.	0.70	1.00	0.70
Alfalfa	Sprin.	0.70	1.00	0.70	Sprn.	0.70	1.00	0.70
Fruit	Furrow	0.61	0.50	1.22	Drip	0.85	0.35	2.43
Maize	Furrow	0.61	1.00	0.61	Drip	0.85	0.75	1.13
Lentil &Chickpea	Border	0.61	1.00	0.61	Sprn.	0.70	1.00	0.70
Onion	Furrow	0.61	1.00	0.61	Sprn.	0.70	1.00	0.70
II. Crop Soy bean	Furrow	0.61	1.00	0.61	Sprn.	0.70	1.00	0.70
II. Crop Maize	Furrow	0.61	1.00	0.61	Drip	0.85	0.75	1.13
II Crop Maize Slag	Furrow	0.61	1.00	0.61	Drip	0.85	0.75	1.13
II. Crop Vegetable	Furrow	0.61	1.00	0.61	Drip	0.85	0.75	1.13
II. Crop Vetches	Border	0.61	1.00	0.61	Sprn.	0.70	1.00	0.70

On the River Euphrates, there are 5 dams and hydroelectric power plants. Keban and Karakaya dams are located upstream of the Atatürk Dam, Birecik and Karkamış Dams downstream (figure 3).

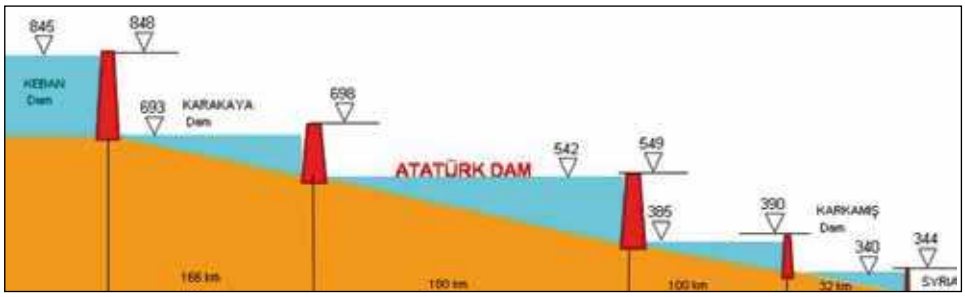

Figure 3. Dams on Euphrates River.
Source: DSI's brochure

Water savings, gained by the Atatürk Dam, will generate energy through the Atütürk and Karkamış hydroelectric power plants (HEPP). The energy generating capacity of Atatürk HEPP, with an energy generating capacity of 8.9 billion kWh annually on average, will display a decrease after irrigation. The River Euphrates Dam runoff volume is about 26.7 billion m³ (Tables 10 and 11). The energy value of water per unit is roughly calculated at about 0.332 kWh/ m³ on average considering the Atatürk Dam HEPP. The annual energy generating capacity of Birecik is about 2.52 billion kWh, that of the Karkamış Dam 0.65 billion kWh, with a runoff amount and energy value per water unit of 30.4 and 30.8 billion m³ and 0.116 and 0.021 kWh/ m³ respectively. The overall hydraulic energy value of water savings due to irrigation technologies of Atatürk Dam Irrigation facilities per water unit is 0.469 kWh/ m³.

Findings

For each irrigation, figures for farming and resource irrigation modules and annual overall irrigation water requirements have been calculated for surface and pressurized irrigation systems. As a sample, figures of the Siverek - Hilvan Pump Irrigation have been given in table 8a and b.

Table 8a. Irrigation module and irrigation water requirement in surface irrigation.

Months	Farming demand (mm/ay)	Farming Module l/s/ha	References Module l/s/ha	Monthly Irrigation water Requirement m³/ay
January	0.0	0.000	0.000	0
February	0.2	0.001	0.001	317,763
March	19.0	0.073	0.079	30,954,203
April	50.8	0.195	0.212	79,986,430
May	170.2	0.655	0.712	277,222,300
June	315.1	1.212	1.317	496,549,888
July	327.4	1.259	1.369	533,199,379
August	340.2	1.309	1.422	554,011,674
September	208.6	0.802	0.872	328,704,267
October	30.3	0.117	0.127	49,360,446
November	0.8	0.003	0.003	1,241,015
December	0.0	0.000	0.000	0
Annual Total	**1,462.7**			**2,351,547,364**
Irrigation water requirement per unit area (m³/ha)				**16,170**

Table 8b. Irrigation module and irrigation water requirement in pressurized irrigation.

