WATER RESOURCES AVAILABILITY, A KEY FACTOR FOR THE DEVELOPMENT OF INDUSTRIAL AREAS: THE CASE-STUDY OF PATRAS (GREECE) INDUSTRIAL AREA

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ABSTRACT

The present paper discusses issues related to water problems in quality and quantity as a constraint for the increasing economic gain and sustainability of industrial parks. The Industrial Area of Patras (IAP) in Greece, which faces a lot of problems concerning water scarcity, is taken as a case study. It is well known that industry is a large water consumer. Hence, in most industrial countries water shortages are becoming increasingly severe, acting as a key parameter for the arrest of growth in industrial sector. Nowadays, the climate change which leads to water resources decrease and the increasing consumption of goods and services, speed up even more the phenomenon of water resources contamination. Therefore, the industrial park managers have the challenge of satisfying the consuming needs in water, without preventing the economic growth of industries or the installation of additional ones in the parks and without degrading water resources of future generations. IAP accommodates almost 100 companies, a fact that highlights IAP as one of the most important poles of growth and financial activity in the whole region. The new Port of Patras that will be connected with the northern Detour of Patras city, the operation of Rio-Antirrio Cable Bridge linking Peloponnisos to mainland Greece and the construction of Ionian and Olympian Motorways create optimal conditions for development of existing businesses and are significant factors for the attraction of new investments. However, water scarcity and rising water prices act as restrictive factors for installation of industries. Hence, the decision tools for smart planning of water resources are much more necessary than ever. The goal of the present paper is to demonstrate that management policies/choices of integrated planning still exist to reduce the water scarcity in quality and quantity in IAP. It is implied that the settlement of water problem in the region provides a big precedence as it will contribute actively to the economic and sustainable development of the major area.

1 INTRODUCTION

Industrial growth brings essential benefits on a nation's economy and competiveness as it is connected directly with its financial development, productivity and prosperity. At present times industrialization is growing intensely worldwide. However, the unstoppable progress of industrialization brings not only economic effects, but also environmental adverse effects that countries must weigh seriously.

During the 50-year period from 1950 to 2000, world industrial water withdrawals climbed from 200 km^3/year to almost 800 km^3/year (300% increase), while industrial water consumption has increased from 20 to about 100 km^3/year (400% increase) (Grobicki, 2007). In 2003, the average percentage was about 22% of total freshwater withdrawal with a breadth going from 10% for low-income countries to 59% for high-income countries (UNESCO-WWAP, 2003). According to AQUASTAT-FAO's information system on water and agriculture- the total globally water withdrawal by industry was 19% for the same time period (http://www.fao.org/nr/aquastat). In 2007, the annual freshwater withdrawal for industrial purposes was 20.1% (http://data.worldbank.org/). By 2025 global annual water use by industry is expected to represent 24% of all water abstractions. This percentage corresponds to a quantity of 1,170 km^3 water per year (UNESCO-WWAP, 2003).

Much of this increase will be in countries now experiencing rapid industrial development such as China, which has become one of the world's largest producer and manufacturer and much of its economic growth has been driven by its industry. Generally, in East Asia/Pacific, industry now provides 48% of the total GDP in the region, and this proportion is still increasing (Grobicki, 2007). However, China nowadays, with 21% of water demand for its industry -a percentage that has increased by 50% in less than a decade- (IWMI, 2005), has to face both water shortages and water quality issues and this water-resource poorness may be one of the costs of its growth. In USA, according to World Bank, the annual freshwater withdrawal in 2005 from industry was 46.1% of total freshwater withdrawal (http://data.worldbank.org/). In Europe, 23% of total water abstraction is used for industry, but the amount of industrial water use varies greatly between European countries (UNEP,2004). Industrial water withdrawals have actually been dropping since 1980, although industrial output continues growing. With its strong emphasis on environmental protection, this is evidence that in Europe water re-use and recycling measures are taking effect, allowing industry to grow without putting further strain on water resources (Grobicki, 2007).

