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Water for Tomorrow: A Living Lab on the Creation of the Science-Policy-Stakeholder Interface

Angelos Alamanos *, Phoebe Koundouri, Lydia Papadaki, Tatiana Pliakou and Eleni Toli

Sustainable Development Unit, School of Economics, Department of International and European Economic Studies, Athens University of Economics and Business, 104 34 Athina, Greece
* Correspondence: alamanos@civ.uth.gr

Abstract: The proactive sustainable management of scarce water across vulnerable agricultural areas of South Europe is a timely issue of major importance, especially under the recent challenges affecting complex water systems. The Basin District of Thessaly, Greece's driest rural region, has a long history of multiple issues of an environmental, planning, economic or administrative nature, as well as a history of conflict. For the first time, the region's key-stakeholders, including scientists and policymakers, participated in tactical meetings during the 19-month project "Water For Tomorrow". The goal was to establish a common and holistic understanding of the problems, assess the lessons learned from the failures of the past and co-develop a list of policy recommendations, placing them in the broader context of sustainability. These refer to enhanced and transparent information, data, accountability, cooperation/communication among authorities and stakeholders, capacity building, new technologies and modernization of current practices, reasonable demand and supply management, flexible renewable energy portfolios and circular approaches, among others. This work has significant implications for the integrated water resources management of similar south-European cases, including the Third-Cycle of the River Basin Management Plans and the International Sustainability Agendas.

Keywords: water resources management; systems innovation approach; policy recommendations; River Basin Management Plans; sustainability

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1. Introduction

Water Resources Management (WRM) includes all methods and practices required for the rationale conversion of aquatic systems in a state that will meet current needs, without undermining future ones (Sustainable), while providing the maximum benefits to society [1,2]. This integrated process requires holistic assessments and includes the combination of multiple disciplines, stakeholders and policy instruments.

During recent years, multiple new challenges have emerged: increased energy and resources demand, reduced resources availability, population movements, recession, COVID-19 and war. These challenges significantly affect several sectors such as energy, fuels, industry, agriculture, international relations and trade, economy and resources, including water, human and natural capital [3–5]. The water management sector has to cope with these challenges (by supporting hydropower and agricultural production), overcoming any existing issues of infrastructure, water scarcity, water quality deterioration, effects of climate change, including extreme phenomena and mismanagement in human, economic and institutional terms [6,7].

Such complex crises often create or intensify conflicts among different water uses and negatively affect management and investment decisions [8,9]. There are several examples in the literature describing such conflicts and drawing lessons from their resolution process, In the case of the Indus River in Pakistan, a key challenge is the water allocation among riparian states with often conflicting needs under an uncertain supply–demand gap. Recent

research underlines the need for stakeholder engagement along with scientific support to evaluate the different management options [10]. A scientifically guided stakeholder involvement process was applied in El Carracillo region (Spain), where there is an ongoing water conflict between horticultural farmers and environmental conservation [11]. The authors note that, although solutions exist, neither side wants to step back, indicating the importance of proper communication to understand the benefits of more reasonable management. In the Yahagi River Basin in Central Japan, where irrigation water use was excessive, it was necessary to follow a holistic approach to avoid conflicts, i.e., to control the regional economic growth and simultaneously apply water-saving technologies [12]. The proper coordination of such holistic actions in complex inter-jurisdictional interactions is key to facilitate the implementation of water management strategies, ensure the necessary level of stakeholder participation and avoid conflicts, as Wang et al. [13] note for China. Ensuring that the actions will benefit multiple stakeholders (rather than only maximizing their overall utility) is recommended [14]. In order to achieve this, Potters et al. [15] find stakeholder engagement processes to be highly valuable approaches to strengthen agricultural and water management knowledge and innovation systems. However, stakeholders often find it difficult to influence central government actors and this leads to disappointment and demotivation [16,17]. White et al. [18] analyzed stakeholders' perceptions and found that integrated water governance could be improved through awareness and education, consensus and collaboration, transparency, economic incentives, working across scales and incremental reforms [19].

Summarizing, the literature highlights the need for scientifically supported stakeholder engagement, properly communicating the existing problems and the benefits of improved management strategies, ensuring that these strategies will be holistic and will benefit multiple (and diverse) stakeholders [20,21]. Although scientifically supported stakeholder analysis, aiming at holistic solutions, is not a new approach in the literature of WRM [22,23], it has been rarely used in Greece. The project *Water For Tomorrow* focused on Thessaly, a Greek rural Basin District (BD) facing, historically, several environmental and management problems and brought together for the first time a diverse multi-stakeholder group (living lab) aiming to improve current water management. This research incorporated the aforementioned lessons from the literature: involving key stakeholders on a long-term basis, ensuring a multi-level cooperation to co-develop holistic solutions [6,24], cultivating the necessary capacity and culture to support them [25] and avoiding thus potential conflicts [26]. These characteristics of the project, together with its length (19 months for workshops, 24 months including the design) allowed the building of relations based on trust, understanding, learning from each other and developing solid and integrated policy recommendations addressing all management levels. This is in line with the literature that suggests that participatory processes with similar characteristics lead to more (cost-)effective solutions and more successful outcomes in the long-run [27], as well as robust co-developed visions for future action [28,29].

The novel framework Systems Innovations Approach (SIA) [30,31] was applied in this study. SIA is based on systems theory and is particularly useful for assessing complex problems and developing innovative solutions. The SIA is a concept developed in our living labs [30–32], where human-environmental-technological systems are assessed with the aim of co-developing a set of solutions/common visions for the future, together with key stakeholders. This is particularly important for the implementation of the solutions, that aim to overcome the current challenges. A combination of scientific support and stakeholder analysis, through the living labs, unravels unexplored human and technological solutions that are innovative in relation to the problem and in the way they interact [30]. To our knowledge, this is the first application of a SIA-living lab process for sustainable and integrated water management in Greece. Other benefits of the approach followed refer to the easier co-creation capacity among diverse stakeholders through 'deep' listening and scientific support; the creation of communication bridges with policy actors to strengthen influence; and the ability to easily place the input and insights of all participants in a

broader planning framework, providing thus scientific, multi-level, commonly acceptable and supported policy recommendations.

The BD of Thessaly is a particularly useful case study and the systemic approach followed and the resulting recommendations are expected to be of broad interest: Thessaly faces multiple problems that are common to several agricultural regions, not only in the Mediterranean, but also in other areas with similar water scarcity issues [33,34]. As explained in the next section, the stakeholders of Thessaly have conflicting views regarding the way that the region will develop, the water management options, the water allocation among different uses and the responsibilities of the different authorities to act. Overcoming such conflicts through a living lab in Thessaly BD using the SIA framework was regarded as a difficult task and the goal of providing commonly accepted policy recommendations was considered as very ambitious. Presenting this 2-year effort and the main principles that were followed is expected to provide useful insights for other cases that work towards integrated and feasible proposals as necessary steps to improve current water management.

2. Study Area

Thessaly BD is a rural area of 13,377 km^2 in Central Greece [35]. Thessaly is the driest region of Greece, with an average annual precipitation of 600–800 mm and an average annual temperature of 16–17 °C [36,37]. It is also a major agricultural producer—as Figure 1A shows it is a predominately rural area.

