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A Perpetually Interrupted Interbasin Water Transfer as a Modern Greek Drama: Assessing the Acheloos to Pinios Interbasin Water Transfer in the Context of Integrated Water Resources Management

Case Study

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ABSTRACT

Interbasin water transfer is a primary instrument of water resources management directly related with the integrated development of the economy, society and environment. Here we assess the project of the interbasin water transfer from the river Acheloos to the river Pinios basin which has intrigued the Greek society, the politicians and scientists for decades. The set of criteria we apply originate from a previous study reviewing four interbasin water transfers and assessing whether an interbasin water transfer is compatible with the concept of integrated water resources management. In this respect, we assess which of the principles of the integrated water resources management the Acheloos to Pinios interbasin water transfer project does or does not satisfy. While the project meets the criteria of real surplus and deficit, of sustainability and of sound science, i.e., the criteria mostly related to the engineering part, it fails to meet the criteria of good governance and balancing of existing rights with needs, i.e., the criteria associated with social aspects of the project. The non-fulfilment of the latter criteria is the consequence of chronic diseases of the Greek society, which become obvious in the case study.

Keywords
Acheloos, Greece, interbasin water transfer, integrated water resources management, socioeconomic

1. Introduction

The study of interbasin water transfer (IWT) is necessarily interdisciplinary. Aspects of the related problems should be examined, using knowledge from scientific and engineering fields (geomorphology, hydraulic engineering, hydrological science and engineering, water quality, water resources planning etc.) as well as humanities – social sciences fields (administration, ecology and environmental protection, economics, law, politics etc.) [*Gupta and van der Zaag, 2008; Yevjevich,* 2001]. The IWTs contribute 14% of global water withdrawals and 17% of water withdrawals in Europe (e.g. Gupta and van der Zaag [2008]). Notably, the water supply of several cities comes from water basins that are located hundreds of kilometers away (e.g. Los Angeles, Athens). The scientific literature includes several cases of IWT assessments, whether the projects are materialized or pending, as well as water management plans that include IWTs in several parts of the world, such as China [*Ma et al.,* 2005], India [*Misra et al.*, 2007], South Africa [*Speed et al.,* 2013], Southeast Asia [*Lebel et al.,* 2005], Spain [*Albiac et al.*, 2003; *Saurı and del Moral,* 2001; *Videira et al.*, 2006], Turkey [*Karakaya et al.*, 2014] and the US [*Bretsen and Hill,* 2009; *Feldman,* 2001; *Palmer and Characklis,* 2009; *Ward,* 2007].

The IWTs induce major conflicts and disputes, mainly due to the potential environmental damage and the water loss of the donor basin. The problem becomes even more complicated when the number of goals served by the transfer increases [*Yevjevich,* 2001]. The assessment of IWT projects is accomplished using various methods. However, the analysis of legal instruments has shown that they do not contain specific rules which regulate IWTs [*Karageorgou,* 2011]. Some studies attempted to form a sufficient framework for IWT project assessment, in view of the absence of concrete legal rules. Karageorgou [2011] attempted to form such a framework in the context of sustainable water use. Gupta and van der Zaag [2008] proposed five criteria for evaluating such projects. The use of these criteria can help in deducing whether the water transfer is compatible with the concept of integrated water resources management. Game theory has also been used to find the optimal solution for such problems [*Mahjouri and Ardestani*, 2010; *Wei*, 2008; *Wei and Yang,* 2014].

There exist two views in the water resources management globally. The traditional view aims to serve the total water needs, which are constantly growing, while the second and most recent one emphasizes the use of alternative, non-structural, measures. A representative of the alternative view is Gleick (2000) who proposed the so-called "soft path" suggesting smaller scale projects, such as smaller dams and local management. He notes that it is better to meet the constantly increasing needs, to adapt our habits to what can be met from available resources and to maintain the ecological cycles than to look for water. Tarjuelo et al. (2010) conclude that large-scale projects, such as IWT projects are only justified if all the alternative smaller scale projects have been exhausted and the IWT serves vital needs.

On the other hand, Koutsoyiannis (2011) strongly criticized the "soft path" concept. He concludes that more dams are needed globally to meet the growing needs in water, food and energy, more water transfer projects are needed to meet the water needs of large cities and irrigation, and large-scale projects outweigh the small-scale ones because they are the only effective for energy production, they are multipurpose and, under a holistic view, they may be less damaging to the environment. In particular, according to Koutsoyiannis (2011, 2013) water shortage has mainly economic reasons and indicates a lack of technological infrastructure for water. Areas with high population growth suffer most from lack of water and areas with water shortages have a low level of public health. He also raises several questions, such as whether can water be used by people without being transferred, or what is the essential difference between the IWT and the water transfer within the basin. It is apparent that the issue of the IWT is part of the dispute on the need for smaller scale projects.

Here we investigate the case of the IWT from the Acheloos basin to the adjacent basin Pinios, a highly debated project in Greece. There is an ongoing discussion since 1983 on the usefulness of the transfer, while part of the required infrastructure has been constructed but not put in operation. In our investigation we particularly assess the satisfaction of the set of the five criteria proposed by Gupta and van der Zaag (2008) as a necessary and sufficient condition for the IWT feasibility. The novelty of our study is that we use an existing integrated framework to assess the project, while previous studies just enumerated advantages and disadvantages of this particular IWT.