Greece is a country with its economy in transition which plays a significant role in the region of south-eastern Europe. In Greece, agriculture is the biggest user of water and by far takes the largest withdrawal of water resources. Industrial uses are much less, as the utilization ratio for industrial water is 1,7% of total consumption. However this percentage is not representative due to the fact it is referred only to the extraction and cooling equipment (IOBE, 2010). The percentage sharing of each main category of water uses (urban, rural, industrial and energy) in Greece is 86% , 11%, 2% and 1% for rural, urban, industrial and energy uses, respectively (Mimikou, 2005). Despite the small percentage of industrial water use, the contribution of the industrial sector to problems with water scarcity and contamination is growing rapidly. A characteristic case is the Industrial Area of Patras (IAP) in Peloponnisos that allerts a lot of our attention. Specifically, water demand in IAP has exceeded the reliable supply of surface water and renewable groundwater, by putting pressure on local surface and ground water bodies (DNR, 2003). This overdraft depletes existing water resources in the area and cannot continue indefinitely. Due to growing competition for scarce water resources coupled with the economic crisis that knocks the industrial production, IAP will be on course for yet more economic trouble.

2 INDUSTRIAL AREAS IN GREECE

Industrial Areas (IA), in terms of organised industrial estates providing a series of facilities, began to be designed in the early 1960's in Greece. Central goals of this idea were decentralization of production activities outside urban and residential areas, improvement in business competitiveness, modernization of industrial production, reducing per-business expenses by offering transport, power and communication facilities, attracting new investments etc. The Greek legal framework concerning IA is National Law (NL) 4458/65, NL 742/77 and NL 2545/97. ETVA VIPE, a governmental institution, had the leading role to establish and operate the first IA, one of which was founded in Patras region (http://www.sevipa.gr). Since then, via several legal framework changes, ETVA VIPE lost partly its governmental character (today public possession is 35%) and its exclusive right to manage IA. Hence, now ETVA VIPE SA owns 32 of 45 existed industrial estates and entrepreneur areas throughout Greece and provides comprehensive services to companies located or planning to locate in IA. Table I describes main features of 25 industrial estates that most of them are supervised by ETVA VIPE SA (Antonopoulos et al., 2011; Moutsiadis, 2010)

Table I. Industrial Areas (IA) and Parks in Greece

No	Industrial Area	Foundation (year)	Total surface (x 1000 m^2)	Settled industries (number)	Coverage (%)
1	Sindos (Thessaloniki)	1965	9400	569	100
2	Volos I	1966	2759	131	100
3	Iraklio	1969	1723	284	100
4	Patras	1972	4104	82	57
5	Volos II	1972	1734	30	68
6	Florina	1975	1105	15	35
7	Drama	1975	2155	73	41
8	Xanthi	1975	1542	30	42
9	Ioannina	1976	2058	150	54
10	Komotini	1976	4342	142	72
11	Kavala	1977	2080	53	28
12	Preveza	1978	2012	45	45
13	Serres	1978	1239	52	47
14	Larissa	1979	2415	70	30
15	Kilkis	1979	1612	48	77
16	Lamia	1979	1625	55	55
17	Alexandroupolis	1980	1072	20	50
18	Tripoli	1981	1600	90	53
19	Sperchogeia (Kalamata)	1983	251	12	15
20	Meligalas	1983	1061	17	17
21	Edessa	1984	572	4	20
22	Petrea (Pella –Imathia)	1986	1931	-	-
23	Thisvis	1987	3987	2	45
24	Karditsa	1990	660	-	-
25	Kozani	1997	709	-	-

In IA, good transportation access, rainwater drainage systems, wastewater treatment plants, telecommunication networks, high-power electricity supplies, and other facilities, utilities and services are provided to industries. Hence, the idea of the organized areas, where a community of industries and businesses are located together on a common property, improves the economic performance of participating members. Recognising that the collective benefit is greater than the sum of each individual benefits each member could gain, industries located in IA have reduced costs and augment their competiveness. Even more, IA improve not only the economic performance of participating companies, but also assure the collaboration in managing environmental and resource. So, environmental and social impact reduction of industrial uses consists another benefit of the planned areas. Figure 2 illustrates the spatial location of IA in Greece supervised by ET.VA VI.PE. S.A.