The region faces a number of water quantity and quality issues. In particular, the BD is hydrologically dry, with a negative annual water balance for most water bodies because of over-exploitation for irrigation (92% of the total water consumption) and high losses from the aged, open networks and the inefficient irrigation methods [36,38]. The intensified irrigation water use causes surface and groundwater overexploitation: 24% of the irrigation needs are covered by surface water and 76% by groundwater resources, through legal or illegal (unregistered) drilling wells [35]. According to the Greek Ministry of Environment, more than 44% of the surface water bodies is below good status (ecological and chemical), while 33% and 12% of the groundwater bodies are in a bad quantitative and bad chemical status, respectively [35]. In general, the intensification of agriculture that is accompanied by excess water consumption and the unreasonable use of fertilizers is attributed as the main driver of the degradation of water quantity and quality [39–41]. These negative impacts are even more serious under severe climate change impacts, the ambitious production-economic objectives of agricultural production, continuous (historically) drought and flood events, conflicts and administrative, accountability and economic issues, as analyzed below [31,35,37].

From centralized authorities to Organizations of Land Reclamation (OLRs) (the Greek Committee for Environment (GCE) coordinates the related policies and programs and measures in cooperation with the Prefecture of Thessaly; the Agricultural Organizations of Land Reclamation (AOLR) are responsible for the agricultural water management; the actions at local level are coordinated by the Local Organizations of Land Reclamation (LOLR).) and users, there are several economic and administrative issues [31]: lack of overarching control and inspection, lack of (trained) personnel, silo communication gaps, no cooperation, micro-political issues, no public engagement, lack of transparency and accountability, poor management of infrastructure (including incomplete and non-operating dams, reservoirs and networks), lack of monitoring, data and record-keeping, water theft (illegal wells), debts, water underpricing and no cost recovery of water services (OLRs face high debts). Moreover, European funds are not being absorbed because there is no capacity to plan and coordinate the necessary works.

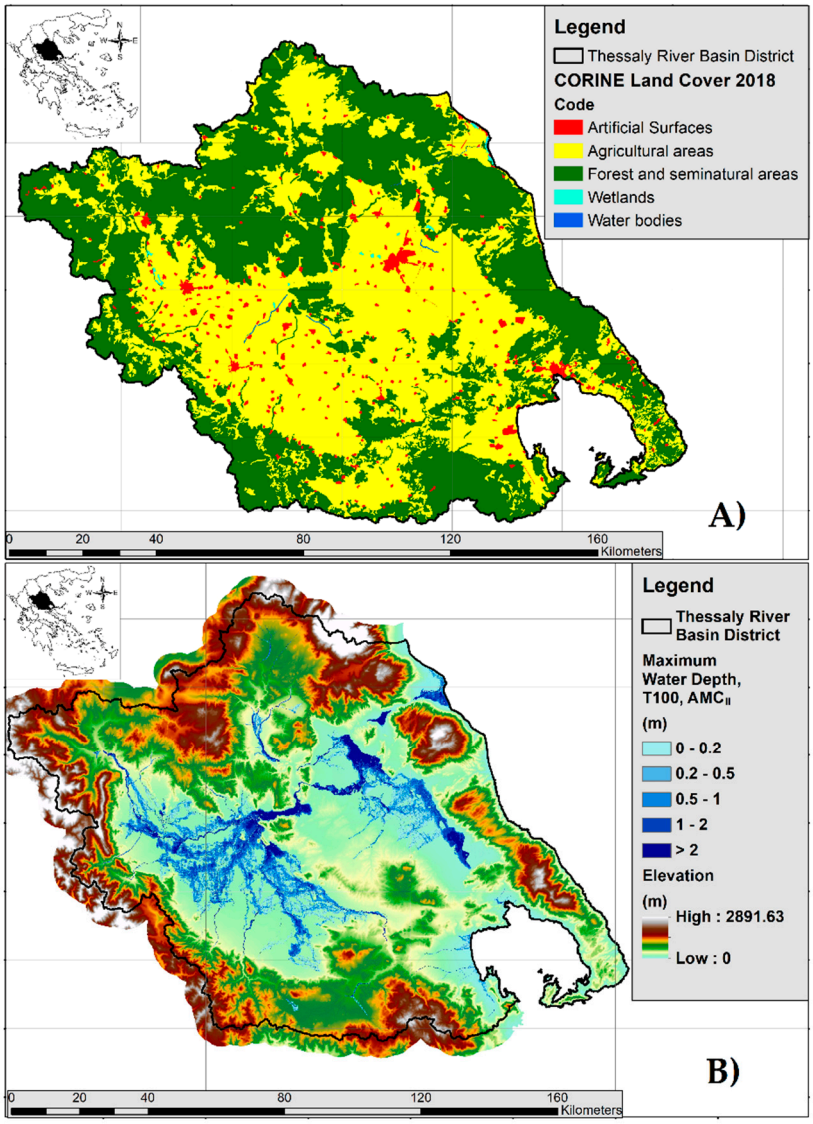

Figure 1. (**A**) The Basin District of Thessaly, with the mainland uses according to the Corine Land Cover (2018), (**B**) Indicative results of 2-D flood (T = 100) simulations for Thessaly (Adapted from [27]).

Extreme phenomena, including severe drought and flood events have been historical pressures in Thessaly, more than in any other Greek region (Figure 1B) [37,42,43]. Recently, there are evident signs of such phenomena with increasing severity, frequency and intensity. The projected increased temperatures and reduced rainfall are expected to increase the water and energy requirements and reduce the available water reserves [44]. Economy, agriculture, fisheries, health, transport and tourism are expected to be the most vulnerable sectors, so efficient water management, especially in agriculture, is a necessity [45].

Finally, the broader management of the region is subject to several conflicting approaches and views. In particular, the scarce water conditions have created disagreements on the way that the BD will develop; considering agriculture as a high priority for the BD means that the excessive water demand for irrigation will continue, in contrast to managing a pause in growth (and to stop cultivating in some instances) to avoid further environmental degradation [46]. In addition, water scarcity creates conflicts among agriculture and other uses, often leading to illegal drilling wells for water supply [47–49]. The water management options have been another conflicting issue for Thessaly, particularly conflict between the increase of water supply and the application of water demand management strategies. Historically, the supporters of increasing water supply for Thessaly, demand trans-basin water transfers from the neighboring BD of western Greece and diversion works

from Acheloos river, while the other side argues that the problem can be solved with more efficient water use for agriculture [50,51]. Although this argument has been in the spotlight for many years, there has not been any considerable progress for either side [52]. This limited progress regarding water supply or demand management [53] is often attributed to the lack of understanding of the responsibilities of the different authorities and their disagreement regarding a realistic ability to undertake such projects [54], a general problem, beyond the borders of Thessaly [55–57].

3. Methodology

3.1. The Systems Innovation Approach

The methodological framework followed, the Systems Innovation Approach (SIA), is a process for coordinating, developing and structuring discussions and the sequence of meetings, depending on the situation, the problem studied and the progress. It is mainly a conceptual guideline rather than a strictly methodological framework. It is based on system theory and follows the principles of providing continuous scientific support at all levels and for all topics covered.

