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Report

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Estimating irrigation water requirements in Arta plain and relevant savings in water and money by implementation of IRMA project

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Introduction

FAO-AQUASTAT (2012a) states that in Greece about 70% of the available water resources are used for irrigation purposes (82% in Epirus according to Karavokiris (2011)). According to EU Water Framework Directive (WFD) 2000/60/EC (EU, 2012), action is needed to protect waters in both qualitative and quantitative terms. Among the various measures which member states are proposed to adopt is the promotion of water-efficient technologies and water-saving irrigation techniques. In the framework of the UN Environment Program, UNEP(DEC)/MED WG.277/4 (2005) states that a challenge of water-related issues for Mediterranean countries is to integrate water demand management in agriculture and to develop added value tools to optimize efficiency in irrigation. The EU Water Initiative (2012) includes this goal to its main objectives.

Irrigation efficiency (IE) is a measure of the quantity of water which is used beneficiary by plants. IE is estimated by measurements of the irrigation system characteristics and the applied irrigation management procedures (Irrigation Work Group, 2005; Burt et al., 1997; ASAE, 1983 and 1999).

With the given infrastructure, agricultural cultivation and landscape irrigation systems efficiency could promptly increased, if efficient irrigation systems like microirrigation substituted current low efficiency systems and if systems design, installation and maintenance passed through regular auditing procedures and more reasonable water management was applied (Howell, 2002; YPAN et al., 2003). The average efficiency of a microirrigation system is estimated to be between 80-90% percent while sprinkler systems have 70% and surface irrigation 50% (Greek Ministry of Agriculture, 1989; ASAE, 1999). According to the Irrigation Association (Spears, 2004), water use efficiency can be shifted up to 50% after resolving problems revealed by an audit (water quality, irrigation system characteristics and applied irrigation scheduling).

Static or web based information systems have been developed all over the world in order to assist agrometeorologists, agronomists and irrigation engineers to carry out calculations for evapotranspiration and crop water use studies, or for setting up efficient irrigation schedules. Top examples of such systems are CropWat (FAO, 2012b), AquaCrop (FAO, 2012c) and the CIMIS (2012). In the programme area, LP, in the framework of ProBioSis project (I2101029 Interreg III Greece – Italy,) developed a pilot web tool for irrigation scheduling (Tsirogiannis and Triantos, 2009, available at: www.agriculture.gr/arta). More than 7500 advices have been provided during the last 3 years and local farmers demand an extension of the covered area.

Irrigated agriculture is facing rising challenge worldwide for access to reliable, low cost, high quality water. Irrigation stakeholders are under regulatory pressure to improve irrigation efficiency. The proposed project is targeting exactly to this as the examples from other worldwide applications of relevant systems present outstanding results. An evaluation of CIMIS (2012) showed impressive results, as it is reported reduction on water consumption for irrigation at levels of 44% for agricultural irrigation. In the cities, the amount of water for landscape irrigation represents about 50% of the overall urban water usage (Baum et al., 2003). Also in urban vegetable gardens the use of drinkable water for irrigation is a fact. In such cases, system audits and adjustment of irrigation schedules based on actual evapotranspiration data can lead to up to 40% reduction in water consumption (Dukes et al., 2005).

IRMA (Efficient Irrigation Management Tools for Agricultural Cultivations and Urban Landscapes) project outputs include irrigation survey studies, application manuals, development of a web tool based on meteorological data, satellite images and GIS mapping for irrigation management counseling, research results and creation of a networking and training platform. The outputs because of their character have the potential to be directly implemented and contribute to immediate irrigation water savings. This has also to be considered in the framework of irrigation water pricing policies that are expected to be implemented in the near future and will affect the operative cost of productive agricultural SMEs and local communities.