2.0 Study area and methods

2.1 Description of the study area

The river basin district (RBD) of Thessaly, where the Pinios river lies (Figure 1), is hydrologically poor, while

Figure 1. Major hydrological basins of Greece with marking of the Acheloos and Pinios basins.

the RBD of Western Sterea Hellas, which includes the Acheloos river basin, is hydrologically rich. The RBD of Thessaly is an important region for the Greek agricultural sector, but an increase in the agricultural production resulted in shortage of water resources and environmental degradation [Koutsoyiannis et al., 2002]. The RBD of Western Sterea Hellas has been crucial for hydropower as Acheloos produces the 35% of hydro energy in Greece [Efstratiadis et al., 2012], while the needs for urban water supply and irrigation are very small in comparison to water availability [Koutsoyiannis et al., 2008]. To solve the problem of the RBD of Thessaly, the water transfer from Acheloos to the Pinios basin has been proposed. This project is known as the Acheloos diversion scheme, and achieves the co-management of water of both basins.

The idea for the implementation of water management projects at the Acheloos basin goes back to ancient Greece. As mentioned for example in Koutsoyiannis et al. (2007), the myth of Hercules fighting with Acheloos, deified as son of Poseidon, symbolizes the battle against the destructive force of water. The idea for the IWT is also old but, despite the partial completion of several subprojects, the overall project still remains incomplete. The discussion on the project recurred in 1972 [*Hadjibiros*, 2003].

The engineering part of the project was designed in 1983 for the first time. It was included in a European Union financing programme within an investment scheme mainly for irrigation and secondarily for hydroelectric energy production [*Hadjibiros,* 2003]. Over the last 20 years, a dispute continues with harsh legal battles between the state and non-governmental organizations that wish for the project annulment [*Valavanidis and Vlachogianni,* 2011; *Valavanidis and Vlachogianni,* 2012]. We note here that another IWT project for the same basins already exists since 1960 with the Plastiras lake (reservoir) fed by Tavropos river, tributary of Acheloos, whose water is diverted to Thessaly. More than 100 hm^3 per year of the Acheloos water is transferred to Thessaly for hydroelectric energy production, water supply of the city of Karditsa and irrigation of the Thessaly plain [*Efstratiadis and Hadjibiros,* 2011]. The beauty of the landscape with the

Plastiras reservoir attracted tourists since 1990s, which led to development of the area and was accompanied by change in the reservoir management to include the goal of the landscape beauty [*Christofides et al.*, 2005].

2.2 Acheloos and Pinios basins as a geographical and planning unit

The idea of a basin as a planning unit dates back to the 18th century [*Molle,* 2009]. In the case of IWTs the basin planning unit is required to be expanded. Usually, the boundaries of a basin do not coincide with administrative or political boundaries. Simultaneously, there may exist conflicting socioeconomic forces within the planning unit [*Molle,* 2009]. Often, water resource planning is made at the scale of the basin. However, the water transfer requires a common planning for the two (or more) associated basins. Thus, in IWT projects, the concept of spatial planning of the water resources is of great importance, while the administrative division of the two areas is also significant [*Yevjevich,* 2001].

The boundaries of Western Sterea Hellas and Thessaly RBDs do not coincide with the boundaries of the corresponding administrative regions, including the prefectures within them, as shown in Table 1. They also do not coincide with the Acheloos and Pinios basins. However, the available data, depending on their type, are spatially classified either in prefectures or in administrative regions. This will not constitute a problem for our analysis, because the large-scale project mainly affects the Etoloakarnania prefecture, which belongs almost entirely to the RBD of the Western Sterea Hellas and occupies the largest area and approximately 70% of its population (Table 1). The project also affects the prefectures of Larissa, Magnesia, Trikala and Karditsa which constitute almost entirely the Thessaly RBD (Table 1) and of which the largest part belongs to the aforementioned RBD. Here the spatial planning unit is defined by the Acheloos and Pinios basins (Figure 1). The Acheloos basin contains the Etoloakarnania prefecture, in which the bulk of economic activities of the Western Sterea Hellas RBD is concentrated. The Pinios basin includes the prefec-

Prefecture	Prefecture area in the RBD (km^2)	Percentage of prefecture area in the RBD (%)	Population of the prefecture in the RBD (2001)
Evrytania	1 869	100	32 053
Etoloakarnania	5 362	98	222 858
Lefkada	356	100	22 506
Phocis	1 219	58	18 251
Karditsa	472	19	7 513
Trikala	676	20	4 832
Arta	241	15	3 750
Phthiotis	4	0	0
Total Western Sterea Hellas	10 199		312 516
Larissa	5 283	98	279 305
Magnesia	2 242	85	190 642
Trikala	2 667	79	133 215
Karditsa	2 163	82	121 380
Pieria	113	7	4 934
Grevena	167	7	5 237
Phthiotis	742	17	15 732
Total Thessaly	13 377		750 445

Table 1. Size and population of prefectures in the Western Sterea Hellas and Thessaly RBD. Source: Koutsoyiannis et al. [2008, pp. 237, 375].

River basin district	Western Sterea Hellas	Thessaly
Primary sector GDP (%)	34.8	33.5
Secondary sector GDP (%)	18.8	26.1
Tertiary sector GDP (%)	46.4	40.3
Water demand for irrigation (hm^3/year)	366.5	1 550
Water demand for animal husbandry (hm^3/year)	9	13
Drinking water demand (hm^3/year)	22.4	69
Total water demand (hm^3/year)	397.9	1 632
Irrigated area from public irrigation projects (ha)	53 575	76 950
Irrigated area from private works and water boreholes (ha)	2 066	159 142
Irrigated area (ha)	55 641	236 092

Table 2. Economic and water resources related variables of Western Sterea Hellas and Thessaly RBDs. Source: Koundouri et al. [2008, Appendix 1], Koutsoyiannis et al. [2008, pp. 267, 268, 412] after adaptation.

tures of Larissa, Magnesia, Trikala and Karditsa and small parts of other prefectures. The economic activities of the Larissa, Magnesia, Trikala and Karditsa prefectures are highly positively correlated with the economic activities in the Pinios basin. Consequently, the conclusions which are referred to the RBDs or their prefectures could be transported to the corresponding basins, without losing much in the precision level.