Figure 2. Industrial Areas (IA) in Greece (Source: http://www.etvavipe.gr)

3 Case Study: the Industrial Area of Patras (IAP)

3.1 Topological and morphological characteristics

IAP, employing a surface of 415 hectares, is located about 250 km W of Athens and lies 25 km SW of Patras. Patras is the third largest city of Greece with about 200000 inhabitants, sited in the NW corner of the Peloponnisos peninsula and it is linked through the Rio-Antirrio Cable Bridge with the mainland Greece. Also, Patras has been Greece's maingate to Western Europe via its port and has collected plenty economic and productive activities. Despite the severe deindustrialization during 1980-2000, where many productive units shut down, the whole area with a long manufacturing tradition still retains its developing and metropolitan character, as an industrial, commercial and transportation centre by producing 3.4% of the Greek Gross National Product in manufacturing (http://www.proinno-europe.eu/ ; http://urbact.eu/).

Nowadays, 69% of IAP is planned to accomodate industrial and manufacturing sites, 10% hosts communal plots and 21% occupies roots, pavements, crossing pipeline spaces, greenfield and landscape. The mean altitude is 88 m apon sea level and belongs to hydrological basin of Peiros-Parapeiros. There is no any protected area next to IAP. The mountainous areas of Oros Erymanthos (GR 2320008) and Oros Panachaiko (GR2320007) are NATURA sites that are located 15 and 17 km respectively far away from IAP. The whole area around IAP occupies agricultural uses and nearby there are small settlements, such as Ag.Stefanos, Palaia Peristera and Haikali. The local community is mainly employed in agriculture and part time in manufacturing (ETVA VIPE SA, 2006).

The spatial coverage of usage is 57% (ETVA VIPE SA, 2006). Only 5 companies have adopted and apply the Integrated Pollution Prevention and Control (IPPC) Directive (CWA, 2008). The sector of manufacturing focuses mostly on the sectors of food and beverages, textile, clothing, wood-cork industry, non metal minerals, metal products and in the sector of machinery, equipment and construction (ETVA VIPE SA, 2006). The total infrastructure contains the typical industry services such as water system supply, a central waste treatment unit (even though several tenant companies have their own wastewater treatment equipments) that discharges in Patraikos Gulf. The new harbor of Patras will be connected with the northern Patras Detour where IAP has direct access creating optimal conditions for existing businesses. Even more, the operation of Rio-Antirrio Cable Bridge and the construction of Ionian and Olympian Motorways bring more advantages.

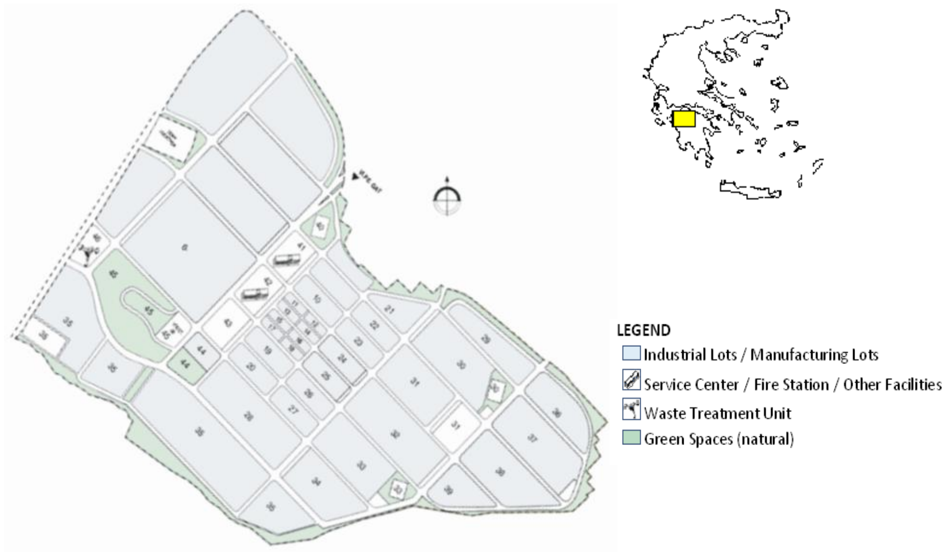

Figure 3. A plan view of Industrial Area of Patras (IAP)