This includes, first, an understanding of the complex interactions of the problems' components, the reasoning behind the process based on international practice, experience and research, the exploitation of local input and knowledge, scientific stakeholder analysis and mapping and the connection with innovative opportunities for flexible and holistic solutions [31,32]. For this purpose, the research team initially presents the problems of the BD and the participants comment further, expanding or correcting them. Second, the challenges are further analyzed from a number of perspectives (environmental, technological, policy-related, economic and social), dividing the problem into its different components. The goal of this stage is to understand that these issues interact (and how they do so) and to understand each other's perspectives and responsibilities, crucial in overcoming the challenges. A subsequent stage would be the analysis of the past and existing initiatives and efforts, for two main reasons: first, to see what has been done already in the study area and to examine if this knowledge is available, concentrated, accessible to the public and if the key stakeholders are aware; second, to draw lessons from the successful and unsuccessful actions of the past. Analyzing these with the local stakeholders, using examples from international practice and literature for similar cases, provides insights regarding factors that must be sought or avoided in future initiatives. There are some cases where stakeholders have proposed their own solutions or are aware of more actions and plans, so it is important to allow them to explain these, analyze how they could assist the problem-solving process and even reconsider their views. This is similar to what happened in our living lab. Moreover, the stakeholders identify common areas of cooperation and enhance the understanding of what each other does, or what are their motives and goals, which is fundamental to co-design the areas for action. If the areas for future action are formulated in such an environment, co-developed by local knowledge and understanding of each other's functioning, with as objective and realistic a judgment as possible based on the lessons learned and scientifically supported, it is easier to place them in the broader context of the systemic problem.

3.2. The Living Labs

The project involved monthly virtual meetings (structured workshops) from March 2021–July 2022 (Table 1), as COVID-19 restrictions did not allow in-person meetings. The living lab consisted of a five-member research team (authors) and 27 key-stakeholders. These were representatives from Central Government (General Water Directorate, Agency of Land Reclamation Works), the Prefecture, Local Authorities, agricultural co-operatives relating to water and agricultural management, OLRs from Thessaly and other Greek regions, experts and experienced professionals, Non-Governmental Organizations (NGOs), start-up, technology experts, researchers and academics.

Table 1. Timeline of the Living Labs' workshop structure (Adapted from [31]).

March 2021 Goals of living labs, introductions and expectations	**April 2021** Understanding the challenges and their consequences from a cross-disciplinary perspective	**May 2021** Understanding the different stakeholders' views and reaching to a holistic description of challenges	**June 2021** Understanding and evaluating various policy measures-actions (existing and proposed ones)
July 2021 Understanding the implemented projects, their results, comparison with international cases	**August 2021** -	**September 2021** Understanding what went wrong in the past (obstacles for works, policies, initiatives, engagement)	**October 2021** Supply and Demand Management and policy ground to support them
November 2021 Examples of stakeholders' experience, knowledge, applied projects (no.1)	**December 2021** Examples of stakeholders' experience (no.2): fields for cooperation	**January 2022** Balancing supply and demand—working towards a unifying framework	**February 2022** Sustainability vision development (policy and economic instruments)
March 2022 Ideation of the suggested actions, opportunities, strengths and weaknesses	**April 2022** Building the policy recommendations framework	**May 2022** Framing the policy recommendations in the broader picture	**June 2022** Building partnerships—Dissemination plan

The stakeholder group included government (central and regional) and local authorities' representatives, as well as the region's agricultural organizations and professionals, to address all levels of water management, as well as the local perspective—a recommended good practice [58]. The participants' selection aimed to ensure the necessary insight from the centralized and local policy actors and sufficient expertise from different scientific and technical areas. It is crucial to maintain a level of equal representation and knowledge among different scientific fields, fully representative of the problems of the region, together with regulatory insight from policy actors and locals' knowledge [59,60].

All participants were approached initially through emails and telephone calls and all accepted the invitation to participate. Many of the stakeholders had never participated in such processes. They appreciated the initiative, as they believe that the water management problem of Thessaly is of major importance, nd the fact that they could invite other relevant stakeholders (even beyond the geographical limits of the study area) that could contribute to the workshops. A positive element from the workshops was that, in the end, all participants expressed their appreciation and even gratitude for their inclusion, the completeness of the approach (bringing together a quite diverse group) and the way that the process was coordinated.

The role of the research team was to coordinate the meetings and the analysis, post-analyze the discussion and continuously search for the necessary scientific evidence and information, depending on the meetings' needs. This process also included the presentation of the problem, the review of the relevant literature for the study area, presenting examples from this and from international practice in dealing with similar problems, the relevant management initiatives that have been in place up to date, the development of the meetings' agendas or other material to distribute to the stakeholders, constant contact with them and updating/upgrading of the process with their feedback and new information. The stakeholders from Central Government were representatives of the General Water Directorate, who are responsible for the River Basin Management Plans (RBMPs), the Agency of Land Reclamation Works, the Prefecture and Local Authorities. Their role was to give their perspective on the strengths and weaknesses of the state's mechanisms, to evaluate the

feasibility of the proposed actions, to clarify what is already established through regulations and what is not, to explain the responsibilities of each institution and the unavoidability of being challenged in terms of what they can do or not and to analyze the "mistakes" of past and current managerial and accountability mechanisms. Stakeholders from agricultural cooperatives relating to water and agricultural management, including OLRs from Thessaly and other Greek regions, brought in their views on what problems they are facing, what efforts and initiatives had been explored so far, what obstacles they have faced regarding solutions to the problems and what kind of support/cooperation they would expect/need from the central government. Among the stakeholders, there were also three representatives (water utility manager, OLR manager and agricultural cooperative manager) from other Greek regions, for comparison purposes regarding the problems they face and the ways they have tried to overcome them. Another group of stakeholders, namely the experts and experienced professionals, including start-ups and technology experts, provided useful insights based on their experience from previous projects, technological solutions that have been used and the associated pros and cons. Finally, researchers and academics had relevant experience in a broad range of areas, including agriculture, hydrology and hydrogeology, engineering, new technologies, digital management and economics. Their insight was complementary and referred mainly to the techno-economic, environmental sustainability and state-of-the-art research aspects of each initiative and proposed action.

The different colours in Table 1 express the different phases of the process, in line with the SIA framework:

1. First, the existing situation with all problems identified in the study area was presented and analyzed, in order to reach a common understanding of connections and of the diverse perspectives of all stakeholders;
2. Starting from a common ground regarding the perception of problems and the management objectives, the existing approaches and measures were presented, analyzed and evaluated;
3. Next, most stakeholders presented their own projects, experiences, initiatives, etc., and the progress of each was further discussed.

Finally, the goal is to reach to a commonly acceptable list of policy recommendations to put well-structured, holistic and scientifically supported pressure on the policymakers. This is an ambitious goal, considering the scale, the situation and the past experiences of the BD. In the beginning of the project, most participants were pessimistic about the project's outcomes, doubting if it was possible to reach a commonly supported list of recommendations. These policy recommendations were drafted by the research team and were finalized by the stakeholders in a process of reaching consensus and ensuring that all views are reflected in the final report.