Table 2 presents economic and water resources related variables concerning both RBDs. Regarding the economy, it seems that the primary sector is approximately equal in both RDBs, however the secondary sector of Thessaly RDB is significantly superior, as a percentage of the total economy compared to the secondary sector of Western Sterea Hellas RDB. The tertiary sector of Western Sterea Hellas RDB is significantly superior, as a percentage of the total economy compared to the tertiary sector of Thessaly RDB. In terms of water demand, the Thessaly RDB requires four times more water for irrigation. This is due to the fact that the irrigated areas of Thessaly RDB are four times bigger than those of the Western Sterea Hellas RDB. Here we highlight the fact that the types of crops in both RDBs seem to require the same amount of water per unit area and thus there is no differentiation in favor of the Thessaly RDB.

Table 4 presents economic data for the whole of Greece noticing that these data are not directly comparable to those presented in Table 2. Comparing economic data of Greece to those of other countries of the world, we observe that for states of similar economic power per citizen, Greece has a relatively larger proportion of GDP derived from agriculture as depicted

Prefecture	GDP per capita in 2006 (€)
Etoloakarnania	13 100
Karditsa	11 900
Larissa	16 500
Magnesia	19 600
Trikala	13 400
Greece	22 200

Table 3. GDP per capita as at the year 2006. Source: Rodríguez-Pose et al. [2012].

Country	Agricultural sector (% of GDP)	Industrial sector (% of GDP)	Services sector (% of GDP)	GDP per capita ($/capita)
Greece	3.80	13.79	82.41	21 965

Table 4. Economic data as at the year 2013. Source: The World Bank after adaptation (http://data.worldbank.org/).

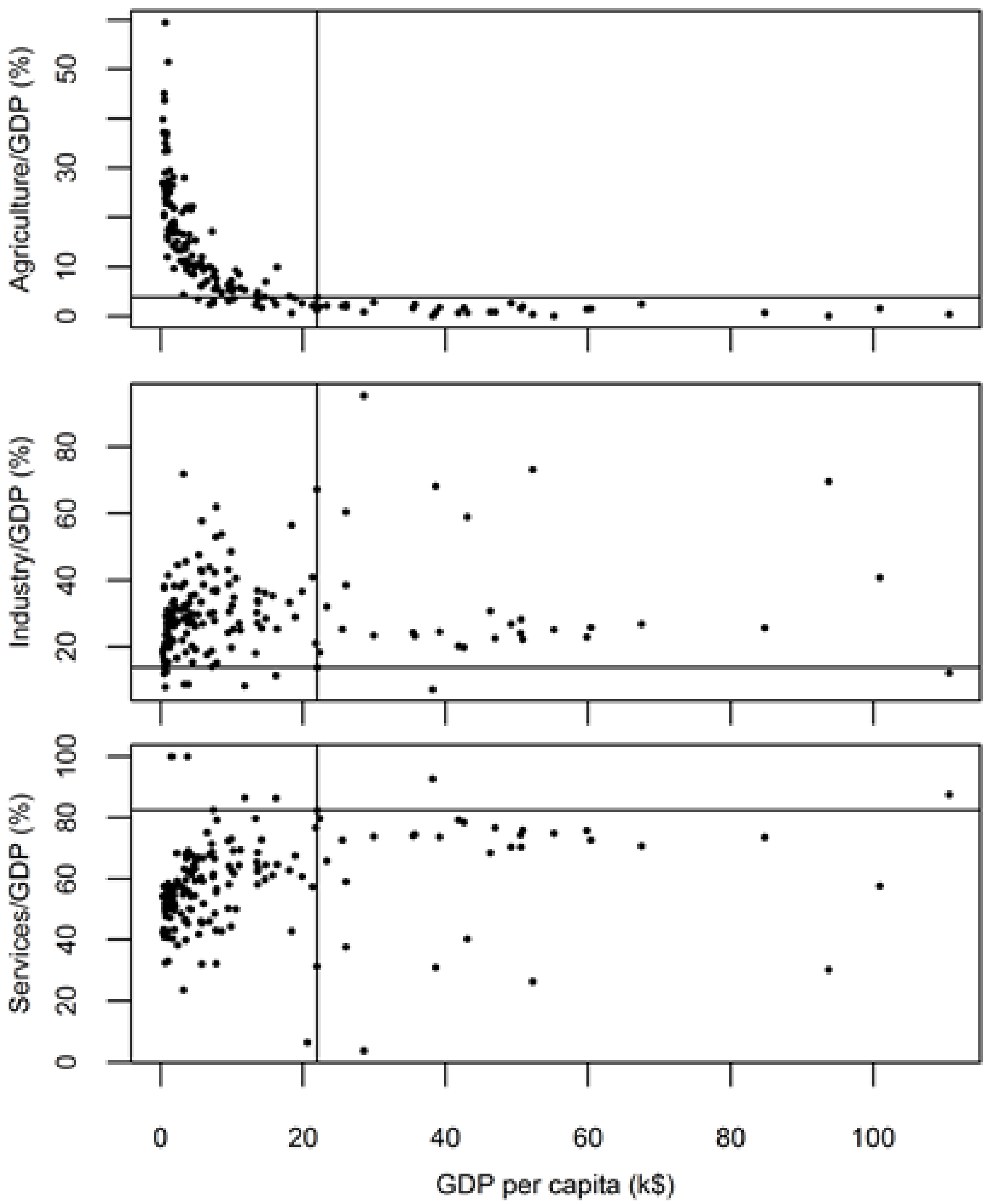

Figure 2. Percentage of GDP derived from agriculture (top), industry (middle) and services (bottom) in relation to GDP per capita as at the year 2013. All countries of the world are represented. Greece is located at the intersection of the horizontal with the vertical line. Data source: The World Bank (http://data.worldbank.org/).