Project area, climatic conditions and main cultivations

Project area

The Region of Epirus is located at the North-West part of Greece and has a total area of 9.203km^2. Agricultural land corresponds to the 14% or the total area. FAO's Aquastat (2012a), estimates that the regional area equipped for irrigation is 50.910ha. Epirus has a population of 353.820 inhabitants. The regional unit of Arta (39°15′N 21°15′E) is located north of the Ambracian Gulf. Arta borders on the regional units of Preveza in the west, Ioannina to the north, Trikala in the east, Karditsa to the east and Aetolia-Acarnania to the south (Figure 1). The plain of Arta (Figure 2) is the biggest agricultural plain of the Region of Epirus and belongs to the Aracthos hydrological basin (GR14) (YPEKA, 2012).

Figure 1 Regional Unit of Arta of Region of Epirus (source: http://en.wikipedia.org/wiki/File:Nomos_Artas.png)

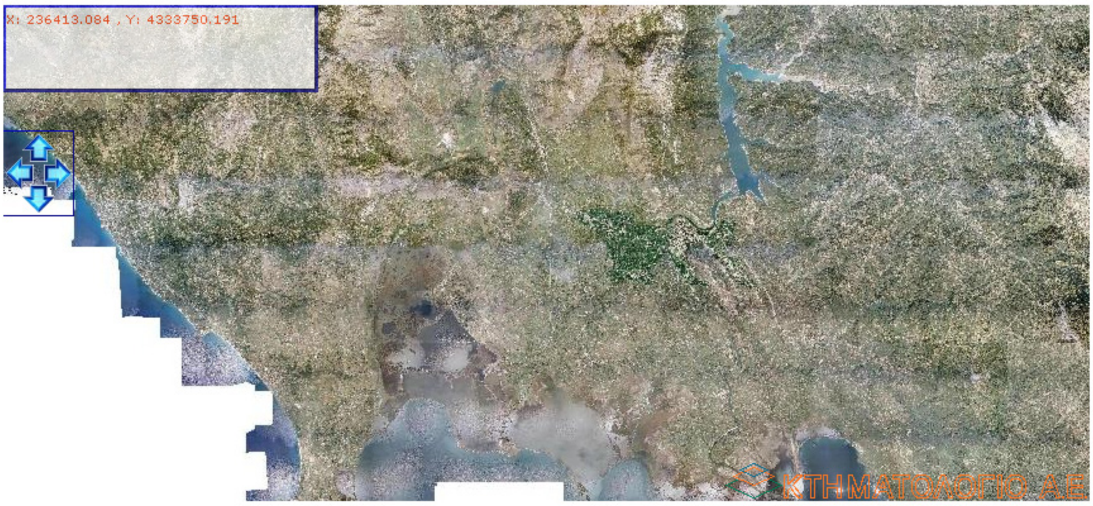

Figure 2 The plain of Arta (north oriented orthophotograpy, source: Ktimatologio S.A., http://gis.ktimanet.gr/wms/ktbasemap/default.aspx)

Climatic conditions and xerothermic period

Arta's plain climate is of Mediterranean type, with hot summers and rainy moderate winters. The relevant climatic conditions (Arta station: Longtitude 21°0'0" / Latitude 39°10'0"/ Alt 10,5m, data period: 1976-1997) are resumed in the following tables (HNMS, 2012).

Table 1 Climatic conditions of Arta (HNMS, 2012)

1° Semester	JAN	FEB	MAR	APR	MAY	JUN
Monthly Min Temperature	4.7	5.2	7.0	9.9	13.9	17.3
Monthly Average Temperature	8.7	9.4	11.9	15.2	19.9	24.0
Monthly Max Temperature	13.3	14.0	16.7	20.1	25.0	29.1
2° Semester	JUL	AUG	SEP	OCT	NOV	DEC
Monthly Min Temperature	19.5	19.9	17.1	13.4	9.4	6.0
Monthly Average Temperature	26.5	26.5	23.1	18.3	13.5	9.9
Monthly Max Temperature	31.8	32.0	29.0	24.1	19.0	14.9

1° Semester	JAN	FEB	MAR	APR	MAY	JUN
Monthly Average Humidity	71.7	70.6	68.9	68.8	66.0	61.4
2° Semester	JUL	AUG	SEP	OCT	NOV	DEC
Monthly Average Humidity	59.2	59.4	63.6	67.7	74.1	73.2