Months	Farming demand	Farming Module	References Module	Monthly Irrigation water Requirement
	(mm/ay)	l/s/ha	l/s/ha	m³/ay
January	0.0	0.000	0.000	0
February	0.2	0.001	0.001	276,908
March	16.7	0.064	0.070	27,266,697
April	43.6	0.168	0.182	68,766,701
May	112.1	0.431	0.469	182,497,817
June	180.6	0.695	0.755	284,667,591
July	185.1	0.712	0.774	301,415,436
August	192.6	0.741	0.805	313,677,147
September	119.6	0.460	0.500	188,417,528
October	19.0	0.073	0.080	31,016,274
November	0.4	0.002	0.002	630,849
December	0.0	0.000	0.000	0
Annual Total	**870.0**			**1,398,632,947**
Irrigation water requirement per unit area (m³/ha)				9,617

The given tables show that, in case of surface irrigation conditions, the irrigation network capacity, expected to be 1.422 l/s/ha to meet water requirement in August, retrograded to 0.805 l/s/ha with a 43% capacity decrease when preferring pressurized irrigation system. Similarly, the annual water requirement for Siverek - Hilvan Pumping Irrigation, covering an area of 145,427 ha, is of about 2.35 billion m³ in case of surface irrigation, but regressed to 1.40 billion m³ with pressurized irrigation.

Calculations for each irrigation have been summarized in table 9.

As the table displays, water requirement for irrigations through the Atatürk Dam by utilizing surface irrigation system will be 10.1 billion m³/year; but it drops to 6.5 billion m³/year when using convenient pressurized irrigation systems. With water savings of 4.4 5 billion m³, energy of 2.07 billion kWh/year will be generated. This saving nearly accounts for the annual capacity of the Birecik Dam. When taking into consideration that 1 kWh has the value of 0.045 £/kWh (€ = 1.95 YTL) at the electricity generation point, additional electricity of 92.2 billion £/year will contribute to the economy of the country.

In spite of the fact that water savings will be achieved when converting from surface irrigation to pressurized irrigation, energy will be spent for pressurized irrigation. Since less water will be used with pressurized irrigation, less energy will be used for pumping irrigations, which elevate the water up to 60 - 70 m. By using surface irrigation, on the other side, water has to be elevated up to 35m with greater energy consumption. Table 10 reports the energy consumption values. When utilizing pressurized irrigation systems at the Atatürk Dam, additional energy of 65.5 billion kWh/year will be used; this figure of 3% is insignificant when compared with the energy value of the saved water. Furthermore, through piped irrigation networks, due to the topography no additional pressure will be needed in 30 - 35% of cases. This again shows that there will not be the need for additional energy requirement, considering the overall irrigation networks taken into consideration.

Table 9. Farming demand, irrigation module, annual irrigation water requirements and water saving according to the Surface and Pressurized irrigation systems.

Irrigation Name	Surface Irrigation (DSİ)				Pressurized Irrigation (This study)				Total Water Saving (million m^3/year)
	Farming demand (mm/month)	Irrig. Module (l/s/ha)	Annual irrig. water req. (million m^3/year)	Unit area Irrig. Water Req. (m^3/ha/year)	Farming demand (mm/mounth)	Irrig. Module (l/s/ha)	Annual irrig. water req. (million m^3/year)	Unit area Irrig. Water Req. (m^3/ha/yearl)	
Akçakale	1564	1.522	164.9	17287	961	0.852	97.6	10236	67.3
Atatürk Pumping	1102	1.095	303.4	12177	652	0.616	179.5	7204	123.9
Bozova * Pumping	1208	1.209	600.6	13340	733	0.710	364.7	8099	235.9
Bozova * Merkez Pumping	1208	1.124	13.4	12397	733	0.660	8.1	7527	5.3
Mardin-C. pınar (Gravity+ Pumping)	1553	1.520	3619.5	17172	918	0.855	2138.6	10146	1480.9
Paşabağı	1468	1.368	6.2	15547	868	0.766	3.7	9187	2.5
Samsat Pumping	1079	1.064	91.5	11797	638	0.599	54.1	6.976	37.4
Siverek Hilvan Pumping	1463	1.422	2351.5	16170	870	0.805	1398.6	9167	952.9
Suruç Pumping	1299	1.208	1266.2	14360	810	0.726	789.3	8951	476.9
Ş.Urfa Harran	1468	1.476	2306.4	16770	868	0.826	1362.9	9909	943.5
Yaylak* Pumping	1125	1.070	211.8	12432	681	0.640	128.1	7518	83.7
Total			10935.4				6525.2		4410.2
Saved water energy equivalent (billion kWh)									2,07

**Presently, irrigation is carried out by sprinkler irrigation system. Irrigation at irrigation units displays that 30 – 35% excess water is being used, because of lack of know-how of the Farmers.*

Table 10. The energy consumption of irrigation network based on the surface and pressurized irrigation methods.