in Figure 2, even though no large differentiation appears. Furthermore, with the downward trend of the Greek GDP of recent years, this ratio will move to the mean ratio of states with similar economic conditions. However, as seen in Figure 2, the proportion of GDP derived from industry is much lower compared to that of states of similar economic abilities, while the percentage of GDP derived from services is much higher. This is maybe an indication that the Greek economy is not sustainable.

At this point, we note that as Monastiriotis and Psycharis [2014] conclude that the allocation of public resources in Greece in recent decades was not optimal, and the reduction of economic resources which now depend increasingly on external funding (with its own terms and conditions) makes it necessary to change the public investment strategy. In our view, this is one reason why we observe this distribution pattern of GDP between sectors. Additionally, the reduction of economic resources makes it necessary to more carefully allocate the existing capital, thus the thorough examination of such large projects is of critical importance.

2.3 Required infrastructure for the interbasin water transfer

Figure 3 shows the reservoirs in the Acheloos basin. Overall for the operation of the project four reservoirs are required of which at present only the reservoir of Mesochora has been fully built, with the Sykia dam being incomplete. Two of the reservoirs are located in the Acheloos basin, while the other two are located in the Pinios basin. Table 5 shows the reservoirs of the project, their condition and storage capacity, and their potential to produce hydroelectricity.

2.4 Integrated water resources management

Gupta and van der Zaag [2008] define the IWT as the transfer of water from one geographically distinct river catchment, or basin to another, or from one river reach to another. They note that the "donor" and "recipient" basins or rivers are distinguished. They attempt to investigate how the IWT is associated with the concept of integrated water resources management, according to which there must exist a balance between the environmental, social and economic dimensions in the decision-making. After studying four large-scale IWT projects in various locations of the world, they propose five criteria that must be satisfied so that an IWT be compatible with the concept of integrated water resources management. These criteria are as follows:

"- *Real surplus and deficit: there is a real surplus in the donor basin and a real deficit in the recipient basin.*
- *Sustainability: the transfer scheme is sustainable in terms of economic, social and environmental aspects.*
- *Good governance: the scheme is developed through a process of good governance (including participatory decision-making, transparency, accountability, the rule of law, etc.).*
- *Balance existing rights with needs: the scheme respects existing rights; if necessary adequate compensation measures are agreed. No person will be worse off because of the scheme, and there are no negative extra-territorial effects.*
- *Sound science: the scheme is based on sound science, it adequately identifies uncertainty and risk and gaps in knowledge. All possible alternatives have been considered.*"

An integrated approach on the implementation of large IWT projects is also presented by Yevjevich [2001], who notes that IWT projects require long periods to study and large planning. He discusses about the controversies among donor and recipient regions and the three standard methods of conflict resolution, i.e. the administrative-legal, arbitration, and market decision.

3.0 Environmental and engineering, social and legal aspects

3.1 Environmental dimensions

Environmental value of the Acheloos delta

Acheloos is the largest river in Western Greece, with the highest discharge and the second longest in the Greek territory with a total length of 220 km. The basin area is approximately 6 250 km2 and contributes significant amounts of water and sediment in the lower catchment area. Because of its size, Acheloos presents complex physical geography and geomorphology [Mertzanis and Mertzanis, 2013]. Acheloos has a large estuary with wetlands of high environmental importance [Fourniotis, 2012]. Nikolaidis et al. [2006] explored several scenarios and actions to improve water quality under the Water Framework Directive (WFD-2000/60/EE).