1° Semester	JAN	FEB	MAR	APR	MAY	JUN
Monthly Average Rainfall	99.9	99.9	93.8	81.5	58.5	21.8
Total days of Rain	12.1	11.1	10.6	9.6	7.4	4.2
2° Semester	JUL	AUG	SEP	OCT	NOV	DEC
Monthly Average Rainfall	12.6	17.2	43.5	99.9	99.9	99.9

Total days of Rain	2.5	2.5	4.9	8.1	11.9	13.0
1° Semester	JAN	FEB	MAR	APR	MAY	JUN
Monthly Average Wind Direction	NE	NE	NE	NE	NE	NE
Monthly Average Wind Speed	6.5	6.5	6.1	5.7	5.3	4.7
2° Semester	JUL	AUG	SEP	OCT	NOV	DEC
Monthly Average Wind Direction	NE	NE	NE	NE	NE	NE
Monthly Average Wind Speed	4.6	4.7	4.6	5.1	5.0	6.1

According to these data the Gaussen's ombrothermic diagram can be developed (Figure 3). From this it is obvious that the xerothermic period (period during which irrigation will probably needed) for the plain of Arta is stretched from middle May to middle September.

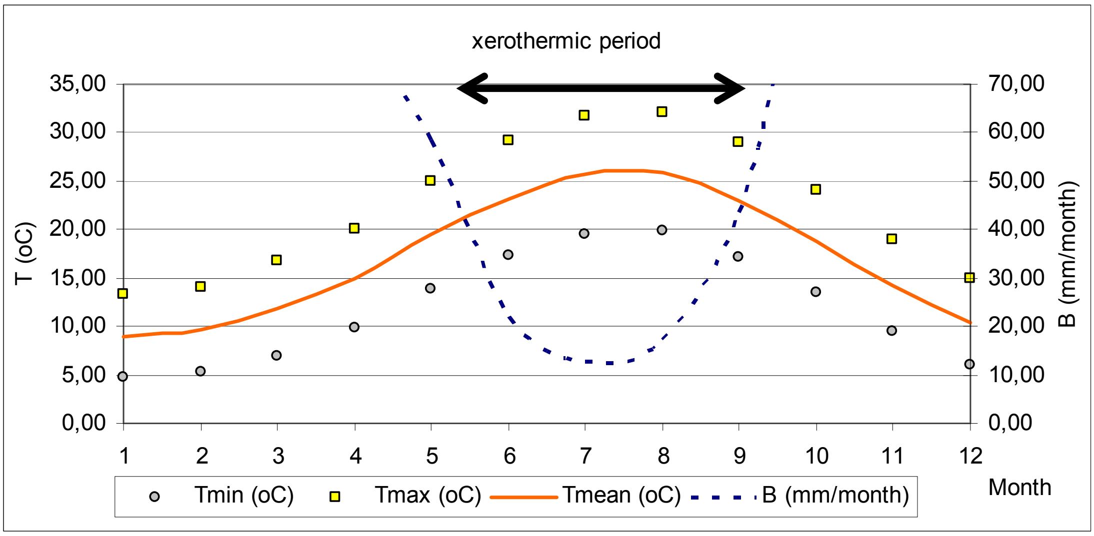

Figure 3 Gaussen's ombrothermic diagram (T in °C, R in mm month^{-1} / xerothermic period, data from HNMS (2012)/Arta st.).

Main cultivations

The cultivations of the plain of Arta and the relevant irrigated and not irrigated acreage is presented in Table 2 (Directorate of Agriculture of the Regional Sector of Arta, 2012).