4. Application of the SIA Framework and Insights

The SIA framework enables the group to uncover hidden reasons and challenges that cannot be found in the literature, unblock the process of deep listening, i.e., the process of listening in order to learn about and understand each other's perspectives, which is essential for the group to work towards a common good [61].

The platform MIRO [62] was used in parallel with the discussions, as a visual board-tool that allowed all participants to make notes while discussing each topic, thus making it easier to categorize the perspectives and links among the different aspects of the problems. Figure 2 is an indicative example of how MIRO was used in parallel with the discussions, illustrating the example of the pentagonal problem: This was framed in the first phase of the living lab process, to visualize the environmental, economic, social, technological and political aspects of the challenges. During the workshops, we reached a common understanding of the overall picture of those challenges, perceiving them as interconnected sub-systems, seriously affecting all sectors and everyone's interests. The idea that one-sided policies (e.g., emphasis on intensified agriculture) are not sustainable, the importance of

cooperation versus maintaining conflicting views and the idea that there are solutions to support integrated forms of development, all started to be cultivated.

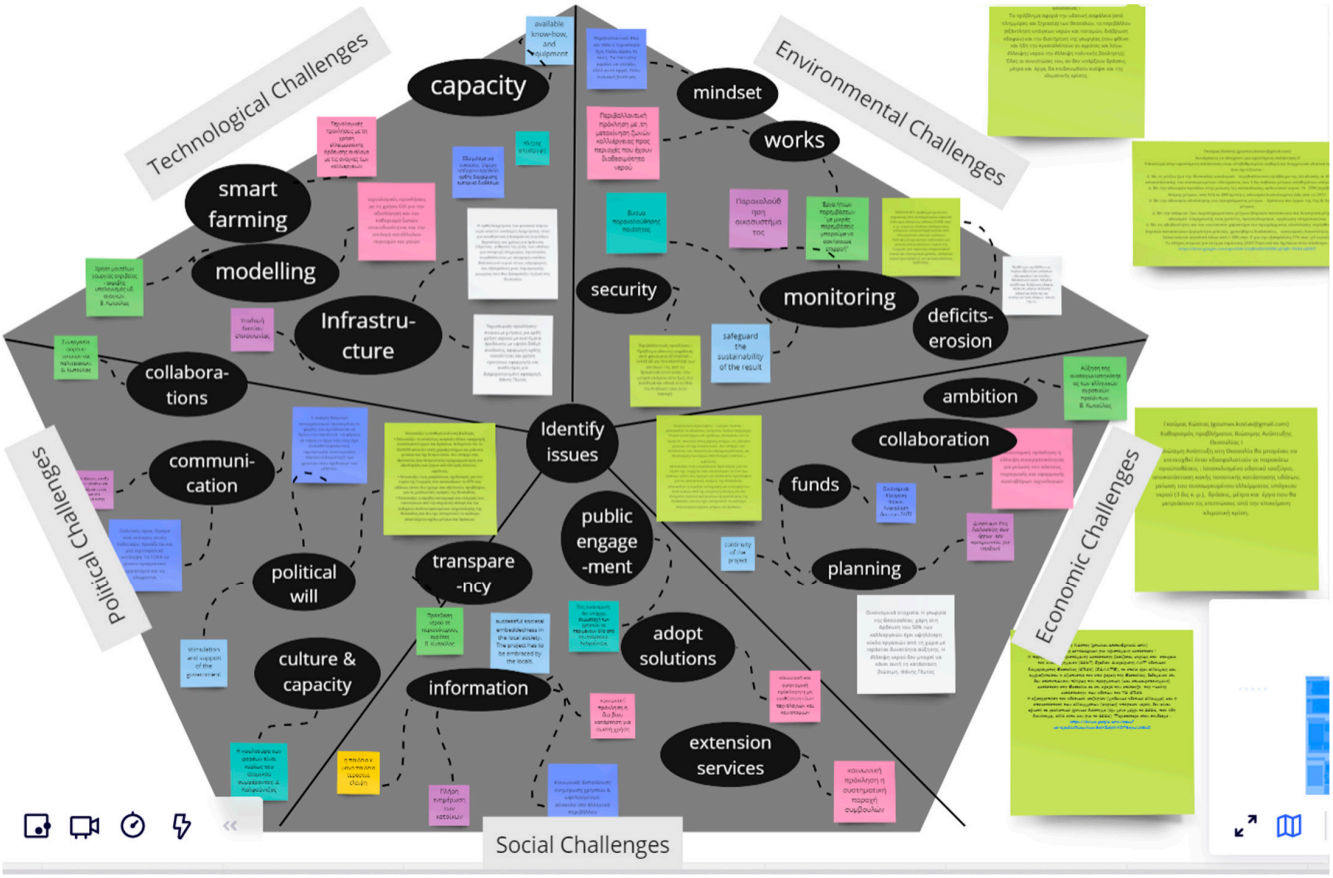

Figure 2. The Pentagonal problem as framed in MIRO, indicatively showing how the Environmental, Technological, Economic, Political and Social issues were simultaneously described by inserting notes, descriptions and connection links in the respective section of the pentagon during the discussions (Adapted from [31]). Here the first level of notes, keywords in black colour, are mainly presented per category of challenges, indicative of the challenges perceived by the stakeholders, expressed by just one word. The other comments are further arguments (in Greek) to support the (English-translated) main keywords provided and to emphasize their importance.

In particular, all stakeholders recognize the environmental issues of the region (referring to water quantity, quality, climate change, extreme events), so the environmental challenges are clearly perceived more efficient and reasonable management tools to cope with them and ideally to overcome them. The technological challenges are mainly the absence of modern means for monitoring and of smart farming. The economic problems reflect in principal the institutional weaknesses and lack of capacity of the local policy-makers to plan, understand the current regulatory procedures in order to implement the works and absorb the available funds as investments to improve water management. These create a number of social challenges, including disappointment, lack of public participation in the decision-making processes and a broader sense of non-transparent planning. The political challenges justify this general unwillingness and/or incapacity to improve the situation. As mentioned before, these challenges are interconnected and that was well-understood by the group. The benefit of that understanding, together with knowing each other's views, is that the recommendations will be placed in a holistic context, where each one should take his/her own responsibility. The participants believed and supported that the only way to reverse the situation in Thessaly is through coordinated action and teamwork. This was key to resolve conflicts that support one form of development (continuous growth versus

'stop cultivating') or one type of water management (increased supply versus demand management) over another—or similarly, to overcome the idea that only one authority should take responsibility. It would be insufficient if only one group of stakeholders tries to address a single challenge (e.g., monitoring, or technological tools) and, similarly, it would be impossible to solve the environmental challenges, for example, with no changes in the other four sections of the pentagon.

