Simple hydro-economic tools for supporting small water supply agencies on sustainable irrigation water management

A. Alamanos

The Water Forum, Centre for Freshwater and Environmental Studies, Dundalk Institute of Technology, Marshes Upper, Dundalk Co. Louth, A91K584, Ireland
E-mail: angelos.alamanos@dkit.ie

ABSTRACT

In the Mediterranean countries, agriculture poses challenges in terms of its production expectations, resources availability, pollution, general management and implementation of economic tools (e.g. full cost of irrigation water, according to the Water Framework Directive). This study attempts to provide useful approaches for small water supply agencies facing multiple management, funding, environmental, and practical issues. A representative case in Central Greece is examined, in order to describe the situation in understandable terms supporting sustainable management. Simple hydro-economic tools were used to address these challenges; water balance, profits from agriculture, water value, management strategies, and full cost of irrigation water were simulated and incorporated into a Decision Support System (DSS), using Multi-Criteria Analysis (MCA), involving experts on water resources management and local policymakers. This is the first hydro-economic study designed for a Greek rural agency, aiming to improve and encourage integrated monitoring and management at multiple levels, communicating more efficient water use approaches to local irrigation management communities.

Key words: decision support system, full cost of irrigation water, hydroeconomic modeling, irrigation water efficiency, Pinios, water resources management

HIGHLIGHTS

• Addresses agricultural water management problems with scarce and overexploited resources.
• Management solutions for high production expectations, economic and resources sustainability.
• Facilitates application of economic tools (full cost of irrigation water according to the WFD).
• Combines methods for the first time for small water agencies, aiming to assist them with the above challenges.
• Integrated multidisciplinary approach.

INTRODUCTION

Most European countries are facing several environmental, technical, and socioeconomic issues, concerning sustainable and efficient water resources management. Greece is no exception to such problems, especially in the agricultural sector, which is the largest water consumer. Irrational rural management and intensification of agriculture have caused many environmental problems in Greek catchments, such as water scarcity and quality issues (Varouchakis et al. 2019). Local Administrations of Land Reclamation (LALRs) are responsible for catchment management and specifically the use of irrigation water (allocation, pricing, works, investments, etc.). LALRs’ are under the jurisdiction of the Agricultural Agency of Land Reclamation (AALR) of the respective District, which are managed either by the Prefecture or by the Ministry of Environment. LALRs is maintained by farmers and facing several management problems (e.g. lack of records, monitoring, water underpricing, poor maintenance of the existing infrastructure, losses and cooperation difficulties). and they mainly seek subsidies. Poor management, losses and funding issues combined with the stakeholders’ mindset contribute to the many illegal wells that attempt to cover the increased water demand.

Increase in water pricing was expected from June of 2018, following the implementation of Article 9 of the Water Framework Directive (European Commission 2000). However, to date, no Greek LALR has begun charging the full cost of irrigation water as a sum of monetary, natural resource and environmental cost in a countermeasure for the resources’
degradation. Considering the variety of issues LALRs must manage, the institutional difficulties in changing their structure and in training their personnel, the contribution of research in providing useful and handy tools is necessary.

Integrated hydro-economic modeling, considering hydrologic, environmental and economic aspects of water resources systems within a coherent framework (Heinz et al. 2007; Brouwer & Hofkes 2008; Blanco-Gutiérrez et al. 2013; Hellegers & van Halsema 2019) could help water managers to move from a static view of a simple single objective economic or water demand-problem, to the combination of the above factors, leading thus to wiser decisions. Various types of modeling frameworks have been developed to address the different scales and objectives in agro-economics (Volk et al. 2008; Peña-Haro et al. 2009; Esteve et al. 2015). In fewer studies, the outcome of a hydro-economic model is used in a Decision Support System (DSS), based on optimization (Varouchakis et al. 2019) or MultiCriteria Analysis (MCA) (Bartolini et al. 2010; Alamanos et al. 2018) of desirable goals. There is not a superior or best-fitting technique for a DSS. The technique depends on the characteristics of the studied problem (Munier 2011). Hydro-economic models, due to their complexity and data requirements, remain inside academic circles so far, instead of being usable tools for local decision-makers (DMs).