Table 2 Cultivations of the plain of Arta (Directorate of Agriculture of the Regional Sector of Arta, 2012)

	Area		Yield	
	ha		(tn/ha)	
	Not irrigated	Irrigated	Not irrigated	Irrigated
Cereals				
Wheat soft	200,00		2,50	
Rye	3,00		1,67	
Barley	80,00		2,00	
Oat	300,00		2,00	
Maize	150,00	1200,00	3,33	8,33

	Area		Yield	
	ha		(tn/ha)	
	Not irrigated	Irrigated	Not irrigated	Irrigated
Total rise	**0,00**	**90,00**		
Rise Indica		30,00		6,67
Rise Japonica		60,00		6,67
Total cereals	**733,00**	**1290,00**		
Dry pulse				
Faba brean	4,50		2,67	
Lupine	10,00		2,30	
Tare	20,00		1,65	
Lentil	14,00		1,43	
Total dry pulse	**48,50**	**0,00**		
Potatoes	**0,00**	**555,00**		
Spring potatoes		350,00		9,71
Summer potatoes		200,00		15,00
Fall potatoes		5,00		8,00
Total potatoes	**0,00**	**555,00**		
i. Hay annuals	**1510,00**	**0,00**		
Cereals	470,00		2,98	
Pulse	1040,00			
ii. Hay multiyear	**0,00**	**4500,00**		
Clover		4500,00		
Total i + ii	**1510,00**	**4500,00**		
Fresh vegetables				
Cauliflower, Brocolli		15,00		11,33
Cabbage		70,00		11,00
Celery		6,40		10,00
Leek		14,00		14,29
Lettuce open field		30,50		11,48
Lettuce greenhouse		0,55		23,64
Chicory		8,80		10,00
Spinach		14,00		9,29
Artichoke		1,00		10,00
Tomatoes open field		210,00		21,90
Tomatoes greenhouse		12,50		124,80
Cucumber open field		15,00		30,00
Cucumber greenhouse		4,20		135,71
Melon		4,00		13,75
Water melon		28,00		32,14
Eggplant open field		50,00		16,00
Eggplant greenhouse		0,80		40,00
Zucchini open field		60,00		20,00
Zucchini greenhouse		0,60		50,00
Pepper open field		32,00		9,38
Pepper greenhouse		0,40		25,00
Carots		3,50		15,43
Garlic		40,00		4,88
Onion fresh		36,00		6,67
Onion dry		110,00		7,73
Radish		1,30		10,00

	Area		Yield	
	ha		(tn/ha)	
	Not irrigated	Irrigated	Not irrigated	Irrigated
Pea fresh		12,00		5,42
Beans fresh open field		210,00		8,10
Beans fresh greenhouse		1,80		20,00
Beet		3,50		14,29
Gumbo		10,00		9,00
Parsley		0,50		8,00
Total fresh vegetables	**0,00**	**1006,35**	summer	
Fruits				
Apples				
Apples	1,00	188,00	5,00	5,32
Pear	55,00	17,00	6,00	14,71
Quince	8,00	1,00	6,25	10,00
Total apples	**64,00**	**206,00**		
Stonefruits				
Peach		20,70		13,04
Apricot		20,00		10,00
Cherry		29,00		4,83
Sour cherry	1,00	5,00	4,00	1,40
Nectarine		2,00		30,00
Plum	12,00	5,00	3,33	10,00
Total stonefruits	**13,00**	**81,70**		
Fagales				
Walnut	914,00	20,00	0,98	3,00
Hazelnut	65,00	40,20	2,77	5,47
Almond	97,00		1,03	
Chestnut	665,00		2,86	
Total fagales	**1741,00**	**60,20**		
Citrus				
Grapefruit		5,80		3,45
Lemon		52,00		3,85
Orange	550,00	4173,00	20,50	40,74
Tangerine		780,00		32,05
Bitter orange		3,00		6,67
Citron		1,00		5,00
Kumquat		0,50		2,00
Total citrus	**550,00**	**5015,30**		
Various fruits				
Fig	29,00	5,50	6,90	18,18
Kiwi		890,00		28,09
Promegranate	2,00	60,00	3,00	0,83
Total various fruits	**31,00**	**955,50**		
Total fruits	**2399,00**	**6318,70**		
Grapevines				
Grapevines for wine		50,00		6,40
Table grapevines				
Total grapevines	**0,00**	**50,00**		
Olives				