3.2 Hydrologic and geological characteristics

As mentioned before, IAP is drained mainly by Peiros River and Parapeiros tributary. Table II describes main features of Peiros-Parapeiros river basin. The average annual rainfall is according to Araxos meteorological station 688 mm and the 91% of the annual rainfall occurs from October to April. The potential evapotranspiration is 930 mm and real evapotranspiration of the area is about 66% of the annual precipitation

(ETVA VIPE SA, 2006). Geologically the study area consists of alluvial deposits, eroded Pliocene-Pleistocene sediments and gavrovo flysch deposits in the southern part of the basin. Plio-Pleistocene sediments that consist of clays, sandy marls, sands and sandstones, form a deep multiple aquifer system that has low storage and transmissive properties. Recent deposits form an unconfined aquifer, which is very permeable. The groundwater extracted from this aquifer is basically filtered river water. Generally, groundwater flows from SE to NW. Based on the fact that wet period is from October to April, the natural recharge period of the aquifers that supply IAP takes place during winter and spring. Hence, the groundwater reaches a maximum level around April–May and a minimum in October–November. The draw-down of the groundwater level between May (the end of wet period) and October (the beginning of the wet period) ranges from 6 to 31 m (Voudouris, et al., 2006).

Table II. Peiros river basin-General information (Source: CWA, 2008 ; I.G.M.E., 2001).

Catchment area	600 km^2
River length	33 km
Mean catchment elevation	463 m
Mean annual precipitation	986 mm
Flow	All the year
Average Discharge (outlet of the basin)	265 hm^3 / year
Maximum flow	0.5 hm^3 /day

3.3 Water supply and water use

The economic development of the IAP is influenced by the availability of water resources. Water supply of IAP is ensured by a central pumping station that is located inside the industrial area. The percentage share of each source varies during the year but the majority of water comes from the deep confined aquifer. Water withdrawal is succeeded by using drilled wells; some of them are located inside IAP and others outside of it, especially in sites nearby Peiros River. During winter, 60% of total water withdrawal comes from drilled wells of Peiros area, while during summer period due to decline of 30% the deficit is covered by drilled wells that are located inside IAP.

Today, there are almost 35 drilled wells (15 are now operative) which range from 15-160 m deep that pump 30-200 m^3/h water. There are also 5 recharge wells in order to enhance the ground-water reservoir during winter period, from November to April, when excess water is available and limit the draw-down when pumping is increased. The programme of artificial recharging started in 2001 aiming to increase the groundwater reserves in the IAP and to prevent the intense rise of the groundwater level (ETVA VIPE SA, 2006) that happened during 1980-90 due to over-pumping combined with prolonged dry periods. Also, a new dam is under construction in the nearby area (Peiros Perapeiros Dam) that will supply electricity and water to Patras city and to IAP. Although the future completion of dam constructive works, problems concerning water scarcity expected to exist due to urbanization. It should be mentioned that there are many private boreholes and wells outside the IAP which are used for irrigation purposes and contribute to significant decline in the piezometric level of the aquifer in the wider study area. Figure 4 demonstrates water consumption in IAP during 1982-1998.

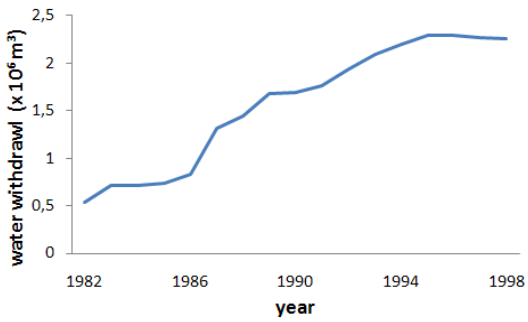

Figure 4. Water withdrawal in IAP (Source: ETVA VIPE SA, 2006)

During the last three years the water demand in IAP exceeds the 2.5 hm^3 and it is estimated to outreach the quantity of 3 hm^3 in the following years. As perceived, maximum consumption happens during summer period. On July water demand is 0,3 hm^3 and the bigger user is the brewing industry which during the specific time period consumes 50% of total water withdrawal. Unfortunately, existing system of collecting water data is restricted to basic information, such as company contact information, annual water use quantity and basic characteristics of effluents.