This study combines factors such as (i) water balance, (ii) profits from agricultural activities, (iii) water value, (iv) water quality, and (v) full cost of water, in order to provide a holistic DSS designed for Pinios LALR (Central Greece). The proposed alternatives are simulated as demand-management scenarios and are evaluated from DMs and experts in the field of water resources using the MCA technique MAUT (Multi-Attribute Utility Theory). Except the previous local-scale studies of Alamanos et al. (2018, 2020a), there are no similar applications in the study area, and to our knowledge, this is the first study that addresses these topics for a Greek LALR. The overall aim of the study is to: (a) illustrate the situation in the examined area, (b) sensitise Pinios LALR to further and to constantly monitor the simulated parameters (e.g. climate and crop data, water use, consumption, quality, and socio-economic factors), (c) provide a useful hydro-economic tool to assist Pinios LALR control the above parameters and facilitate its decision-making process, and (d) pave the way for a dynamic cooperation between DMs and experts towards a sustainable management. The combination of the above components, in a single framework is a novelty, while its successful implementation by a small water agency gives it an operational character.

**STUDY AREA**

Lake Karla catchment is an agricultural area of 1,663 km² in the southeast of Thessaly, between Volos and Larissa. Lake Karla was drained in 1962 for flood protection purposes and for more agricultural land. However, due to a number of environmental problems (such as depletion of the underlying aquifer, pollution of the groundwater, floods, and extreme climatic events), a reconstitution of the Lake was decided in 1981. The plan was to refill a part of the former lake with water from Pinios’ river. Today, even though the work has been completed, Karla reservoir is still not operating due to lack of management attention and funding. In addition, farmers are using water from Pinios for (free) irrigation before it reaches the reservoir, according to the LALR’s observations.

In the last decades, subsidies and high product prices, developed a preference for more water demanding crops such as cotton. The intensification of irrigation caused a drawdown to the underlying aquifer and water pollution. As Karla reservoir is still inactive, water demand is covered by the surface water of Pinios LALR and mainly from the overexploited aquifer. The surface network of Pinios LALR uses open canals which results in huge losses due to evaporation and poor maintenance. Until 2015 there was another LALR in the catchment, Karla LALR. It stopped operating due to debts and limited personnel. Today, Pinios LALR remains the only management body in the area overseeing irrigation water. It is responsible only for 154 km², namely the area of its surface network, and is also responsible for some pumping wells operating inside that area. Subsequently, most of the wells in the groundwater area are illegal. The total cultivated area is around 90 km². Pinios LALR uses an area-based pricing system, aiming at standard revenues to the LALR. The areal based charges are not correlated at all with actual water consumption levels, and their main purpose is to cover their operating costs only (Alamanos et al. 2020a). Furthermore, this system does not provide any incentive for water conservation.

The responsibilities of Pinios LALR are many and complex: COVERING operations cost, maintaining the river’s pumping stations and its irrigation canals, paying its limited personnel, paying State’s deductions, and ensuring that the necessary amount of water reaches Karla reservoir, are only some of them. As a result of the large farmers’ debts to the LALR, the LALR is in turn accumulating debts to the State. The above services are very difficult to provide by an underfunded and mis-managed organisation. Even the basic monitoring and record keeping of basic parameters is not always possible. Additionally, from June 2018, according to the Water Framework Directive (WFD) a new challenging measure was expected:
pricing the full cost of irrigation water. Clearly, there is a growing need for useful tools to meet and facilitate the above objectives, for improved water services, as well as to improve cooperation between farmers and DMs. We strongly support modeling and management at catchment level, as in our previous works (Alamanos et al. 2020a, 2020b), but the focus here is on small rural water supply agencies (as Pinios LALR); acknowledging their challenges and the limited relevant literature, this framework aims to support them meet their objectives.