	Area ha		Yield (tn/ha)	
	Not irrigated	Irrigated	Not irrigated	Irrigated
Olives for olive oil	428,00		2,34	
Table olives	3589,00	1600,00	3,06	5,00
Total olives	**4017,00**	**1600,00**		
Total area (ha)	**8707,50**	**15320,05**		
1ha = 10.000m2	main cultivations			
Total area (ha) of main cultivations	6243,00	7883,00		
	72%	51%		

Crop Water Requirements

Reference potential evapotranspiration

The reference potential evapotranspiration (ETo) was calculated according to Penman-Monteith equation as described in FAO p.56 (Greek Ministry of Agriculture, 1992; Allen et. al., 1998). The calculation was made using CropWat software (FAO, 2012b).

Crop evapotranspiration and crop water requirements

Crop evapotranspiration (ETc in mm/day) and crop water requirements (CWR in mm/year) were calculated according to Penman-Monteith equation using CropWat software (FAO, 2012b). The relevant crop coefficients were taken from the data base of CropWat. CWR in m^3/year was calculated by multiplication of CWR in mm/year by the area of each cultivation. The calculation were made only for main irrigated cultivation of Table 2 and are presented in Table 3. A total of 51.155.542,10 m^3 of water per year is needed to irrigate the main irrigated cultivations of Arta.

Table 3 Crop Water Requirements of main irrigated cultivations of Arta plain

Cultivation	Area ha		CWR mm/year	CWR m^3/year
	Not irrigated	Irrigated		Irrigated
Maize	150,00	1200,00	383,90	4.606.800,00
Summer potatoes		200,00	417,60	835.200,00
Clover		4500,00	378,50	17.032.500,00
Summer fresh vegetables	0,00	1006,35	424,60	4.272.962,10
Orange	550,00	4173,00	324,00	13.520.520,00
Tangerine		780,00	322,80	2.517.840,00
Kiwi		890,00	472,80	4.207.920,00
Table olives	3589,00	1600,00	260,80	4.172.800,00
Total CWR of main irrigated cultivations			**373,13**	**51.166.542,10**

Estimated savings

Probable water savings from efficient irrigation

Application of efficient irrigation techniques (proper system, auditing and scheduling based on real metrological data) can result in reasonable terms a 30% reduction in irrigation water use (Lopez-Gunn et al., 2012). According to Tsirogiannis and Triantos (2009) it is estimated that over irrigation in the plain of Arta reaches a level of 50%. Thus for the main irrigated cultivations (which represent only the 51% of the total irrigated agricultural land) of the plain, a total of about 100.000.000m^3 of water is expected to used per year. In this case, the estimated savings from efficient irrigation can be about 30.000.000m^3 of water per year.
This is a 30% savings, if in future the same rate could be reached for the whole region of Epirus where the estimated water consumption for irrigation is 650 Mm^3 per year (Karavokiris, 2011), the total expected savings could be up to 195 Mm^3 per year, and this is a really big number.

Additional environmental benefits

The reduction of the water volume that is used for irrigation will also have a positive effect in the salinisation of underground water. According to Karavokiris (2011), the plain of Arta has a significant salinisation problem because of over pumping water from drillings.