In the second phase of the procedure, all actions proposed by the state, including the RBMPs' measures, actions under the Resilience and Recovery Plan (RRP), academia, private sector and local initiatives, were listed and discussed, in order to evaluate them and learn from their outcomes. Around 84 specific actions (Basic Measures as defined in the EU Directives, water demand and supply management, project management, trans-basin diversion works and non-state initiatives) were discussed (pros and cons of each approach) and evaluated based on their usefulness, importance and urgency. The explanation of the intention of the measures and their expected outcomes (e.g., in hm^3 of water saved, or additional water, or communication/administration gaps to be covered among authorities) was the basis for a clear and objective evaluation. The stakeholders also assisted in clarifying the feasibility and the progress of each measure, especially the representatives of the central and local government, while explaining which authority is responsible of each. These were also key for clarifying misleading perceptions (or partial knowledge) that cause conflicts. Among the lessons learned from the overall process were the importance of having scientific support for explaining the different categories of the measures, their significance and expected outcome. This was a learning process for all participants, including the research team and also led to a better understanding, which overcomes conflicts and allows the co-development and overall support of the policy recommendations (important missing elements so far).

Most actions evaluated were, overall, acceptable by the participants and there was also an overall agreement in terms of their prioritization. The group prioritized: (a) the completion of incomplete water supply works, (b) a proper, clear and transparent project management, (c) demand management works, (d) trans-basin diversion works. This was an important outcome, as for the first time in the region there was an agreement over the different water management strategies and a recognition of the importance of each one. Thus, the need for coordinated multi-level action put aside a narrow discussion over the conflicting topic of either supporting or not the trans-basin water transfer from the Acheloos basin—on which the general perception so far was that its supporters were not open to other means of water management.

In line with the challenges outlined in the first phase, flaws in the programming of the action-study-implementation sequence were highlighted as the main reason that most of these measures have not been implemented. For example, the Prefecture opened only three invitations to tender after the Second Cycle RBMP of 2017. It is worthy to note that there are 34 measures that can be included in the RRP focusing on "Smart Development" (e.g., smart agriculture, new technologies, innovative products and services and public administration), "Green Development" (3.6 billion € investment in renewable energy sources, infrastructure and networks, energy efficiency, circular economy, etc.), "Social Development", "Infrastructure Development" (networks, potential water supply works, transportation) and other actions focused on culture, tourism, agri-food sector, industries, etc. Unfortunately, the Prefecture has no scheduled or planned actions under the RRP, at least based on their response to the workshops. Lack of capacity, transparency and inactivity from the local authorities, often tied with individual micro-political interests, are identified by the group as the main weaknesses that also prevent the exploitation of EU funds. Lack of long-term vision and commitment and silo communication gaps across authorities, mainly because of changing governments, further support this problematic situation.

The group sees this as the root of most problems and find it difficult to change. As the central-management stakeholders clarified, the regulatory framework exists and clearly sets the responsibilities for each authority, but the problem is that the authorities (both

centralized, regional and local) are not working properly. During the discussions, the disappointment and the expectations of each stakeholder group were made clear. In particular, government representatives had the feeling that they have done everything they could, despite being underfunded and under-staffed—this is a problem that only their superiors, i.e., politicians, can solve. They also stated that it is not their responsibility to ensure that the actions they plan will be implemented, but it is up to the local authorities, even for mandatory measures. Local authorities were found to be incapable of planning and implementing or even managing any project. The local agricultural managers and the representatives from the OLRs explained their problems (i.e., covering unknown water demands with unknown amounts of water available, or having limited guidance and support for water management actions and projects, lack of capacity and necessary skills, etc.), so they convinced the group that they urgently need meaningful support even for basic things. Thus, all sides understood that more cooperation is necessary to improve the situation, become more efficient and avoid criticism and further conflicts.

At this stage, it was becoming evident that the process followed in the workshops so far built a sense of ownership which could be the basis of cooperation, for the first time in the BD. The benefit was that we (as a group) were able to promote and support more decentralized water responsibilities aiming for results-based actions—an established good practice to overcome complex administrative and coordination impediments [63,64]. A prerequisite for this is to have a proper level of data and accessible and transparent information to support decisions for improved management [6].

In the third phase, a space for solutions started materialize and all the initiatives and assets of the stakeholders were about to be exploited: The participants presented their works, solution-oriented proposals and experiences in different fields. Most of the participants were very familiar with the processes of water resources management in the BD and are quite knowledgeable about its current flaws and weaknesses. They have relevant expertise and have worked on several projects themselves (from different perspectives and positions), mostly on demand management. Many participants with significant experience and knowledge in their fields have made proposals to the local authorities (Prefecture) for works and/or improved water management practices. However, all these proposals have been ignored so far. All stakeholders learned from each other and exchanged ideas and views on how to overcome the current problems, how they could cooperate and take more initiatives towards more efficient management (e.g., use of technologies for monitoring, smart agriculture, communication to the relevant authorities and people for each work, scientists with potentially advising capacity, regulatory gaps, etc.). This kind of management referred to a number of actions synthesizing a holistic approach, considering: information availability, reliable data, transparency and accountability; large-scale long-term supply management solutions (e.g., local reservoirs, operation of incomplete works, partial diversion from trans-basin water bodies); smaller scale 'mild' targeted interventions aiming at demand management for a more efficient and reasonable water use (e.g., crop replacement, smart agriculture based on monitoring, more efficient water use); new technologies, digital water management; optimal water resources allocation, technical works for loss reduction (including networks and irrigation methods); institutional actions to address existing communication, planning capacity and regulatory gaps (including new institutional management structures to support the existing mechanisms). These proposals had strong policy/techno-economic bases and were seen positively by the group. Next, they were placed in a broader context according to SIA's principles, so the framework of Figure 3 was developed, aiming at sustainable and resilient systems. The supply side includes environmental, social and economic factors that need to be analysed and assessed as assets, either to the degree that we can control or better manage them. Supply can be increased sustainably through more efficient and smarter use of assets. The demand side also includes multiple parameters and disciplines (environmental, social, economic) that can be optimized and used efficiently. The institutional/policy-regulatory sub-system aims to (and has to) balance supply and demand in order to make systems operate sustainably

(both environmentally and economically)—based on and exploiting national and international policy agendas. Therefore, the ground is prepared and more solutions can be provided to address the various challenges and thus achieve resilience.