**METHODS**

An integrated hydro-economic model was developed for Pinios LALR, based on the following key components: water balance, agricultural profits, water value, water quality, and full cost of irrigation water. The procedure is shown in Figure 2 flowchart.

Summarizing the above, the model results in the following outputs:

**Water balance**

Three pumping stations are used for watering Pinios LALR’s surface network and one pumping station is used for transferring water from Pinios to Karla reservoir. The total discharge is 211.2 hm³ of which the 100 hm³ are required for refilling the reservoir, according to the design studies.

Regarding water demand, the area’s crops were classified in 12 main classes. For estimation of irrigation water demand a single CROPWAT (FAO 2015) and MS Excel model of the method Blanney-Criddle (Blaney & Criddle 1962) was used. Irrigation requirements were increased by the respective losses’ coefficients for the network and the irrigation methods efficiency, as they were found from field surveys (Hydromentor 2015).

Given water supply and demand, the water balance was calculated for the serviced areas from Pinios LALR.

**Profits from agricultural activities**

A simple logistic straightforward model was developed for estimation of net profits, as described in Equation (1):

\[
NP = GP - TPC
\]

where NP stands for Net Profit, GP for Gross Profit and TCP for Total Production Cost.

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![Figure 1](image-url)  
**Figure 1** | (a) Lake Karla watershed. Pinios network is shown with the orange color. (b) Pinios LALR’s open irrigation network.
Gross Pro
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gress were calculated as the sum of gross revenue plus subsidies. Total Production Cost of each crop was calculated as the sum of expenditures incurred for producing one unit of product (costs of lubrication, herbicides, seeds, two sprays, defoliants, harvesting cost, pumping costs, electricity, oil, labor, planting cost, mechanical operations, and agricultural deductions).

Water value

‘Net Income Change’ method was applied for the indirect estimation of irrigation’s value in agricultural income. The method was selected due to lack of data concerning water contribution in the production process of the study area. Following the method, net profits between a BAU Scenario and a non-irrigated scenario were compared (as calculated above, step ii), with all other factors remaining constant. Thus, the only difference in net profit between the two conditions is solely due to the irrigation water (Gibbons 1986). The non-irrigated scenario used the corresponding non-irrigated crops to the existing ones, as they occurred from linear programming maximising profits, subject to cultivation, labor and market constraints (Latinopoulos 2006). This parameter plays an important role to the practical understanding of the supplied water’s contribution expressed in monetary terms for the LALR, and a useful factor for the planning process.

Water quality

Greek Ministry of Agricultural Development and Food is in charge of assessing the Pinios River water quality (mainly for irrigation) by collecting data from 21 sampling stations. In the study sampling data was collected and analysed in order to check which pollutants’ concentrations are above the maximum allowed limits (as established by World Health Organization and European Union) (Loukas 2010). Furthermore, the total fertilizing demand was estimated for the studied area, concerning crop distribution and their average fertilizing requirements.

Full cost of irrigation water

The full cost of irrigation water is not depicted in Figure 2 flowchart, as it occurs from separate calculations, based on three basic outputs of that flowchart: water balance, net profits and water quality. The total cost was found for Pinios LALR’s serviced areas, as the sum of:
Monetary (direct) cost for the water supply company. It was calculated as the sum of capital cost, cost of maintenance and operation, investment and administrative cost (at their present value), as obtained and estimated from annual balance sheets of Pinios LALR.