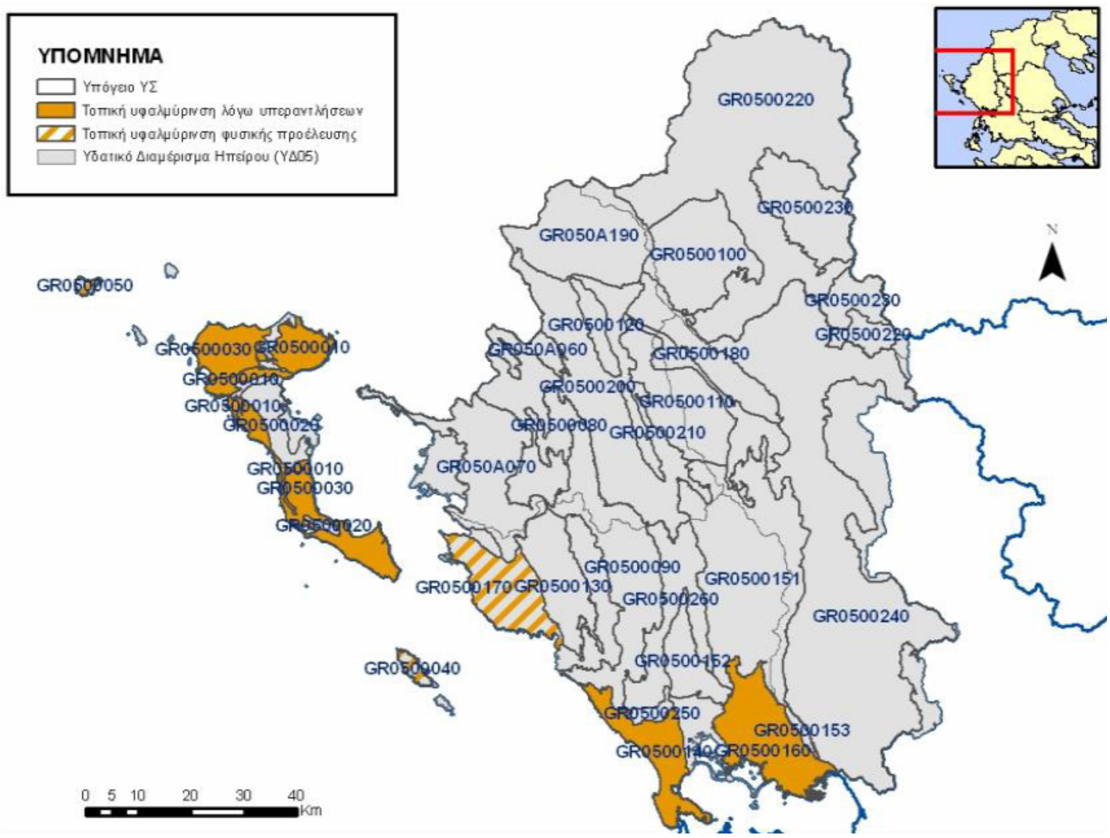

Figure 4 Salinisation problems of underground water (brown: local salinisation due to over pumping) (source: Karavokiris, 2011)

Cost of savings

Article 9.1 of EU Water Framework Directive 2000/60/EC (EU, 2012), is referred to the recovery of the cost of water services and explains the different components that have to be taken into account in the total cost of water services.

In Epirus, according to Karavokiris (2011) the lowest charge of agricultural water is limited to 0,6 eurocent per m^3 (TOEB Kallitheas) when the highest charge is 4,3 eurocents per m^3 (TOEB Vrisselas). The average cost of water for irrigation in Epirus is 0,038€/m^3 (Karavokiris, 2012).

In this framework, the very conservative estimation of irrigation water savings for the plain of Arta (30.000.000m^3 of water per year) which is expected to result from the application of IRMA corresponds to a money savings of 1.140.000€ per year.

References

Allen, R.G., Pereira, L.S., Raes D., Smith M., 1998. Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper56. Rome.

ASAE Standards, 46th Ed. 1999. EP458. Field evaluation of microirrigation systems.St. Joseph, MI.:ASAE.

ASAE. 1983. Designs and Operation of Farm Irrigation Systems. St. Joseph, MI.

Baum M. C. , Dukes M. D., Miller G. L., 2003. Residential Irrigation Uniformity and Efficiency in Florida. American Society of Agricultural and Biological Engineers. Paper number FL03-100, 2003 Special Meeting Papers.