Irrigation Name	Total Energy Consumption (million kWh/year		Difference (million kWh/year)
	Surface Irrigation	Pressurized Irrigation	
Akçakale	0.0	13.4	-13.4
Atatürk Pumping	68.3	65.0	3.3
Bozova Pumping	148.3	90.1	58.3
Bozova Merkez Pumping	3.1	1.9	1.2
Mardin-Ceylanpınar Gravity+Pumping)	662.4	684.4	-22.0
Paşabağı	0.0	0.5	-0.5
Samsat Pumping	21.0	19.9	1.2
Siverek-Hilvan Pumping	522.0	502.1	19.9
Suruç Pumping	297.6	240.7	56.8
Ş.Urfa-Harran	0.0	186.7	-186.7
Yaylak Pumping	41.3	25.0	16.3
Total	1,764.0	1,829.5	-65.5

Along with the contribution of pressurized irrigation to the country's economy, Table 11 displays its contributions to the Farming economy. In the GAP Region, the overall size of an agricultural holding is about 1.1 ha. When using surface irrigation, the Farmers consume additional energy, but by using pressurized irrigation, they save energy due to water savings. Holdings with additional energy consumption are Mardin - Ceylanpınar, using surface and pump irrigation and Şanlıurfa - Harran, Akçakale and Paşabağı, using only surface irrigation. Farmers, using pump irrigation, pay less for energy when converting to pressurized irrigation, compared to surface irrigation.

Table 11. Consumed energy together with its financial value at the average agricultural enterprises.

Irrigation Name	Surface Irrigation		Pressurized Irrigation		Distance (£/year)
	Consumption in energy kWh/year	Money value £/year	Consumption in energy kWh/year	Money value £/year	
Akçakale	0	0	1,543	108	-108
Atatürk Pumping	3,014	211	2,869	201	10
Bozova Pumping	3,624	254	2,200	154	100
Bozova Merkez Pumping	3,136	220	1,904	133	86
Mardin-Ceylanpınar (Gravity+Pumping)	3,457	242	3,571	250	-8
Paşabağı	0	0	1,384	97	-97
Samsat Pumping	2,985	209	2,816	197	12
Siverek-Hilvan Pumping	3,949	276	3,620	253	23
Suruç Pumping	3,712	260	3,003	210	50
Ş.Urfa-Harran	0	0	1,493	105	-105
Yaylak Pumping	2,667	187	1,613	113	74

III – Results and Proposals

1. By using pressurized irrigation systems, 40% of water saving is achieved compared to surface irrigation. The capacity of water savings amounting to 4.4 billion m³/year with regard to the River Euphrates energy system has a value of 2.07 billion kWh and 192.2 billion €.
2. The network capacity will decrease at a rate of 39 - 44%. This will result in significant savings in irrigation investments.lass
3. The overall energy requirement of the Atatürk Dam irrigations by way of surface irrigation is about 1.8 billion kWh/year, but will insignificantly increase (65 million kWh/year) when turning to pressurized irrigation. This increase constitutes 3% of the additional energy generation and is thus insignificant.
4. Farmers, using surface irrigation, are paying additional amounts for water, but by using pump irrigation costs for water will decrease.
5. Since drinking water resources are diminishing, requirements of other sectors are increasing and energy prices are escalating; piped networks and pressurized irrigation systems, which provide savings in water, shall be preferred. In this respect, in Turkey, newly constructed irrigation networks fall within an economical framework, designed as low and high-pressure piped networks. In order to ensure the widespread use of pressurized irrigation systems, funds from national resources, from the European Union and the World Bank have been utilized to enable Farmers to convert to these systems by using 50% of these funds as aids or credits with no interests.
6. In order to ensure the widespread use of pressurized irrigation systems, the benefit of these systems shall be explained and demonstrated to the Farmers.
7. By the beginning of the year 2008, it has been observed that credits without interests, allocated by the Ziraat Bankası (Agricultural Bank for Agriculture), have been utilized for pump and well irrigation throughout the province of Şanlıurfa. Despite the fact that surface irrigation comprises 80% of the irrigation system in Şanlıurfa - Harran Plain Irrigation, 17% of the credit without interest for irrigation has been utilized. Thus, coercive measures shall be taken besides measures to encourage pressurized irrigation systems for surface irrigation.

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