Table III describes basic characteristic of operative wells IAP's ownership.

Table III. Characteristics of IAP drilled wells for industrial use

Well	Type	Location	Year of construction	Drilling depth (m)	Flow rate (m^3/h)
Y3	PW	I	1980	103	60
Y6	PW	I	1980	101.5	110
Y9	PW	I	1989	135	130
Y10	PW	I	1989	170	180
Y11	PW	I	1992	180	120
Y12	PW	I	1992	216	-
Y13	PW	I	-	-	-
W500	PW	I	1994	550	100
Y14	PW	I	2008	160	150
Γ6A	PW	O	2008	60	140
Γ7	PW	O	1979	22	70
Γ10A	PW	O	2008	60	100
Γ11	PW	O	1979	23	145
Π1	PW	O	1984	16.5	160
Π2	PW	O	1984	16.5	200
EY1	RW	I			
EY2	RW	I			
EY3	RW	I			
EY4	RW	O	2008	130	
EY5	RW	O	2008	140	

PW = pumbing well ; RW= recharge well ; I= inside IAP terrain ; O= outside IAP terrain

4 SWOT ANALYSIS AND RECOMMENDATIONS

SWOT analysis (SWOT is an abbreviation for Strengths, Weaknesses, Opportunities and Threats), a method inspired by marketing management and decision support, is a useful tool for the environmental planning and decision making by providing the basic frame of analysis. The advantage of simplicity of the method contradicts with the disadvantage of being highly subjective. Even though, SWOT analysis remains a satisfying user-friendly application for preliminary assessment.

In the present paper, SWOT analysis was performed for an effective identification of the characteristics of IAP concerning water issues (only the environmental aspect). Weight factors are incorporated in order to overcome SWOT subjectiveness. A brief presentation appears in Tables V and VI , while the results are illustrated in Figure 5.

Table V. SWOT analysis in terms of water issues (internal factors).

Strength Rating					
Question	Response	D	N	A	Rating
IAP has settled water supply infrastructure	A	0	0	1	3
IAP has settled waste infrastructure	A	0	0	1	3
IAP has firms that recycle water	N	0	1	0	2
IAP has systems that recharging aquifers	A	0	0	1	3
IAP has a compulsory scientific team	A	0	0	1	3
IAP has well-conceived functional monitoring	N	0	1	0	2
IAP has access to economies of scale	A	0	0	1	3
IAP is insulated from competitive water pressures	D	1	0	0	1
IAP has many green industries	D	1	0	0	1
IAP offers motives for less water consumptive industries	D	1	0	0	1
IAP has strong water management	D	1	0	0	1
IAP has a cost/price advantage	A	0	0	1	3
Total Strength rating		**4**	**2**	**6**	**26**

Weakness Rating					
Question	Response	D	N	A	Rating
IAP has no clear strategy about water management	N	0	1	0	2
IAP has a poor track record in implementing strategy	N	0	1	0	2
IAP has high-water consumption industries	A	0	0	1	3
IAP facilities (such as pipelines) are obsolete (i.e. leakages)	N	0	1	0	2
IAP can exploit other reservoir resource	N	0	1	0	2
IAP has fragmented water management practice	A	0	0	1	3
Managing authority of IAPis missing key	D	1	0	0	1
IAP is not an eco-industrial park	A	0	0	1	3
Businesses in IAP are reluctant to change their product line	A	0	0	1	3
IAP is unable to finance needed strategy changes	A	0	0	1	3
Water needs divert from inteagrated water management	N	0	1	0	2
Given its location, IAP is far away to have access to seawater	A	0	0	1	3
Total Weakness rating		**1**	**5**	**6**	**29**

A= Agree ; N=Neither Agree or Disagree ; D= Disagree

Table VI. SWOT analysis in terms of water issues (external facrors).