Burt, C.M.; Clemmens, A.J.; Strelkoff, K.H. 1997. Irrigation Performance Measurements: Efficiency and Uniformity. Journal of Irrigation and Drainage Engineering, ASCE, 123(6), 423-435

CIMIS, 2012 (accessed). California Irrigation Management Information System (available at: www.cimis.water.ca.gov)

Directorate of Agriculture of the Regional Sector of Arta, 2012. The main cultivations of the plain of Arta and the relevant irrigated and not irrigated acreage – Agricultural Statistics

Dukes M.D., Miller G.L., Haley M.B., 2005. Residential Irrigation Efficiency Assessment Monitoring Final Report. Agricultural and Biological Engineering Department Institute of Food and Agricultural Sciences University of Florida.

EU Water Initiative, 2012 (accessed). EU Water Initiative Goals (available at: www.euwi.net)

EU, 2012 (accessed). The EU Water Framework Directive - integrated river basin management for Europe (available at: http://ec.europa.eu/environment/water/water-framework/index_en.html)

FAO, 2012a (accessed). AQUASTAT, FAO's global information system on water and agriculture / Main country database (available at: www.fao.org/nr/water/aquastat/main/index.stm)

FAO, 2012b (accessed). CropWat (available at: www.fao.org/nr/water/infores_databases_cropwat.html)

FAO, 2012c (accessed). AquaCrop (available at: www.fao.org/nr/water/aquacrop.html)

Greek Ministry of Agriculture, 1989. FEK 428.2.6.1989, Decision F.16/6631. Determination of minimum and maximum quantities for the sustainable use of water in irrigation. (in Greek)

Greek Ministry of Agriculture, Directorate of Land Reclamation, 1992. Decision No 120.344 regarding the update of the methodology used for the calculation of plants water requirements. (in Greek)

HNMS, 2012 (accessed). Hellenic National Meteorology Service, Climatogy / Arta (available at: http://www.hnms.gr/hnms/english/climatology/climatology_region_diagrams_html?dr_city=Arta)

Howell, T., 2002. New Ideas for Improving Irrigation Water Use Efficiency. Report in the framework of the Research Project: Irrigation Methods, Technology and Management for Increased Water Use Efficiency

Irrigation Work Group, 2005. Draft Findings, Recommendations and Proposed Actions From Work Group Two: Irrigation

Karavokiris, 2011. Review report regarding significant issues for water management at the water district of Epirus. Made for YPEKA – Plans for water basins of the rivers of the water districts of Thessaly, Epirus and Western Sterea Ellada, according to the guidelines of the Water Framework Directive 2000/60/ EU, for the application of law 3199/2003 and P.D. 51/2007 (in Greek)

Karavokiris, 2012. Economic analysis and definition of the current level of cost recovery for water services in the water district of Epirus. Project No.: 2010ΣΕ07580000. Made for YPEKA – Plans for water basins of the rivers of the water districts of Thessaly, Epirus and Western Sterea Ellada, according to the guidelines of the Water Framework Directive 2000/60/ EU, for the application of law 3199/2003 and P.D. 51/2007 (in Greek)

Lopez-Gunna E., P. Zorrilla, F. Prietod, M.R. Llamase, 2012. Lost in translation? Water efficiency in Spanish agriculture. Agricultural Water Management, 108: 83–95

Spears, T.D., 2004. A New Model for Basin Wide Water Use Efficiency. Irrigation Association U.S.A.

Tsirogiannis I., Triantos S., 2009. Survey of irrigation practice in Arta and development of web tools for irrigation management. National Conference of the Greek Society of Agricultural Engineers, Thessaloniki, 8-10/10/2009 (pp. 51-58, in Greek)

UN Environment Program, 2005. Mediterranean Strategy for Sustainable Development - A Framework for Environmental Sustainability and Shared Prosperity. UNEP(DEC)/MED WG.277/4 (available at: http://www.un.org/esa/sustdev/natlinfo/indicators/egmIndicators/MSSD_latest_eng.pdf)

YPAN, EMP, IGME, KEPE, 2003. Plan for the country's water recourses management (in Greek)

YPEKA, 2012 (accessed). Public Deliberation for the Country's Water Resources Management Plans (available at: http://wfd.opengov.gr/ in Greek)