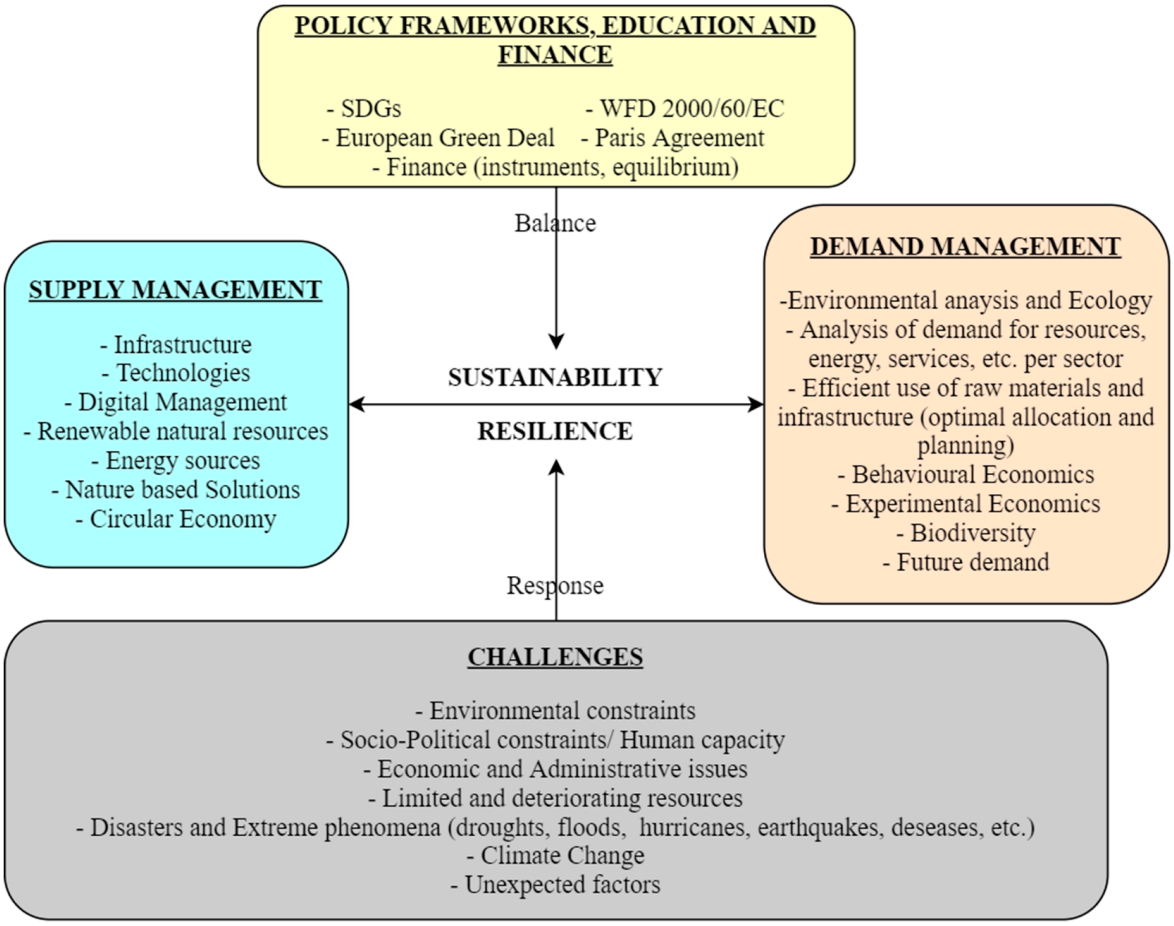

Figure 3. The most common components of the supply and demand sides, which must be balanced to achieve sustainability (environmental, economic, etc.); the challenges that our systems are facing in trying to become more resilient. The policy-finance frameworks and education will provide the necessary ground for action [31].

The process was beneficial as areas were shaped for cooperation to improve each one's knowledge, exploit their work in terms of implementation and institutional ground. It also reflects a fundamental change in the way that the creation of knowledge is perceived and endorsed. It shifts attention away from one-sided views (e.g., solely technological inventions or research), towards the whole process of innovation, where such views are only one component. The participants identified many common views and rationale in their approaches to solve the problems outlined. This served as the basis for their collaboration towards co-developing a list of recommendations.

5. Co-Development of Recommendations

The last phase of the project concentrated in co-developing a list of complementary, acceptable and feasible recommendations with multiple benefits.

In order to provide high-quality and consistent water services, it is necessary to have data and information to guide policy, to make the best use of resources and infrastructure and to have clear mechanisms for the roles, responsibilities and capabilities of those involved. The nature of these visions considered also the existing governance context, as in the past there major issues have been identified regarding silo communication gaps

across the different authorities and stakeholders. Data and information gaps and unclear accountability mechanisms further contributed to these problems. Therefore, transparency and enhanced communication were deemed to be the most realistic and effective solutions. Thus, a way to overcome such issues was found to be through the development of a geospatial database (information platform) for the digital management of land use and resources. Agricultural, agronomic, physical (soil/topographic data), data on water available for use, water demand based on crops, pollution potential, etc., would be useful factors to be collated into an accessible interactive map. Such tools are used internationally to promote transparency as a form of effective governance (creating a sense of responsibility, informal control). This is expected to provide multiple benefits on many levels: managerial, administrative, accountability, covering data gaps, information sharing to enhance the work of all individual actors and bodies, decentralizing some water management actions, informed decision-making, modernization of current tools and practices and holistic approaches in terms of a more integrated planning. The participants also expressed a position which is in line with relevant research [65], that they all consider it necessary to have direct access to both information and to new technologies.

Complementarily, the need for a record of the relevant water and agricultural management studies is recognized: A digital library to concentrate this knowledge and these applications (existing works) currently does not exist. Such a service would leverage any attempt for research and practical implementation of action: It would speed up the understanding of the baseline situation in the region, help researchers avoid duplicating previous works, easily build on previous knowledge and allow the identification of potential cooperation links among actors.

The above two recommendations can facilitate actions that will be: (a) based on relevant data and information, hence more science-supported than the current management; (b) more obvious to local managers, sometimes allowing them to act faster, avoiding obstacles related to the governmental formal procedures that are perceived to be restricting, due to their complexity. The rest of the proposed actions have the role of simplifying results-based science- and technology-supported actions and enhancing their uptake.

The institutionalization of a stakeholder consultation body could effectively contribute to the general management of agriculture and the environment of the region. According to the recommendations of OECD [66] and of RBMPs, public involvement must be part of the decision-making process. The process and outcomes of this project that involved multiple and diverse stakeholders are encouraging signs that public participation has to offer its valuable insights and can be meaningful in Thessaly. It will be crucial to institutionalize and maintain continuity for this initiative and have the stakeholders involved as allies in order to improve water management [67]. Furthermore, the project's recommendations are expected to be useful for the development of the upcoming RBMP (3rd Cycle 2022-27) and can speed up the process in an effective way since they have been communicated directly to the representatives of the General Secretariat of Water (participants), instead of waiting until the public consolation of the RBMPs. This is a significant achievement of the project, as it connects its outcomes with the respective regulatory and institutional frameworks that will determine the future water management of the BD. Efforts that lack this regulatory component (as well as its interaction with the participatory processes) have resulted in limited changes towards a more effective governance for sustainable water management [34,68].

Another element that arose in this stage was the need for more science informed policies for integrated water–agricultural management, able to cope with the future challenges [6,69]. Thus, the active and ongoing cooperation of knowledge institutions (universities, research centers) with the General Water Directorate and the relevant Ministries must be established (e.g., the Agricultural University of Athens is already an official advisor of the Ministry of Agriculture and Rural Development).

The improvement in the existing institutional mechanisms, with emphasis on the General Water Directorate and the Prefecture, is essential. Commitment and cooperation among

central and local government must be established (e.g., using tactical meetings) focusing on covering existing gaps to implement the actions. Upgrades, investments, capacity building programs, hiring and campaigns and modernization of local authorities should be seen as a precondition for healthy communication and the successful implementation of most actions [70].