The water balance in Thessaly district

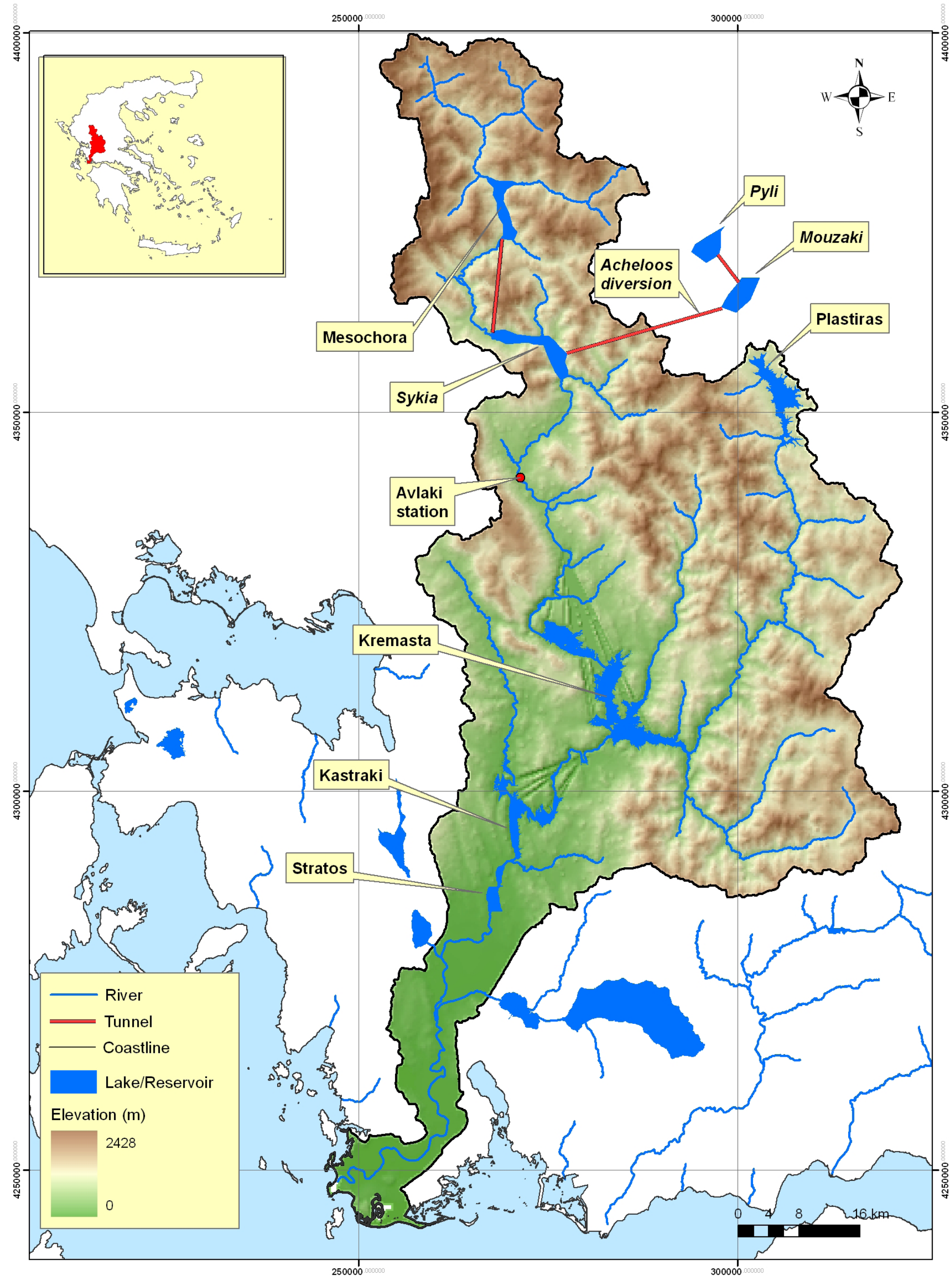

Figure 3. The Acheloos basin and its reservoir system. Future projects of the plan of the Acheloos to Pinios interbasin water transfer are indicated in italics. Source: Efstratiadis et al. (2014).

The total annual water consumption in the Thessaly district is approximately equal to 1 632 hm^3, of which 69 hm^3 for domestic use and 1 550 hm^3 for agricultural use (Table 2). Generally, the increasing demand for water for irrigation is met with the overexploitation of groundwater resources [*Loukas et al.,* 2007]. In some regions a drawdown of 100 m of the water level has been observed [*Koutsoyiannis,* 2008, p. 394]. Many problems about the water resources in Thessaly have been encountered, because of the negative water balance such as downgraded

Reservoir	Storage capacity (hm^3)					Hydroelectric factory
	Minimum	Maximum	Basin	Condition	Number of units	Installed power (MW)
Mesochora	132.8	358.0	Acheloos	Built	2	160
Sykia	94.0	590.8	Acheloos	Under construction	2	120
Kremasta	999.0	4 500.0	Acheloos	Operating	4	436
Kastraki	750.0	800.0	Acheloos	Operating	4	320
Stratos	60.0	70.2	Acheloos	Operating	2	156
Pyli	21.7	68.7	Pinios	Designed	2	260
Mouzaki	54.4	237.2	Pinios	Designed	2	270

Table 5. Reservoirs for the Acheloos to Pinios interbasin water transfer, with their storage capacity and the proposed installed hydropower. Source: Koutsoyiannis et al. [2002].

water quality, saltwater intrusion and the gradual desertification of land [*Margaris et al.,* 2006].

Existing policies and proposals for problem solving

As mentioned by Margaris et al. [2006], water shortage in Thessaly is partially due to the draining of lakes in the region. Drainage was made to reduce malaria and increase the farming land. Margaris et al. [2006] also attribute the arising problems to the cotton crops, however they do not quantify the gain in quantity of water, in case of change of crops. In our view, this gain would be insignificant compared to the amounts of water which are already consumed. Loukas et al. [2007] also attribute the problem of water shortage to the cotton crops but also to the suboptimal management of water resources, due to which the demand for water increased considerably.

Suggestions for solving the water shortage problem in Thessaly [*Loukas et al.,* 2007], include better management of water resources with drastic reduction of poorly irrigated areas in which the available water resources do not fully meet the demand for irrigation, reduction of the total irrigated area, and change and improvement of irrigation systems to minimize water losses and the change of the type of crops to less water demanding. Similar suggestions abound in regional literature and local press; however, it is often forgotten that such measures cannot be materialized by wishful thinking but in fact are costly. The proposed measures for increasing the availability of water resources in Thessaly, which may be less costly, are the management of surface water resources in the basin through the development of a system of dams and reservoirs, and the transfer of a quantity of water from the Acheloos basin.

3.2 Cases of investigation of the Acheloos and Pinios basins hydro-system in the scientific literature

In this Section we present the results of scientific works concerning the Acheloos to Pinios IWT. These results concern mainly the economic and environmental dimensions of the diversion scheme.