Natural Resource Cost. This component is related to the damage or negative impact due to water scarcity or resource misallocation. It was treated as opportunity cost, since water may not be allocated to its optimum use, but to other less profitable uses (WATECO 2002). In that case the natural resource cost expresses the difference between the current and the optimum water allocation (Tietenberg & Lewis 2011). This estimation is achieved by finding the optimum crop distribution resulting from a Net Profit (NP) maximization problem, with water demand, fertilizer, labor, and production expectations constraints. The remaining areas (since water demand is constrained) are filled with non-irrigated crops, again with the same optimization problem logic. The difference of the BAU’s overall agricultural profits ($NP_{existing}$) from this theoretical optimum scenario ($NP_{optimized}$) are representing the Natural Resource Cost ($RC$), as shown in Equation (2) (Alamanos et al. 2020b):

$$RC = NP_{optimized} - NP_{existing}$$

In the case of water surplus, it is considered that there are no water scarcity conditions (no deficit), so there is no RC cost.

Environmental Cost, associated with the qualitative degradation of water resources. It is connected with step (iv), as it was considered equal to the necessary cost of restoring water quality to its original condition (quality standards). Namely, the depollution cost needed to bring the environment back to its original state (WATECO 2002; Greek Ministry of Environment 2012) was calculated using depollution cost-functions, as described in Alamanos et al. (2020b).

Agricultural use values were taken into account for the full cost calculations, as other non-use values do not exist in the study area. For further details on the full-cost estimation methods, see Alamanos et al. (2020b).

Demand management scenarios

All the above outputs were simulated for the set of scenarios aiming to a reduced water demand. These scenarios were actually the ones discussed from the local authorities as possible measures for implementation in the near future, and include technical measures and crop replacement:

- BAU Scenario (Scenario 1), the present situation (Business-As-Usual scenario).
- Scenario A: The open irrigation canals result great losses, especially the peak irrigation period of summer months. The water transfer efficiency (network) was estimated around 40% for the surface network and 80% for the groundwater network, based on field surveys. This scenario suggests a proper cleaning (from plants and rubbish) and maintenance of the networks. Subsequently, the water transfer efficiency of the surface network was considered equal to 75 and 90% for the groundwater network.
- Scenario B: According to older questionnaire surveys in the catchment, it was reported that the majority of the catchment’s farmers are using sprinkler, although there were subsidies for adopting drip irrigation (Hydromentor 2015). This scenario suggests replacing sprinkler systems with drip irrigation (and overhead sprinkles where necessary) in order to achieve higher irrigation efficiency (efficiency coefficients increased to 90% instead of 70%).
- The last five years, the need of adopting a less water consuming cropping pattern is more and more promoted by the Common Agricultural Policy (CAP) (Greek Ministry of Environment, 2015). Crop replacement according to CAP’s recommendations highlights the importance of reducing the water-demanding cotton crops in Thessaly with less water consuming crops. Through observing the Product Prices and the subsidies of the last five years, two crop replacement scenarios were developed. Scenario C: where the 25% of cotton area was replaced by winter wheat, and
- Scenario D, where the 20% of cotton area was replaced by winter wheat (10%) and corn (10%).

The above scenarios were simulated in the software WEAP (Water Evaluation And Planning) (weap21.org) in order to estimate the water demand and thus the water balances for each situation. The implementation cost of these scenarios was also calculated from LALR’s past data and experts’ estimations and is included in each scenario’s direct cost.
The DSS

The final step of the study was to make use of the above outputs to evaluate different alternatives (i.e. the management scenarios). The integration of the above into a DSS was achieved with MCA. Based on our previous research (Alamanos et al. 2018) more MCA methods were tested (AHP, ELECTRE, TOPSIS) however, the best-fitting technique for the examined problem was found to be MAUT (additive utility function). MAUT is based on Utility Theory (Neumann & Morgessnsten 1953; Churchman et al. 1957) using a value-weight system (utility functions), similar to a decision maker’s logic (Keeney & Raiffa 1976), where the alternative with highest utility is considered to be the most appropriate.