All proposals are not competitive, but complementary and coherent. The best way for their proper and effective operation is through mutual commitment and seriousness from many sides. Therefore, the individual proposals of the participants in this direction should be supported. In that context, the demand and supply management measures should be considered and implemented. Supply management has focused on the completion and operation of the works that have stayed incomplete and unused for years (e.g., dams of Sykia, Enipea, Koiladas and Kranona reservoirs, dams of Agioneri, Neochoritis, Lithaios, Narthakiou, Halki). Moreover, the consideration of local reservoirs to exploit the renewable water resources must be scientifically planned and well-coordinated. Demand management recommendations included several acceptable actions proposed by the RBMP and individual stakeholder work, such as: improved monitoring and modeling of alternative management strategies, upgraded irrigation networks to reduce losses, smart and precise irrigation (and more efficient application methods), crop replacement, private investments at farm-level to increase water-use efficiency, investments to LOLRs to modernize them and enhance their capacity, water reuse, reasonable water costing and pricing.

The need to adopt practices using new technologies to manage assets and current infrastructure elements and modernize the current water services was also highlighted. Participants from start-ups and companies showed examples of low-cost applications that enhance the overall control of agricultural and irrigation services. Moreover, the exploitation of the available information and data through integrated models is crucial to enhance informed decision-making. Such models are common tools considering environmental-agricultural-energy-social-economic aspects and serve as Decision Support Systems (DSS).

Furthermore, ensuring transparency, accountability and controllable distribution of roles and responsibilities is fundamental, as it can help overcoming several obstacles that currently hinder the implementation of more reasonable management.

Finally, on the occasion of the recent war in Ukraine that brought to the surface several mismanagement issues related to energy, resources and agricultural production, and amidst the development period of the Greek Common Agricultural Policy (CAP), the discussions also included measures to cope with those challenges. Circular, regenerative, low-cost and environmental-friendly (in terms of resources use and emissions) agri-food systems must be supported [8], in contrast with the prevailing mindset that sees agricultural production to be competitive with the use of land, water and energy.

The list of policy recommendations is shown in Table 2.

The final action of this project is its dissemination plan, aiming to the uptake and elaboration of the proposed recommendations and the continuation of the initiatives discussed. In particular, a series of parallel actions is about to start in the beginning of October 2022. These include the communication of the project through in-print and digital media, radio and TV, press releases, as well as the communication of the whole procedure through the website that covers environmental issues of Thessaly (ypethe.gr, with which we are cooperating). Moreover, a series of in-person meetings and talks have been scheduled, including a presentation at the Greek Parliament, the organization of a workshop/seminar and potentially a conference. These dissemination actions aim to expand the scope of the recommendations beyond the BD of Thessaly, for the country in general, since there are similar problems. Furthermore, the scientific publications in journals and conferences will be used as references, together with the technical reports of the project to further document the process and the results to the audience that is interested. A website has been developed for the project (nerogiatoavrio.gr) summarizing the program with additional material and information for further outreach. Communication actions and campaigns through social media are also underway. Finally, follow-up meetings with all stakeholders

and participants will be set up from the beginning of 2023, in order to further promote work to their networks and in general to achieve a continuous communication of the outcomes, gathering thus more supporters to put pressure for the materialization of the proposed recommendations.

Table 2. The summary list of policy recommendations, with brief descriptions.

Recommendation A: Upgrade of Geopuli (geospatial information platform by the Greek Ministry) as a water management application—geospatial database, interconnected with the relevant institutions, with a series of services to be provided through a digital interactive map.
Recommendation B: Development of an electronic library—repository of relevant studies.
Recommendation C: Development of a platform (accompanying Geopuli) with detailed information and data (quantitative/qualitative status, pressures, measures, progress of the River Basin Management Plans—RBMPs) for each basin of Thessaly (with the corresponding water bodies)—Compilation of detailed reports for each basin.
Recommendation D: 1. Establishment of a stakeholder body for participation in the water resources management process. 2. The existence of a multi-stakeholder platform with a targeted scope and area (e.g., irrigation water management in the BD of Thessaly), as was the case in this project, is a proven good practice. The participation of the appropriate stakeholders (qualified and experienced, with knowledge of the subject and local human and environmental conditions), the scientific guidance and the sense of responsibility and "ownership", also bring valuablecontributions to the planning, decision making and implementation of any measures. An institutionalized nature is essential for the effectiveness of communication and the continuity of the platform; 3. The proposals formulated in this project should be taken into account in the formulation of the new RBMPs, in order to avoid waiting for this communication until the public consultation of the RBMPs.
Recommendation E: Establishment of ongoing cooperation of an advisory nature between academic institutions—research institutes (engineers, agronomists, economists) and the relevant Ministries (Ministry of Environment and Energy, General secretariat of natural environment and water and Ministry of rural development and food). For example, the Agricultural University of Athens is already an official advisor to the Ministry of Agriculture and Rural Development. The scientific community must be heard by the political leadership and their cooperation is expected to bring multiple benefits at many levels.
Recommendation F: Cooperation through meetings on a regular basis between the central and regional authorities (respective services of the General Water Secretariat and the Region of Thessaly, but also OLRs when necessary). The process should focus on covering the existing gaps for the implementation of the actions. The transparency and data that proposals A, B, C will be able to provide, offer material for meaningful cooperation oriented towards the objectives of improving the situation in Thessaly. A prerequisite for this is to adapt the skills of the relevant services in order to cope with the complexity of water management challenges. This need is documented by the lack of progress of the measures proposed in the RBMPs, the inability of appropriate and corresponding planning of actions by the Prefecture, the inability to make use of available information, tools and funds for EU projects, the poor state of the infrastructure managed by the OLRs, the lack of data and monitoring, the lack of the necessary scientific approach and support, the lack of funding, (and/or appropriately trained) staff and therefore the inability to make use of the available information, tools and funds.

Table 2. *Cont.*

Recommendation G: 1. Assessment of decentralized administration bodies to identify areas that need strengthening and restructuring in order to adapt existing capacities to the necessary level of services required. Continuous and transparent evaluation of results-based actions should be also promoted; 2. Establish a single structure for technical support to water service providers per region/BD. Scientific, technological and technical support to the Prefecture and OLRs is expected to have only positive benefits to the services and projects provided; 3. Strengthening of the Prefecture and OLRs with qualified staff (engineers, agronomists, lawyers, hydro-geologists, economists, project managers, etc.) to provide consultancy services (including the exploitation of European funds by the Prefecture). Upgrading, investment, skills development programmes and campaigns and the modernization of local authorities should be a priority as human skills are a prerequisite for the successful implementation of most actions [70].
Recommendation H: Trust those that have knowledge in the fields of irrigation water management, environment, agriculture and rural economy to do their work. Many of the proposals formulated during the workshops are comprehensive, can improve the current situation and should therefore be taken seriously into account. Such proposals have the support of the participants in this project: 1. The proposal to establish an Independent Regulatory Water Authority (IRWA) with its sub-proposals and accompanying actions covers the broadest range of proposals of this project. The point is that political will and consensus are prerequisites for the implementation of any initiatives. The existence of an IRWA must be substantial and not limited to a legislative framework and above all it must include irrigation water use, so that it is relevant to the case of the Thessaly WD; 2. The actions and efforts at local level should be similar. The stakeholder survey on the restructuring of the institutional framework for irrigation water management with a focus on the OLRs briefly suggests: (i) Consolidation of several LOLRs based on size and organizational structure criteria in order to be able to manage their land in an efficient way; (ii) Unified accounting system; (iii) Scientific staff, provision for management by managers, cooperation with the private sector, (iv) Establishment of a Central Agency of Land Reclamation (CALR) within the Ministry of Rural Development for final control over the planning and implementation of studies and projects; (v) Seek good practice examples from national and international practice; 3. Communicate this project and its recommendations for increased political support for its initiatives and partnerships. Complementary to recommendations D and E, this action should be coordinated and continuous; 4. Ongoing information and education to strengthen the sense of social responsibility. Solving complex problems requires taking responsibility and equal effort from all sectors.
Recommendation I (supply management): study, coordination of project planningand management in order to carry out rational water supply management projects. Completion and operation of unfinished and underutilized projects is a priority. In addition, the creation of individual (local) reservoirs for the exploitation of surface renewable water resources must be taken into serious consideration.