Investigation 1 [Koutsoyiannis, 1996]

The study on the Acheloos to Pinios IWT by Koutsoyiannis (1996) introduced and analyzed the pumped storage scheme, and suggested that the transfer of 600 hm^3/year besides solving partially the water shortage problem in Thessaly, can also improve the energy production value through pumped storage.

Investigation 2 [Efstratiadis et al., 2005]

Efstratiadis et al. [2005] investigated the interannual water balance of the West Thessaly region. The region's water demands are covered from surface waters by 21.4%, from water boreholes by 46.1% and from the Plastiras reservoir by 32.5%. During the time period 1972-1993, the irrigation demands of the hydro-system were increasing constantly, while the necessary infrastructure was not completed, causing overexploitation of the aquifer. The renewal of the aquifer is slow compared to the increase of irrigation demands, while the Plastiras lake irrigates larger areas compared to that of the initial planning.

Investigation 3 [Loukas et al., 2007]

After studying the Thessaly hydro-system Loukas et al. [2007] concluded that the existing reservoirs are unable to supply sufficient water to satisfy the present needs. As a result, the unsustainable groundwater pumping is used to cover the huge deficit. The proposed surface water storage projects in Pinios basin (see also Figure 2 in Loukas et al., [2007]) would reduce the large deficit, but it would be impossible to meet the demand. The partial diversion of Acheloos river would increase greatly the availability of water and improve the water balance. However, we would expect a negative water balance during dry hydrological years. Therefore, demand management measures to reduce water demand for irrigation is necessary to restore groundwater resources.

Investigation 4 (Fourniotis, 2012; Mertzanis and Mertzanis, 2013)

Fourniotis [2012] suggests a hydrodynamic tool in an attempt to assess the effect of the Acheloos diversion in the lower part of the river ecosystem. However, he has not completed his assessment. Mertzanis and Mertzanis [2013] also present changes that have taken place in the Acheloos basin from 1950 onwards. The construction of dams results in the progressive reduction of the river sediments. Several geomorphological changes and changes in land use concerning the coastal area have also been identified. The degradation of the coastal region is also accelerated by the saltwater intrusion, the overexploitation of groundwater and the expansion of tourism infrastructure.

Investigation 5 [Bouziotas, 2012]

Bouziotas [2012, see pp. 142, 143] simulated the operation of the Acheloos and Pinios basins system. He concluded that adding the already built Mesochora reservoir to the reservoir system will provide energy benefits, which he estimated at 10 M€ per year. With a water transfer target of 600 hm^3 the system can provide energy equal to 1 759 GWh per year that is estimated to 38% of the current average annual energy production from hydropower plants in Greece. Simultaneously the irrigation and environmental constraints in Etoloakarnania are met even after the IWT with practically zero failure. The entire benefit (energy and irrigation) from the operation of the system is estimated at 150 M€ per year. He also proposes composing a comprehensive management study of the system that combines energy production with appropriate restructuring and exploitation of the farmlands.

Investigation 6 [Koundouri et al., 2014]

Koundouri et al. [2014] estimated the cost of natural resources for Thessaly, i.e. the component of water pricing, which is linked to the present or future shortage due to the overexploitation of water resources beyond the renewal rate approximately at 90 M€, which is the largest in Greece. He attributes this cost entirely to the use of water for irrigation, because of the priority policy for the use of water for urban needs. Because of this policy they considered that the cost of natural resources for urban water demand is zero.

Investigation 7 [Nikolopoulos, 2015, pp. 218, 219]

Nikolopoulos [2015] simulated the operation of the Acheloos and Pinios basins system. The study is notable because it considers almost all the processes occurring within the hydro-system. He concluded that it is of importance not only the total amount of the diverted water, but also its management. The water system, due to its inherent complexity, is very sensitive and small changes in the management policies lead to strong variations in the performance measures (primary energy, failure probability, annual deficits). A typical example is that the water diversion of 600 hm^3 per year, with the sole criterion of energy efficiency, is problematic. Furthermore, its effects are worse than the best compromise of a smaller IWT amount of 250 hm^3. Therefore, management decisions are not simple.

The IWT has a significant positive influence on the primary energy if combined with pumped storage. Even if the IWT project is not materialized, the completion of the Pyli and Mouzaki reservoirs is necessary, as they contribute to significant reduction of the water deficit in Thessaly. The irrigation demand in both basins is high but has potential for significant reduction by improving irrigation practices and with a long-term restructuring of the crop. However, the environmental problem of Thessaly cannot be solved with the IWT project solely, but requires additional technical measures. The environmental constraints of the hydro-system are satisfied with great reliability in all examined cases. The cost of restructuring crops and developing large-scale closed irrigation networks in Thessaly is high and, even with rationalizing irrigation consumptions, the over pumping problem of groundwater aquifers will not be solved. Furthermore, all quantitative environmental constraints will not be completely satisfied. In this regard, Nikolopoulos [2015] concludes that the scenario of a transfer of 250 hm^3 per year framed with rational management policies is both feasible and sustainable, while it is not inconsistent with the principles of the Water Framework Directive (WFD-2000/60/EE).

3.3 Legal and social aspects

The legislation for this type of works was incomplete, at least in the initial period of the project conception. At that time the gap was covered using indirect means. An important role in the attitude of citizens played the mobilization of environmentalist Non-Governmental Organizations (NGO). These issues are discussed in the literature for the time period up to 2008, while for the legal aspects of the recent period the reader is referred to Moules [2013] and Savaresi [2012] and for the social aspect to Frantzeskaki et al. [2016].