MAUT needs independent sub-criteria for the development of the utility functions, and to achieve this every output of the hydro-economic model was examined as an evaluation criterion. The independence and the sufficiency of the model’s outputs were tested with a correlation test, since their performances were known from the previous steps of the model. In summary, the set of sub-criteria we used are: water balance (1.1), gross revenue (2.1), production cost (2.2), monetary cost (3.1), natural resource cost (3.2), and environmental cost (3.3). The other parameters were correlated with these sub-criteria and were excluded. The weights of importance were retrieved from a group of 28 DMs (from Decentralised Management Agency-Water Directorate, Department of Hydro-Economy of Thessaly, Management Agency of the broader Karla catchment, Institute of Industrial and Livestock Plants-IILP of Larisa, AALR of Thessaly District and Pinios LALR) and a group of 32 experts on water resources (researchers from Greek universities). Using these sample groups allows to have a holistic and complete understanding of the management priorities.

Following MAUT method (Munier 2011), the performance values of the alternatives under every sub-criterion were multiplied by the respective weights for each sub-criterion. The sub-criteria values were added for each criterion. Thus, for each one of our criteria arose values that correspond to each alternative. For each criterion, the values (vi) of the sums of the above step (which correspond to each alternative) were multiplied with the alternatives’ weights (wi), and the sum-product of the above was found (as summarized in the additive utility function U(i) as presented in Equation (3)):

\[ U(i) = \sum w_i v_i \] (3)

RESULTS AND DISCUSSION

Table 1 summarizes the results of every output described above, for Pinios LALR’s serviced areas. As expected in every management scenario water demand is being reduced and water balance is being improved. However, in summer months there is still unmet demand, even if the annual balance is positive. In the case of winter months, and of course in Scenario A, that the water balance is positive, thus the RC is zero, a supply management will be applied (pumping will stay below the maximum capacity).

Net profits from agricultural activities change only in the crop replacement scenarios, as they are the only scenarios that crops’ areas change. Water values are low in the study area. Decreases in water requirements lead to increased water values.

| Scenarios/Outputs | 1-BAU | Scen.A | Scen.B | Scen.C | Scen.D |
|-------------------|-------|--------|--------|--------|--------|
| Water demand (hm³) | 122.001 | 61.001 | 116.159 | 112.600 | 117.917 |
| Max. pumping capacity (hm³) | 111.20 | 111.20 | 111.20 | 111.20 | 111.20 |
| Water balance (hm³) | –10.801 | 50.199 | –4.959 | –1.400 | –6.717 |
| Net profits (€) | 9,145,714 | 9,145,714 | 9,145,714 | 8,563,330 | 8,944,612 |
| Water Value (€/m³) | 0.0529 | 0.1146 | 0.0555 | 0.0470 | 0.0506 |
| Monetary cost (€) | 1,888,468 | 2,168,824 | 2,397,584 | 1,888,468 | 1,888,468 |
| Natural resource cost (€) | 862,527 | – | 368,722 | 96,462 | 415,625 |
| Environmental cost (€) | 2,882,126 | 3,035,930 | 3,373,397 | 1,620,163 | 1,916,378 |
| Implementation cost (€) | – | 280,356 | 3,636,010 | – | – |
In the case when profits are getting lower, also the water value is getting lower. So, it is obvious that crop distribution is a key factor for water value as it affects both profits and water requirements.

Regarding water quality results, it was found that the average fertilizer quantity needed for the cultivation of the examined areas is 2.84 tons. For Scenarios C and D this amount would be 2.65 tons and 2.81 tons, respectively. However, farmers are using much more than the required fertilizers due to the intensification of agriculture in the region. As proof to this statement, 36 physicochemical, inorganic pollutants and pesticides were found in Pinios surface water samples. 13 of them are above the allowable limits and several of them are close to these limits (or exceeding them in certain irrigation periods). The water quality of Pinios water is crucial not only for the river and the irrigated areas from Pinios LALR's surface network. It is very important for the water transfer to the reservoir of Karla, as well, since it is its only supply source. Additionally, part of this surface water affects the quality of the underlying aquifer, through the component of infiltration. Hence, improving the water quality will result multiple benefits.