Opportunity Rating					
Question	Response	D	N	A	Rating
Completion and operation of the Peiros-Parapeiros Dam	A	0	0	1	3
There is green industrial policy in Greece	A	0	0	1	3
There are offered potentials on reducing water-consumption	N	0	1	0	2
There are offered potentials on reducing pollution loads	N	0	1	0	2
Existence of scientific networks in Greek Univercities	A	0	0	1	3
Existence of EU/Greek funds	N	0	1	0	2
Water-saving tecnology grows faster than in the past	A	0	0	1	3
There is progress on clean production technology	A	0	0	1	3
Cooperation among enterprises concerning water resources	N	0	1	0	2
Updated regulatory requirements for industrial water use	N	0	1	0	2
Total Weakness rating		**0**	**5**	**5**	**25**

Threat Rating					
Question	Response	D	N	A	Rating
Urbanization augments drinking water requirements	A	0	0	1	3
Water consumption in agriculture acts as a competitor	A	0	0	1	3
Drilling new wells without official approval	A	0	0	1	3
Economic crisis disheartens industries to innovate facilities	N	0	1	0	2
Regulatory requirements are becoming onerous	A	0	0	1	3
Bureacratic procedures	A	0	0	1	3
Climate change favors prolonged dry period	N	0	1	0	2
Delay of River Basin Management Plans publication	N	0	1	0	2
Total Threat rating		**0**	**3**	**5**	**21**

A= Agree ; N=Neither Agree or Disagree ; D= Disagree

Hence, vulnerable and strong elements of IAP concerning water issues can be detected and SWOT analysis can give an overall assessment used by industrial park managers for improving their policies in the framework of an adaptive management. Specifically, IAP has many weaknesses concerning the water resources. However, SWOT analysis highlights that the opportunity rating is quite promising.

Water use in industry is a double-edged sword. On one hand, water quantity problems arise as industrial water use puts immense pressure on local water resources. On the other, water quality problems become more intensively as industrial wastewater deteriorates the quality of water resources.

Training and education in water demand-side management, combined with water-saving technological application and cleaner industrial production can provide both environmental benefits and improved economic performance of enterprises. Hence, industrial park managers should include, among others activities, constant companies' training on management on water saving and water monitoring support through a computerized system. Further action is required at developing appropriate indicators of water consumption and quality and support the continuing collection of reliable data. Assistance is needed to build these indicators into regional and local water management and to integrate this with industrial, economic and investment planning (UNESCO-WWAP, 2003). An assessment of the economic significance of the major water uses should also be held.