The legal framework

Frantzeskaki [2011, p. 84] divides the project development into three periods. The first period spans from 1950 to 1980. The second period ends in 2000 and is characterized by social reactions. From 1984 to 2000 the project was interrupted several times, after being brought to the court mainly due to the involvement of environmentalist NGOs, led by the Greek Ornithological Society (GOS) and the WWF (World Wildlife Fund) [Houck, 2008] while several times there were changes in the plan with a major change in the amount of water to be transferred from 1 100 hm^3 in 600 hm^3 [*Maragou and Mantziou,* 2000]. We note that there were shortcomings in the Greek environmental legislation, at least until 2000. The Council of State attempted to fill this gap by legislating [*Houck,* 2008]. The third period was completed in 2008. During this period there was an attempt to revive the project. An important role in the attempt for the revival played the residents of Thessaly. The state tried to intersect the project into smaller projects with the aim not to cause social reactions [*Frantzeskaki,* 2011, p. 84]. Since 1999, the strategy changed and the WWF with its allies demanded the interruption of the project (with the excuse of protecting historical and cultural monuments). The work was interrupted for two years, while in 2003 the Council of State halted the project on the ground that it is incompatible with the European policy on water. In 2006, however, there was an attempt to start the project because it was considered of "imperative reasons of overriding public interest" (IROPI), so that it is possible to omit the satisfaction of certain rules. At this point, the European Union stopped to play a role, since they would not finance the project in either way. However, in 2007 the WWF came back to the European Union with a new requirement, considering there was a violation of justice and environmental agreements [Houck, 2008]. Finally, at the last going to the European Court, the conversion of natural ecosystem to manmade ecosystem was allowed, provided the receiving of compensatory measures [*Van Hoorick,* 2014]. The European Court also held that the project could constitute IROPI, concerning its scope for irrigation, to the extent that it may have beneficial consequences of primary importance for the environment [*Moules,* 2013]. However, the project was stopped again by the Council of State.

The European Union

In the first phase of the project (Mesochora dam construction) which was funded by the European Economic Community the European Economic Community emphasized in improving the infrastructure of its least developed countries [*Koutalakis*, 2011]. There was a dichotomy in the European policy targets between aiming for regional development on the one hand and protecting the environment on the other hand [*Long*, 1995]. However, from the 1980s the strengthening of environmental protection policies began, with the gradual incorporation of environmental components and the requirement for an integrated approach to growth rather than assessing each project individually and with the planning of European projects aiming at sustainable development. The main change was the decision for sustainable development [*Christopoulou,* 2011]. Indeed, from 1990 onwards due to the changed EU policy on subsidy issues concerning the agricultural products, the energy production dimension of the IWT was emphasized by the Greek state. Here we note the failure of the Greek state to conform to the European Union regulations in many cases and that major environmentalist NGOs have systematically resorted to the EU complaints procedure with the active assistance of the European Union [*Koutalakis,* 2011]. However, the final decision of the European Court can be considered neutral in our case.

The participation of citizens and the role of the non-governmental organizations

The environmental organizations which were involved in the project since 1984 were supported by local self-organized environmentalist groups [Daut, 2009] and local authorities. Since then, a campaign continues, which includes activities such as alarming the public with press conferences, publishing articles in the press, petition, mobilization, coordination and cooperation between local authorities, NGOs and citizens [*Scoullos et al.,* 2002].

Close [1998, 1999] emphasizes that in early years of the project environmentalist NGOs bypassed the state, linking the local and international activity. Thus, the Greek government now pays more attention to NGOs, while citizens consider that engineering projects destroy the environment. Indeed, the project of the Acheloos to Pinios IWT gave rise to an institutional transition in Greece, in which the role of the central government was reduced and the role of local authorities and NGOs was increased [*Frantzeskaki,* 2011, p. 87].

Social dimension

As Rose [1993] mentions two groups of residents were created. The first group in Thessaly wished the completion of the IWT project, while the second group in Etoloakarnania was opposed to the first group. These groups became coherent and followed different policies compared to the policies of the political parties of the regions. Furthermore, the local communities in Etoloakarnania considered the Acheloos issue as a matter of state sovereignty over them.

Regarding problems at specific spots, these are all recorded in the literature. A characteristic example is a deserted monastery (Agios Georgios) at the village of Myrofyllo has been used by environmentalists as a major weapon to block the project. Residents of the village of Mesochora also opposed to the project [*Houck,* 2008].

The farmers of Thessaly, due to the subsidy policies and the support of the Greek state chose to produce cotton. However, there has not been an integrated plan regarding the agricultural production of the country. For engineers, the Acheloos water which is discharged to the sea is a lost amount of water, which must somehow be exploited [*Houck,* 2008].

4.0 Discussion on the criteria

We investigate whether the five criteria are satisfied, considering the analysis of the previous section.

4.1 Criterion of water deficit and criterion of sustainability

Clearly, Acheloos basin has a big water surplus, and the Pinios basin has water deficit. Regarding the criterion of sustainability of the project, the environmental constraints are met with great reliability as shown by Nikolopoulos [2015]. We note that the work of Nikolopoulos [2015] besides using state-of-the-art technology, in terms of computing power and theoretical knowledge, is the most complete, since it has almost fully modelled the two basins. Furthermore, the results of the work are all quantitative. On the other hand, several works claiming that serious environmental problems are created in the Acheloos basin, do not express quantitatively the problems, at least to the knowledge of the authors, with the exception of Nikolaidis et al. [2006] who deal with the present state of the Acheloos basin. The IWT still creates small scale problems, such as the need to evacuate the Mesochora settlement, which, however, in our opinion are manageable.