Table 2. *Cont.*

Recommendation J (demand management): Demand management measures are equally important and necessary and, as analyzed, can target at several levels. The actions below have been discussed in the project and are considered feasible and applicable: 1. Proposal to study and finance a pilot project for the modernization of the Pinios OLR with the implementation of electronic metering of withdrawals (surface and groundwater), measures to implement precision agriculture, cultivation advisory services and the implementation of telemetry for monitoring the quantity and quality of surface and groundwater crop rotation. The project is in line with proposals A, B, C, G, H; 2. Irrigation network projects to minimize losses and maximize water use efficiency; 3. More efficient irrigation methods, depending on the crop, to minimize losses; 4. User awareness campaigns for demand management and implementation—adoption of relevant measures, such as: o Management technologies & electronic metering of groundwater and surface water consumption (Smart Irrigation Systems); o Use of calculated irrigation, considered precision agriculture, deficit irrigation, water reuse; o Crop rotation/selection of appropriate crops adapted to the specific microclimatic conditions, water availability and demand for final products based on market needs; o Rational and transparent irrigation water costing—pricing system, with emphasis on cost recovery and use of revenues for new projects and investments.
Recommendation K (Monitoring, Modelling & DSS): Exploitation of available data through analytical models: surface and groundwater hydrology models, water demand assessment models, accounting models for production costs–profit–production–water costs, forecasting models (e.g., climate change), management models to compare alternative scenarios (new/alternative water supply sources, demand reduction—conservation, optimal water allocation, cost-effectiveness of investments, etc.). Such models are intended to assist decision making and are known as Decision Support Systems (DSS).
Recommendation L: Formulate a simple outline of the structure of the authorities and their respective responsibilities and a table of the people responsible for each service (their roles and contact details). These should be transparent and readily available to each water management body. Thus, each stakeholder will be able to communicate regularly and be informed about the progress of the measures-action (progress tracking), thus strengthening the cooperation between them, identifying actions and initiatives to overcome any implementation obstacles, but also providing a sense of ownership and accountability and implementation of projects, for all the participants and the bodies represented.
Recommendation M: Formulate policies that promote the concept of interconnected (rather than competing) water–food–energy–economy–justice systems and apply such practices based on the circular production model and regenerative food-energy systems. The international scientific community promotes this approach as the only pathway to solutions and policies that are cheaper (cost-effective), environmentally friendly (water use and pollution), circular, with zero greenhouse gases emissions, better for human health and food systems, with equity and justice in access to resources and distribution of wealth. Renewable energy sources (wind, solar and hydropower), their combined rather than unilateral use, their storage, energy autonomy and use in circular economy and agricultural production models, as well as combined solutions for efficient use of water resources, energy and low emissions of pollutants and carbon, must be adopted.

6. Conclusions

This paper presented an overview of the process of a big living-lab exercise for the future management of the BD of Thessaly, which is based on the management of agricultural water but has multiple sustainability implications. Of course, not all aspects covered can be analyzed in detail in a paper's length; however, we believe that the general picture is successfully communicated. The situation of Thessaly BD in terms of environmental and socio-economic problems, accompanied by a long history of mismanagement, is one of the most challenging case-studies in Europe, so this process and its outcomes can be beneficial

for the rest of Greece and for many countries facing similar concerns. The main areas that were addressed from the policy recommendations are summarized in Table 3.

Table 3. Areas of focus/targets (right column) and the respective policy recommendations (left column).

Recommendations	Areas of Focus/Targets
A, B, C	Data, Information, Transparency
D, E, F	Stakeholder engagement
G	• Adapting the skills of relevant departments to meet the complexity of water management challenges
A, B, C, G, H	• Strengthening central governance, cooperation with decentralized administrative services and OLR; Upgrading their operation using new technologies; Modernize existing management practices, harmonization with European and International agendas and policies
I	Water supply management
J	Water demand management
K	Monitoring, modelling and use of Decision Support Systems (DSS)
L	Ensuring managerial control and progress monitoring
M	• Autonomous energy systems for agricultural production with multiple benefits in the interconnected water-food-energy-economy-justice system

As mentioned in the introductory section, this process can be helpful for other areas facing similar problems: (i) The inclusion of multiple diverse stakeholders, in a scientifically guided process of decomposing the management process and working towards common goals, is a difficult but worthy process for seeing the real challenges. (ii) It is very important to follow integrated approaches in terms of policy recommendations, that cover all areas of Table 3, in line with the broader context of sustainable management as presented in Figure 3. (iii) The policy recommendations can be easily adopted and applied in other contexts, as they aim to enhance the areas described in Table 3, under the principles of systemic and sustainable management.

With respect to the water governance in Greece, the "Water For Tomorrow" project contributed to resolving specific challenges and conflicting issues of Thessaly BD, addressed by the list of the complementary policy recommendations. For the case of Thessaly BD, this was the first time that a group of diverse stakeholders collaborated to develop a list of justified and scientifically supported recommendations that go beyond the traditional perception of water management and follow a "whole-of-systems" approach. According to the participants' impressions, this is a major advantage of this effort, compared to any previous initiative, i.e., the ability to see their contributions as part of a broader management context. In addition, an added value of this effort is the teamwork that characterized the whole process, the creation of cooperative relationships, the overall support for the actions and the team-efforts from all stakeholders involved to achieve them. The project leaves "open doors" for further support and more partnerships and the involvement of more institutions and people to support the initiative, in order to materialize the proposed projects and actions. The project "Water For Tomorrow" has been a process of understanding, learning and informing from all sides and of substantial public participation, in order to formulate a good basis for the future management of the water resources of the Thessaly BD. On this basis, a first step has been taken towards an ongoing process of consultation and the formulation of commonly agreed and accepted positions for more effective management practices.

The policy recommendations are not intended to cancel, undermine, or substitute any of the individual proposals and initiatives of the participants and other stakeholders. The aim is to highlight and promote them as parallel and complementary actions to a broader framework. The communication of the outcomes of this project is expected to speed up the response of the policymakers to the emerging challenges. Communication, education and capacity building, with emphasis on science-supported solutions, targeting to different levels of stakeholders is recommended to make communities part of the solutions and of the implementation/mainstreaming of good practices.

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