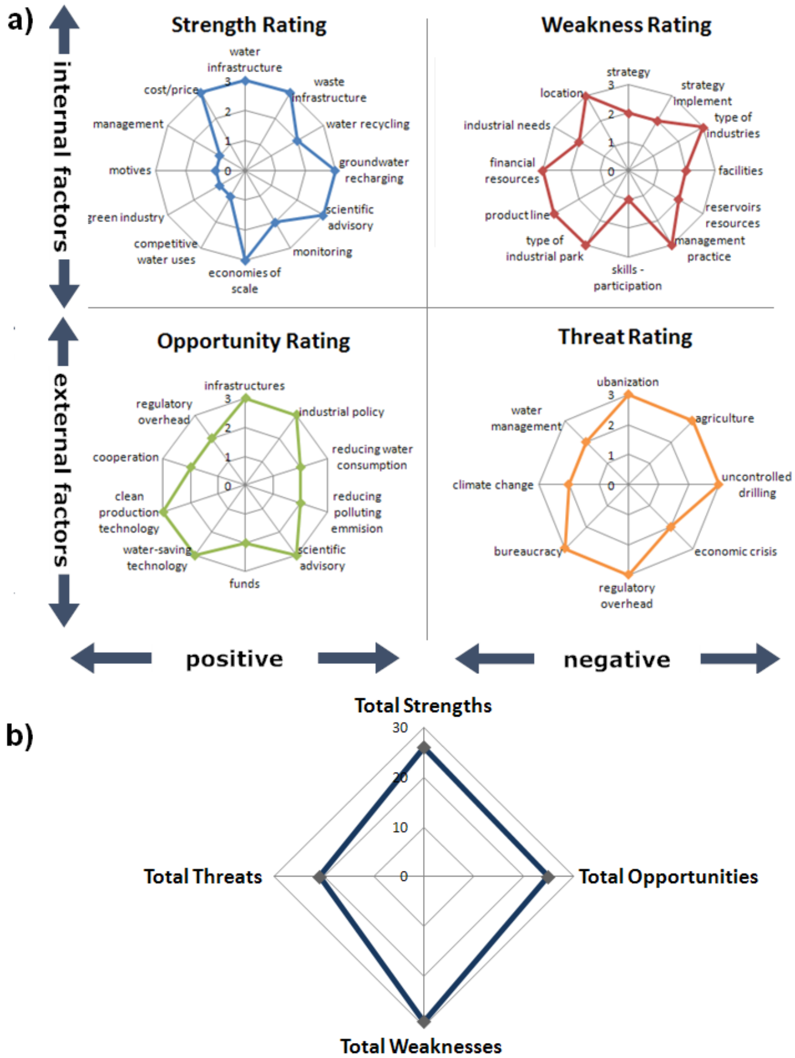

Figure 5. a) SWOT matrix – b) SWOT analysis

The integration of improved supply-side considerations with enhanced demand-side management at government and enterprise levels is important. The promotion of demand-side initiatives at enterprise level is needed to provide positive incentives for industry (UNESCO-WWAP, 2003). Given increasing concern over the scarcity of waster resources, strategy meetings and continuous/regular coordination among the industrial park managers and water state authorities of the region should also be promoted in order conservation proposal to be discussed. During critical periods with water shortages, a ranking of priority in water-use should be followed. Another proposal could be direct water reuse among user-industries. Treated wastewater should be viewed as a resource rather than as a waste to be discarded.

Industrial park managers should also recognize companies efforts to save water by giving awarding certificates and by publicizing in the local newspaper their water-friendly operation. On the other hand, the industrial park manager should give fine and extra fees to industries that not follow a water-saving policy. Another policy is the preference of installation of more restricted water-using industries. When the price of water reflects water resource availability, supply and treatment, then industries have economic incentive to use water rationally, to turn towards water efficient technologies and to generate revenues by their wastewater (Yong and Jun, 2006).

The creation of a framework/network/committee among park managers, industry representatives, tenant representatives, university representatives and government officials may also facilitate the coordination of different claims in water uses (conflict solving) and may enforce the implementation of water policies in the area. Integrated and fair approaches on all stakeholders' wishes and benefits lead to optimal decisions and encourage community involvement in water resource management. A local network on water issues could be a space where industries could exchange their experiences in water issues and collaborate and/or compete in water saving efforts.

Provided that there is a reliable monitoring system that measures water availability in the aquifer of the study area, industrial park managers should run optimization software where the objective function should not refer only to maximizing of industrial profits but also to conserving existing water resources and eliminating pollution and health risks. A comparison study among the emerging results could lead to cost-optimal solutions for implementing strategic management of water resources. Feedback processes are also required as technology, economy and regulations affect the dynamics of development goals and resources management.

5 CONCLUSIONS

Industry requires adequate resources of good quality water as a key raw material. Hence, water resources are becoming important strategies for industrial parks. There is the expression "No water, no business". The continuity and future success of any business are impacted by the availability, cost, and quality of water. Even though water lies high on the business agenda, integrated industrial water management systems at industrial park level have not yet been implemented adequately. Decisions associated to old cost – benefit analysis and top – down approaches are being replaced by multiple objective models, where multiparticipation (government agencies, NGOs, stakeholders etc.) in decision-making process predominates (Yong and Jun, 2006). Weak Greek economy leads to new circumstances that industrial sector, an essential engine of economic growth, has to deal with. In the water stressed IAP, businesses need more and more quantity of water and new industrial investments hesitate to locate in the planned area due to uncertainty in water supplies. That's why industrial park managers, through an holistic analysis should consider the impacts of their options, the broader implication of their decision and should modify the water system supply in order to achieve the optimal economic, environmental and social solution. IAP has the most critical problem in water scarcity among other Greek industrial parks and the application of integrated industrial water management systems may be significant key factors for having a healthy baseline start for eco-industrial and financial growth of the region.

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