The proposed demand management (Scenarios A, B, C and D) also contributes to the improvement of water quality through naturally diluting the pollutants with the water conserved from the water balances. It was estimated that the implementation of Scenario A could reduce the concentrations of physicochemical pollutants by 68% and of pesticides by 18%. The respective concentration reduction percentages for Scenario B are 19 and 3%, for Scenario C are 36 and 6%, and for Scenario D are 31 and 5%.

According to Table 1, the full cost of irrigation water (summing monetary, resource and environmental costs) results in 5.633 mil.€ for BAU Scenario, 5.205 mil.€ for Scenario A, 6.140 mil.€ for Scenario B, 3.605 mil.€ for Scenario C, and 4.220 mil.€ for Scenario D (further detail on the analysis – methods and application, on the full cost of irrigation water can be found to Alamanos et al. 2020b). The higher monetary costs of Scenarios A and B are associated with the costs of maintaining the open irrigation channels and installing drip irrigation.

The following diagram (Figure 3) presents the areas of the crops in two stages: at the current situation (existing) and in the optimized case, as described in the natural resource cost paragraph of the methodology section. The RC results occurred from the application of Equation (2).

The effects of reducing the unmet demand (and thus scarcity) are visible in the reduction of natural resource costs among the studied scenarios. The opposite effect is observed for the environmental costs because with less deficit water the pollutants would be less diluted and thus there would be greater water volume for depollution, resulting in a higher cost. Taking into account the positive effects of the quantitative replenishment on the water quality (through dilution), a more accurate estimation of the full cost is achieved, as double calculations are avoided (Alamanos et al. 2020b). With this approach, the natural resource and environmental costs are addressed together. The results, even as numbers are indicative measures that can be very informative to the stakeholders. Hence, WFD's goals can be gradually achieved, by ‘translating’ confusing terms into commonly accepted terms (such as negative water balance and water pollution) that will, at the same time, prepare the ground for its proper implementation.

**Figure 3** | The comparison of the areas of the crops, before and after the optimization described for the estimation of natural recourse cost.
The higher implementation cost of Scenario B is due to the expenses needed for the purchases and installations of drip irrigation systems, which are in general more expensive. However, these costs are not necessarily paid by the stakeholders, as Greek State provides subsidies for increasing irrigation water use efficiency.

In this stage, the MAUT method was applied, to show how LALR could evaluate different management strategies, using as example the examined scenarios. So, Scenarios A, B, C and D were used as alternatives and the evaluation criteria were water balance (1.1), gross revenue (2.1), production cost (2.2), monetary cost (3.1), natural resource cost (3.2), and environmental cost (3.3). The two sample groups assigned weights to the above sub-criteria (Figure 4) after a questionnaire survey, and the alternatives were evaluated (Figure 5), as described in the previous section. The experts’ group considered ‘environmental’ sub-criteria more important than the ‘economic’ ones, in contrast with the DMs’ group.

The two sample groups concluded with the same ranking for the alternatives (as presented in Figure 5), differing only on the utility values. Scenario A was found to be the most appropriate, followed by Scenarios B, D and C. The results show an overall understanding of the necessity for conservation, losses reduction, and more efficient irrigation. Also, the results revealed a clear preference towards technical measures than a crop replacement policy. The immense losses of Pinios LALR justify this preference. The increased awareness of the situation within the sample group is an encouraging sign.

CONCLUSIONS

The study attempted to address the challenges that a small irrigation water supply agency is facing through simple hydrological and economic simulations in an integrated way, based on three pillars, which are important take-away messages:

![Figure 4](http://iwaponline.com/ws/article-pdf/doi/10.2166/ws.2021.318/937668/ws2021318.pdf)  
**Figure 4** | The weights’ ranges as percentages, as given from (a) the group of experts and (b) the group of DMs.