Regarding the development of the two regions, the IWT can maintain the quantity of agricultural production in Thessaly. Otherwise the agricultural production will continuously decrease as saltwater intrusion significantly pollutes the region. Since at some point in the future, if the GDP is to increase, the only viable solution to maintain satisfactory levels of agricultural production in Greece, whose most important part is the agricultural production in the Thessaly RBD, is the water transfer.

Regarding the development of Greece, we note that in general we need to emphasize the development of the industrial sector, against the service sector, so that a balance between them is achieved for given levels of the GDP. It seems that the construction of two reservoirs in the Acheloos basin, whose operation can (if necessary) be independent of the water transfer to Thessaly, will contribute significantly to the reduction of energy prices, which is an important factor for the industrial development. The hydropower production is not going to decrease, while with the pumped storage installation it will certainly increase.

4.2 Sound science criterion

While in the original design of the project the amount of diverted water was set at 1 100 hm^3 per year then, about 1995 the quantity was revised to 600 hm^3 (see Koutsoyiannis et al. [1995] for preliminary calculations). The most recent calculations estimate the optimum result in 250 - 600 hm^3 per year [*Bouziotas*, 2012; *Nikolopoulos,* 2015]. We think that the results of the recent research are reliable. It is obvious that the optimum solution has not improved the last 20 years, despite the advances in technology. We conclude that the criterion of sound science is met for at least the last 20 years, in view of the study by Koutsoyiannis [1996] and its recent adaptation and verification by Nikolopoulos [2015]. A common argument against the project is that early studies (of the 1980s) were considered by independent institutions as inadequate. However, in projects of this type, we come to the final solution after a long time [*Yevjevich,* 2001]. Furthermore, no other alternatives have appeared. The change of crops and the reduction of water losses, despite being necessary, would not be sufficient for the renewal of underground water in Thessaly.

4.3 Good governance criterion

After the World War II Greece suffered from a civil war (1946-49) and more recently by a dictatorship (1967-74). These political conditions resulted in an authoritarianist Greek state, on the one hand, and lack of respect of the public interests by individuals, on the other hand. Thus, until 1990 the state attempted to impose the project in an authoritarianist manner, while people started to react without considering the public benefit. In particular, the local communities took into account only their own interest, while environmentalist NGOs took advantage of the controversial Acheloos case to increase their political influence. They bypassed the Greek state and addressed directly to the European Union, where environmentalist lobbies were strong. The opposition to the Acheloos WTP became the banner of environmentalist groups and also attracted the State of the Council, which is the supreme court of the Greek state. The positive side of these developments is that, after bringing the case to the court, the process became transparent.

Another problem was the lack of proper environmental legislation until 1990. The Council of State attempted to fill the gap by issuing relevant decisions. However, it was not technically qualified to investigate the matter, while the role of the savior of the environment it assumed may have distracted its actual duty and mission. The enactment by the Council of State, and not by the official legislator, has the risk of legislating without being based on the technological and economical reality. When these laws were established, more problems were created on the long run. Indeed, in our case, environmental organizations began to play an increasingly decisive role in justice. The result was that since 2000, the project is continually interrupted by judicial decisions, without substantive discussion on the subject. Environmental organizations address the issues of water resources management in the rationale of Gleick (2000), which in our opinion is totally inappropriate for Greece (and beyond). To overcome any problems and in these conditions, the government decided to continue the work with indirect means, such as intersecting the project into smaller ones. The result was the continuation of implementation of policies, which were shady. In such situations, finding the optimal solution is impossible, while starting substantive discussions is expected to delay for a long time.

The European Union again, from which the Greek state has asked funding of the project, maintained a neutral stance, waiting for the decisions of the Greek state. At the moment, the project is of little importance for the European authorities and, thus, they do not interfere in the related processed.

4.4 Criterion of balancing existing rights with needs

The project does not harm the interests of the citizens of Acheloos basin. However, formally the water belongs to them when considered as a natural resource. In this case, a fair solution in our view is to take compensatory measures from the rewards of the citizens in the Pinios basin. This would be possible only by direct consultation between the citizens or even through arbitration. In Greece, however, the usual treatment of such issues is the imposition of some group view over the other, while the state usually supports one group (depending on the minister in charge at each time), with an eventual legal battle. So while compensatory projects are necessary, they have not been discussed.

5.0 Conclusions and policy implications

The project of the Acheloos to Pinios interbasin water transfer is economically, environmentally and socially sustainable and is based on sound science. However, while the completion of the project is necessary, simultaneously other necessary (but costly) measures related to the water management in the Pinios basin are required (e.g. modern irrigation networks, change of type of crops etc.).

While the project would be beneficial for the Greek economy, society and local environment, it was not materialized, because of its inconsistent handling from the Greek state in the early 80s, which was the result of the government's authoritarian attitude on the one hand and individuals' incredulity to state's decisions on the other hand. Environmentalist groups were able to continually pause the project construction. At the same time, the Greek justice legislated to cover the gap in the environmental legislation.

From 2000 onwards, the environmentalist groups and the Greek justice began to play a role greater than that corresponding to them, and the Greek state resorted to indirect methods to overcome the obstacles set by the joint actions of environmentalist groups and judges. Thus, the citizens lost their confidence to the government. Therefore, the criterion of good governance was never satisfied. Neither the criterion of balancing existing rights with needs is satisfied, because of the weakness for cooperation between citizens that is typical in Greece.

The issue of the Acheloos to Pinios water transfer revealed deeper problems of the Greek society, such as the shortcomings of the institutional framework, the authoritarian and populism behavior of the state, the unclear separation of powers and the weakness of cooperation between the citizens.

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