![Figure 5](http://iwaponline.com/ws/article-pdf/doi/10.2166/ws.2021.318/937668/ws2021318.pdf)  
**Figure 5** | The alternatives’ evaluation as resulted from MAUT for the whole sample.
Firstly, for any water supply agency monitoring is essential and the knowledge of basic factors of the system is necessary for a sustainable management. In Greece, due to limited funding and lack of appropriate infrastructure, monitoring and databases do not always exist or set as priority actions. Here, an opposite mindset is promoted to the LALR (and part extension to every Greek LALR), using parameters as water availability and demand, water balance and quality, profits, costs, value of irrigation water and its full cost. A limitation of this study is that all these factors cannot be presented in detail in a paper’s length, but the focus in this case is to support irrigation agencies (by combining for the first time those methods), rather than on the modeling aspect (for the later’s details see Alamanos et al. 2020a, 2020b).

Secondly, the management approach should be reconsidered. Most aquatic systems in Greece are either in a bad quantitative or in a bad qualitative condition, or both (Greek Ministry of Environment 2012). Previous attempts to improve the situation included one-sided increment of supply. This study examined demand reduction measures (management scenarios) in order to demonstrate that this can be partially a solution. The widespread belief that only large-scale and expensive water supply projects are signs of development in Greece should be revisited with consideration that development can be stimulated with smaller, smarter, and more modern practices as well. The results proved that the multiple effects of the scenarios could set them as a starting (low-cost) management point (or trying their combinations first). Water supply management is also important and is recommended if necessary (e.g. smaller reservoirs or nature-based solutions).

Thirdly, considering the numerous alternative options that can be considered, a structured decision-making process is important to rank them. Usually agencies try to implement the Ministry’s recommendations in the cheapest and least demanding way (filtering options based on the least-cost approach). In our example, the MCA process used inputs from the analysis, to evaluate (indicatively) four water resources management strategies. The idea was to make use of as many aspects as possible and encourage participation for rational planning. Including both experts and DMs in the sample was expected to create a bridge between them for their future cooperation, making each group aware of the other’s priorities. Moreover, DMs were familiarised with the results of hydro-economic modelling and some of its capabilities for supporting management. After all, the process must be simple in order to be practically applicable. A limitation at this point is that the stakeholders (farmers) were not included in the MCA process, as it was difficult to gather a representative sample, but we are currently working with them, as part of expanding the framework.

The results were encouraging, and some elements are already put into practice, however, more efforts are needed to inform and sensitize a broader portion of DMs, as well as to encourage them to seek better management practices that would lead towards sustainability. They need to consider long-term planning in catchment level and become interested to use scientific tools and experts’ guidance to solve the pressing problems in their regions. LALRs are obligated to be in line with any top-down political guidelines and legislations, however they should keep in mind that their area’s specific characteristics will define the final implementation approach for each separate policy. For example, Pinios LALR uses surface water and open irrigation canals, while the majority of LALRs are using groundwater and drilling wells. Each separate case with its specific characteristics could provide valuable lessons in considering bottom-up approach in overall planning, hence the underlined herein benefits of an interactive and dynamic process. This work shows that classic methods, and simple and known tools can be combined to provide valuable understanding to local policymakers. There is no lack of modeling tools or methodological applications – in fact there are many high-quality approaches using complex and advanced techniques, and this is often the reason that restrains their practical applicability, especially in Greek small water supply agencies who face water scarcity issues. Similar processes as the proposed, can be carried out to other Greek LALRs too, as the nature of their challenges is same. The presented approach can give solutions with limited data and its basic outputs can be used as a starting point for discussion and cooperation between experts and farmers’ organizations, towards a sustainable integrated management.

**DATA AVAILABILITY STATEMENT**

All relevant data are included in the paper or its Supplementary Information.

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